

Annex 1

Description of Work:

BMW Benchmark Models for the Water framework directive

Proposal No: EVK1-2001-00054

Contract No: EVK1-CT-2001-00093

Project Coordinator: Prof. Juha Kämäri, Finnish Environment Institute

Thematic priority: (1.1.1) Strategic planning and integrated management methodologies and tools at the catchment scale

Duration: 36 months

Contact persons for the contractors:

Prof. Juha Kämäri
Finnish Environment Institute, SYKE
P.O. Box 140, FIN-00251 Helsinki, Finland
Tel: +358 9 40300771, fax: +358 9 40300789
E mail: juha.kamari@vyh.fi

Dr Richard Wright
Norwegian Institute for Water Research, NIVA
P.O. Box 173, N-0411 Oslo, Norway
Tel: +47 22185204, fax: +47 22185200
E mail: richard.wright@niva.no

Dr Robert C. Ferrier,
The Macaulay Land Use Research Institute, MLURI
Craigiebuckler
Aberdeen, AB15 8QH
Scotland, UK
Tel: +44 1224 498000, fax: +44 1224 498207
E mail: r.ferrier@mluri.sari.ac.uk

Dr Vazken Andreassian
Centre National du Machinisme agricole, du Génie Rural, des Eaux et Forêts, Cemagref
BP 44, F-92163 Antony, France
Tel: +33 1 40966258, fax: +33 1 40966142
E mail: vazken.andreassian@cemagref.fr

Prof. Alan Jenkins
Centre for Ecology and Hydrology, CEH
Maclean Building, Crowmarsh Gifford
OX10 8BB, Wallingford
Oxfordshire, UK
Tel: +44 1491 838800, fax: +44 1491 692430
E mail: jinx@ceh.ac.uk

Prof. Lucila Candela
Dep. de Ingenieria del Terreno
Universidad Polit cnica de Catalunya, UPC
Edificio D-2
C/Gran Capitan s.n.
E-08038 Barcelona, Spain
Tel: +34 93 4016868, fax: +34 93 4017251
E mail: lucila.candela@upc.es

Ir. Simon Groot
Stichting Waterloopkundig Laboratorium, WL Delft Hydraulics
P.O. Box 177, NL-2600 MH Delft, The Netherlands
Tel: +31 15 2858483, fax: +31 15 2858582
E mail: simon.groot@wldelft.nl

Prof. Francisco Javier Elorza
Universidad Polit cnica de Madrid, UPM
Ramiro de Maeztu, s/n
E-28040 Madrid, Spain
Tel: +34 91 3367020, fax: +34 91 336019
E mail: jelorza@dmami.upm.es

TABLE OF CONTENTS

1	PROJECT SUMMARY	4
2	OBJECTIVES AND INNOVATION	5
2.1	SCIENTIFIC AND TECHNICAL OBJECTIVES	5
2.2	INNOVATION	6
3	PROJECT WORKPLAN.....	7
3.1	PRESENT STATUS OF INTEGRATED RIVER BASIN MODELS	7
3.2	WORK PLAN STRUCTURE.....	8
3.3	CRITERIA FOR BENCHMARK MODELS.....	9
3.4	MODELS FOR DIFFERENT DOMAINS.....	9
3.5	KEY LINKAGES BETWEEN DOMAIN MODELS.....	13
3.6	EVALUATING MODEL CHARACTERISTICS AND PERFORMANCE	14
3.7	INTEGRATION OF DOMAIN MODELS; APPLICATION TO TEST RIVER BASINS.....	15
3.8	TOOLBOX FOR BENCHMARK MODELS	15
3.9	END USERS	16
3.10	PROJECT TASKS, TIMETABLE, MILESTONES AND DELIVERABLES.....	16
3.11	RISKS OF FAILURE	19
4	CONTRIBUTION TO OBJECTIVES OF PROGRAMME	21
5	COMMUNITY ADDED VALUE AND CONTRIBUTION TO EU POLICIES	22
5.1	EUROPEAN DIMENSION OF THE PROBLEM	22
5.2	EUROPEAN ADDED VALUE FOR THE CONSORTIUM	22
5.3	EUROPEAN POLICIES.....	23
6	CONTRIBUTION TO COMMUNITY SOCIAL OBJECTIVES.....	24
6.1	QUALITY OF LIFE, HEALTH AND SAFETY	24
6.2	INCREASING EMPLOYMENT AND SKILLS.....	24
6.3	PRESERVING THE ENVIRONMENT AND NATURAL RESOURCES	24
7	ECONOMIC DEVELOPMENT AND S&T PROSPECTS.....	26
7.1	CONTRIBUTION TO GROWTH	26
7.2	STRATEGIC IMPACT AND POTENTIAL END-USERS	26
7.3	DISSEMINATION OF RESULTS	27
8	THE CONSORTIUM.....	28
9	PROJECT MANAGEMENT.....	31
9.1	CLUSTERING.....	31
9.2	MANAGEMENT AND DECISION MAKING	32
9.3	PROJECT MANPOWER	33
9.4	REPORTING	33
	SUPPLEMENT 1: DESCRIPTION OF WORK PACKAGES.....	34

1 PROJECT SUMMARY

EU Water Framework Directive (WFD) mandates Member States to develop river basin management plans for each river basin district. To achieve this the responsible authorities must have tools to assess alternative management options. The objective of this project is to establish a set of criteria to assess the appropriateness of integrated models for the use in the implementation of WFD. The project aims at testing and demonstrating the use of integrated models applied to selected intensively studied river basins, to answer questions relevant for the implementation of the WFD. The active participation of the end-users will ensure that the criteria and models are operational and functional at the management level. An interactive internet-based Toolbox will be built to disseminate information concerning integrated models.

The overall objective of the BMW project is to establish a set of socio-economic, bio-geo-chemical and systems analytical criteria to assess the appropriateness of integrated models for the use in the implementation of the WFD. The project aims at testing and demonstrating the use of the models fulfilling the defined a priori criteria, applied to selected intensively studied river basins differing in ecotype, land-use, pollution activities and pollution problems, to answer questions relevant for the implementation of the WFD. The active participation of the end-users will ensure that the criteria and the models are operational and functional at the management level. The project will point out development needs of the models, and develop and demonstrate a methodology that can be used for the planning and management of surface waters, groundwater and estuaries.

A scheme for selecting and benchmarking existing model systems will be devised and demonstrated to specifically meet the objectives of i) describing the current water pollution status at the river basin scale, and ii) providing a tool for evaluation of management options. These model systems may integrate models of individual catchment domains which may be defined geographically for land surfaces, rivers, groundwater and estuaries, or by the model function, e.g. for diffuse pollution and socio-economic values. The main products of the project will be inventories, criteria and guidelines for sub-models and integrated systems that can be used to assess the pollution status of water systems and to assess the required control actions to reduce the loads, including the evaluation of best management practices and best available techniques. Links between links of the selected pairs of domain models will be developed and tested. The integration of a chain of domain models will be tested in river basins showing variable natural characteristics and human impact in north-south transect. By doing this we also test and increase the transferability of the models and systems. By performing the inventory of the existing models and establishing the criteria for models (including sensitivity and uncertainty analyses and linkages) and assessment systems we will support the model developers to improve their systems to be used for WFD purposes. Producing the guidelines to use such models and assessment systems will assist the end-users to select best available models and systems, and to use them appropriately and consistently for the implementation of the WFD. The dissemination of information on integrated models will further be enhanced by developing an interactive internet-based Toolbox.

Milestones: 1) Inventory of models, a set of benchmark criteria for integrated model systems; 2) Case studies, evaluating models and their benchmark criteria; 3) Evaluation of economic impacts and multi-criteria decision analysis.

Expected results: 1) Criteria and guidelines for models; 2) Demonstration of applications of integrated model system at 6 river basins; 3) Specification of process-descriptions between key pairs of domains; 4) Cost-effectiveness analysis of management options at 6 rivers.

2 OBJECTIVES AND INNOVATION

2.1 Scientific and technical objectives

The EU Water Framework Directive mandates Member States to develop river basin *management plans* for each river basin district. These plans shall contain a programme of *measures* to be taken such that *ecological objectives* are met. These ecological objectives are defined in terms of the chemical, biological and hydro-morphological characteristics of the water bodies. An increase in *public participation* is also called for.

To achieve this the responsible authorities must have tools available with which to assess the present chemical, biological and hydro-morphological status and, most importantly, to assess the likely impact of management options that might be employed to mitigate any existing problem and thereby move towards “good status”. In terms of water chemistry status, the current water quality needs to be described and sources of pollutants identified and quantified. Further, there must be means by which the authorities can quantify the effect of alternative pollution control options, such that cost-effective measures can be taken. Finally, the involvement of the public and other stakeholders requires tools that can more readily illustrate the present pollution situation and the potential for improvement achieved with various alternative management options. Such a modelling system would also provide essential outputs describing economic costs and benefits.

River basin scale water quality models have been widely constructed and developed but their suitability and performance with respect to assessing the impact of management options has not been thoroughly or objectively evaluated. The present project, *BMW – Benchmark Models for the Water framework directive*, will take steps necessary for the river basin models to be used for implementation of the Water Framework Directive. A scheme for selecting and “benchmarking” existing model systems will be devised and demonstrated to specifically meet the objectives of (i) describing the current water pollution status at the river basin scale, and (ii) providing a tool for evaluation of management options. These model systems may integrate models of individual catchment “domains” which may be defined geographically for land surfaces, rivers, groundwater and estuaries, or by the model function, e.g. for waste water pollution and socio-economic values.

The overall objective of the project is to establish a set of socio-economic, bio-geo-chemical and systems analytical criteria (“tests”) to assess the appropriateness of integrated models for the use in the implementation of the Water Framework Directive. Moreover, the project aims at testing and demonstrating the use of examples of those models that fulfill the defined *a priori* criteria, applied to selected intensively studied river basins, to answer questions relevant for the implementation of the Water Framework Directive. The active participation of the end-users (local authorities) will ensure that the criteria, and thus models to be selected, are operational and functional at the management level.

This project will point out further development needs for the models, and develop and demonstrate a methodology that can be used for the planning and management of inland surface waters, groundwater and estuaries. The demonstration will be made at a number of river basins in Europe differing in ecotype, land-use, polluting activities and pollution problems.

Sub-objectives of the BMW project are:

- to link the output of the integrated models to the *ecological status* of freshwaters, in close collaboration with RTD projects developing criteria for the classification of the ecological status
- to assess the *sensitivity* and *goodness-of-fit* of selected models in order to evaluate the robustness of the models, and the balance between models’ data requirements and data availability
- to collate information on *pollution sources* within each test basin along with inventory of activities causing this pollution
- together with the local authorities run a series of scenarios of possible measures to show the *cost effectiveness* towards achieving water quality goals

2.2 Innovation

The principal aim of the newly adopted EU Water Framework Directive (WFD) is to prevent deterioration and achieve good status for surface and groundwaters within a time span of fifteen years. Through characterisation and classification procedures for surface waters, together with defining background reference conditions for different water types, the threshold limits for loads of different pollutants should be defined based on natural characteristics and status of the receiving water body. This approach is analogous with the 'critical load' concept long used in the context of acidification of soils and surface waters.

The WFD urges member states to assess the susceptibility of waters to pollutant loading, and further to prepare river basin management plans to define emission limits, pollution control measures, best available techniques and best management practices to achieve the goals. In this work, models, more specifically integrated model systems, provide an appropriate tool. Until now, truly integrated models have been built to describe specific pollutants. For example, for addressing the acidification problem submodels for emission, atmospheric transport and deposition, soil, streamwater and lake domains have been coupled. These model systems are transferrable and have been transferred to cover a multitude of catchments and spatial scales within Europe and North-America.

For eutrophication, another major European environmental concern, such truly integrated systems do not exist. During recent decades, much progress has taken place to develop and improve mathematical models for varying purposes (e.g. load assessment and apportionment, management comparisons) and for various domains (e.g. soil, groundwater, rivers, lakes, estuaries). However, only few attempts have been made to integrate these models or to use them to produce an holistic view of a river basin system. Furthermore, little information exists of the transferability of such models to other European regions.

The main products of the BMW project will be inventories, criteria and guidelines for submodels and integrated assessment systems that can be used to assess the pollution status of water systems and to assess the required control actions to reduce the point and diffuse loads, including the evaluation of best management practices and best available techniques. Links between different domain models will be an essential component of the overall objective of achieving integration at a river basin scale. Process descriptions for the links of selected pairs of domain models will be developed and tested. The integration of a chain of selected (potentially promising) domain models will be tested in river basins showing variable natural characteristics and human impact in north-south transect. By doing this we also test and increase the transferrability of the models and systems.

By performing the inventory of the existing models and establishing the criteria for models (including the sensitivity and uncertainty analyses and linkages) and assessment systems we will support the model developers to improve their systems to be used for WFD purposes. Moreover, producing the guidelines to use such models and assessment systems will assist the end-users to select best available models and systems, and to use them appropriately and consistently for the implementation of the WFD. The dissemination of information on integrated models will further be enhanced by developing an interactive internet-based Toolbox full equipped with search functions and cross-referencing capabilities.

In summary, in this project we for the first time intend to

- provide a systematic overview of models that potentially can be used as building blocks for integrated river basin models
- formulate objective socio-economic, ecological and systems analytical criteria for models to be used for the implementation of WFD
- provide an in-depth analysis of the performance and sensitivity of models and relate that information to the derived benchmark criteria
- develop key links for the processes between selected domain models and test their functionality
- demonstrate the ability of models integrated over an entire river basin to respond to the needs of the river authorities.

3 PROJECT WORKPLAN

3.1 Present status of integrated river basin models

The network of European water research institutes (*EurAqua*) organised in autumn 2000 a scientific and technical review of Integrated River Basin Models. The review documented the state-of-the-art of integrated river basin modelling and their applications on river basins in EU member states, Switzerland and Norway. Different models for pollution inputs from diffuse and point sources, lakes, groundwaters, rivers, and estuaries (domains) are being developed, supported and used in different countries. In addition, the level of integration of these domain models varies greatly between countries. For most applications where integrated model systems have been needed and used, the integration has been performed manually by supplying input for a model from the output of another model. Very few truly integrated model systems exist; their development has been initiated only recently based on the need of the Water Framework Directive.

Integration of the domain models has proven problematic. Technically linking a model to another would be a simple task if the upstream model provides the input needed by the downstream model in exactly correct units with compatible spatial and temporal resolution. Difficulties arise from incompatibilities of the models. Most models are designed to describe only certain phenomena and certain conditions. For example, it is not enough if the models for diffuse pollution provide leaching values for high runoff episodes; they should also work during low flow periods. In fact they should work during all meteorological and hydrological situations throughout the year. Most present models fail to do so. This is a scientific challenge for the modellers to respond to this need to the Water Framework Directive.

The recently finalised CHES project used linked models of catchment areas (diffuse sources) and river networks (including point sources) to represent whole catchment systems, and to investigate the impacts which may result from climate change. One of the lessons of the project was that to achieve useful results from a modelling study it is essential that the model is well understood, and that the necessary data are available. In situations where these criteria are not met, the modeller can still produce results from the model, but their validity and usefulness are questionable. The experience of CHES will be of enormous benefit to BMW as it has clearly indicated the steps required to assess available data, select an appropriate model, link the data with the model and then review the utility of the results.

The value of a modelling "Toolbox" is that a number of different approaches can be made available with clear guidance of when each should be used, and clear instructions on how it should be done. The decision to be made is which is the most appropriate model not which is most readily available, or which has the most state-of-the-art process representation. Drawing further on the analogy with maintaining a car, advice could be given on when a do-it-yourself approach using the toolbox is reasonable, and when an expert (mechanic from the garage) is needed, even though the expert may use the same toolbox.

Economic efficiency and political acceptability will be factors in designing river basin management plans. The issue of political acceptability refers to the distributional impacts of various policy measures, and is directly linked with the way and the extent that environmental and resources costs are distributed among various economic sectors. Therefore, river basin management requires a joint consideration of efficiency and equity criteria. Mathematical models offer one tool for minimisation of abatement costs and of resource-cost inequalities. Proper implementation of the WFD necessitates close linking between models for water quality (domain models) and models for economic cost-benefit.

3.2 Work plan structure

The investigations within the BMW project can be divided into four major categories:

- Criteria for benchmarking models (WP1, WP2-WP8, WP9)
- Examination models within specific domains (WP2-WP8)
- Evaluation, integration and demonstration of integrated models (WP9)
- Coordination and dissemination (WP10)

These major categories are illustrated in the flow diagram (Figure 3-1) in which the activities are started with the considerations on criteria on Benchmarking followed by the analysis of domain specific models. At this phase selected inter-links between models are tested and evaluated. Finally selected models are tested and demonstrated in WP9 by integrating them to six test river basins, in close collaboration with river basin authorities. All information originating from the project are collated into a well organised internet based “Toolbox” which during the project serves as a tool for coordination (common work place, server for exchange of information, etc.). At the end of the project the Toolbox will be opened for outside users, scientist and river basin authorities, serving as a tool for dissemination, a well-organised web-service with search capabilities and links to related material and projects.

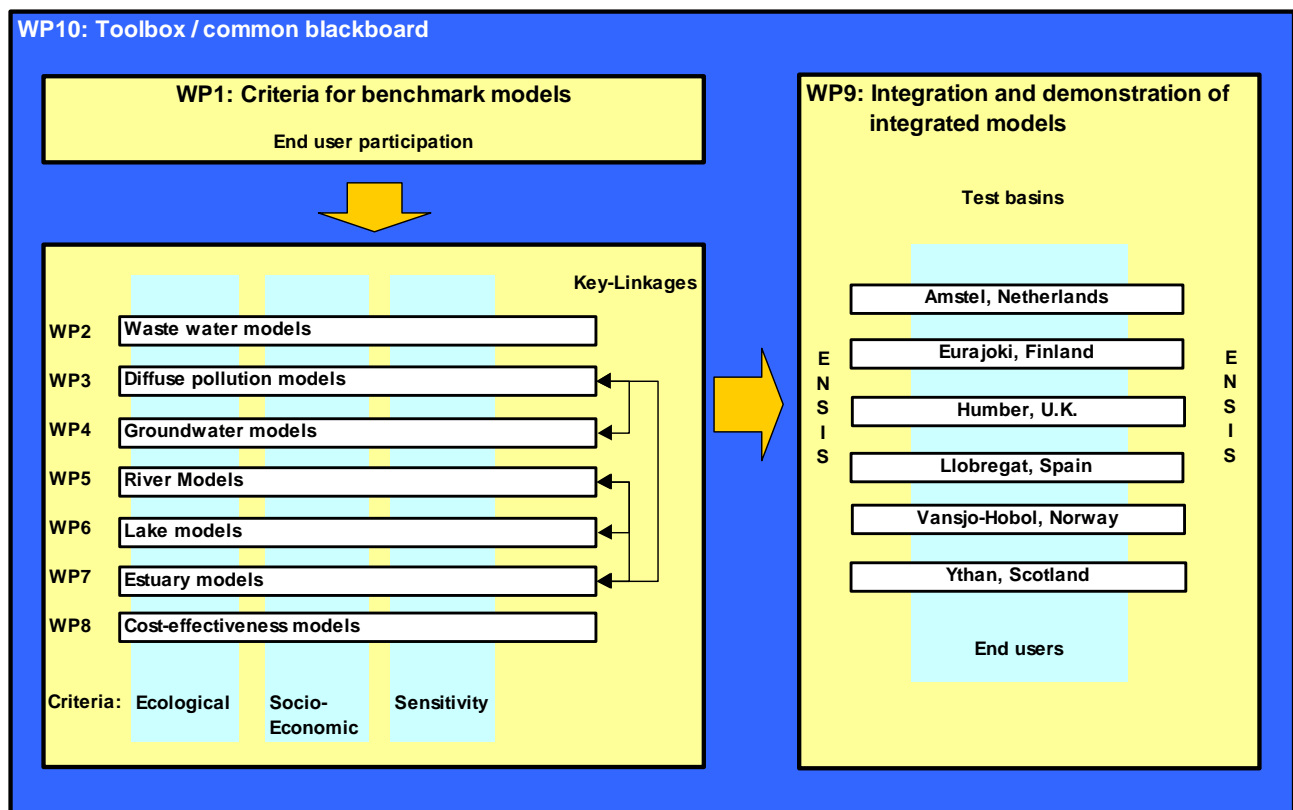


Figure 3-1. Graphical presentation of the project's components

All activities in the above categories will be closely monitored by the respective members of the management team and the scientific coordinator throughout the whole project to ensure that the work in the individual work packages is always oriented towards the general objectives and deliverables (see also Section 9 on project management)

3.3 Criteria for benchmark models

The BMW project will start by describing (1) the definition of a benchmark model, (2) the process of benchmarking, and (3) criteria to be applied for benchmark models. Criteria will be identified for 3 levels: (1) criteria that apply to all models (generic criteria WP1), (2) criteria that apply separately to domain specific models (WP2-WP7) and to cost models (WP8), and (3) criteria that apply to the integration of the domain models into an integrated model (WP9). This work will be conducted in close collaboration with the end-users.

Next, domain-specific criteria for the models will be derived to evaluate their capability to incorporate dose-response relationships, desired spatial and temporal scales and resolution, water quality parameters relevant for key organisms, and sensitivity to key forcing functions. For each domain an inventory of models will be made in which properties and characteristics of the models will be compiled with focus on information relevant for the evaluation of the benchmark criteria. The objective here will be to define the key characteristics of models in each domain with respect to the requirements of the Water Framework Directive. Temporal and spatial scale of operation within each domain and between domains will be identified as will key questions that might be asked of models to test programmes of measures with which to achieve good status.

In the last phase of the project, the domain models will be linked and example integrated river basin models established for six test basins in Europe. In this work, end-users will be involved in the model applications, in particular in assessing the readiness of the model systems to respond to economic questions posed by the Water Framework Directive to these basins, such as Full Cost Recovery (FCR), the marketability of tradeable permits, and the inclusion of environmental externalities. Recommendations will be made related to the models applicability and further development needs.

3.4 Models for different domains

Wastewater pollution

Wastewater emissions to surface waters often play a key role in water quality because: i) emissions define an important part of the boundary conditions for water quality in surface waters; and ii) measures to improve of water quality generally require a reduction of the emissions, and consequently a change in the human activities generating these emissions.

Computer models for wastewater emissions to surface waters are based on monitoring data of point sources. These model or information systems are used in day-to-day water quality management and often related to a system for the preparation and issuing of wastewater discharge permits. Because the level of spatial detail in these information systems is rather high, they are not yet easily applicable to policy evaluation and preparation. Improvement of database systems and computers, together with the easy exchange of data between different database systems, however, means that the demand for this kind of wastewater model will increase.

Another group of wastewater emission models include the description of processes within a wastewater treatment plant (WWTP). Some of these models can also be used for the design of the treatment plant, which implies that such models are detailed and focus on the deterministic description of the treatment processes within a plant, the discharge of pollution from the treatment plant and the sludge production.

Transport of wastewater through sewer systems can be described with 1D models. The models can be used to optimise the design of the sewer system and, by means of real time control modules, to improve the operation of these systems. Discharge of wastewater to surface waters due to combined sewage overflow (CSO) and storm water overflow is included in this type of model.

Discharge of pollutants from wastewater systems come mainly from CSO, the effluent from WWTP and from storm drainage systems. Minimisation of the total discharge is a difficult task requiring

advanced models. At the river basin scale, the contribution from various sources should be included to provide an overall view of wastewater emissions to surface waters. Models generating such an overview of emissions often follow a general approach applied at each individual emission and focus on the contribution of each source, including both point sources and diffuse sources.

Clearly different model-applications are related to different pollution problems. The choice of the most appropriate model is generally related to the nature of the problem to be addressed and the specific wishes from the stakeholders.

Diffuse pollution

Integrated assessments require consideration of the impacts of anthropogenic activities such as such as land use (agriculture and forest) and climate change on the movement of nutrients and pollutants from different landscape types into receiving waters. Modelling approaches to address these issues have taken a range of different temporal and spatial resolutions. Furthest advanced are models for nutrients such as nitrogen and phosphorus.

There are four main criteria through which the appropriateness of delivery models against the background of the requirements of the Water Framework Directive can be evaluated;

- the spatial and temporal scales and descriptions of relevant biogeochemical processes
- the link between biogeochemical processes with transport processes within catchments
- the link between spatial resolution with the scale for potential management options
- the identification of linkages and commonalities between different domain models and their integration

Simple empirical export co-efficient models have been developed to determine nutrient losses from catchments, but such models rarely take into account temporal changes in flow dynamics or seasonality. These models rely on the determination of characteristics such as land use and management which are usually simple to determine at the catchment scale. On the other hand there are a range of detailed process-based models of nutrient dynamics which operate at the soil profile and field scales. These models tend to contain a more rigorous process-based representation of nutrient dynamics and integrate change over smaller time steps such as hours, days or weeks. There is, of course, always an increasing requirement for data as model complexity increases.

Another key element is the linkage between spatial resolution of bio-geochemical processes and transport pathways. Many models consider water and solute transport based on the Richards equation; they may also include mixing and saturated groundwater interactions. The challenge is to integrate process-based understanding at the small scale with flow dynamics and groundwater interactions at the catchment based scale.

The evaluation of diffuse pollution delivery models must consider the optimal spatial and temporal resolution at which to represent dynamics within catchment systems, against the background of appropriate management scales such as the field, landscape, or economic units such as farm enterprises. These latter spatial scales represent the key scales at which management will be invoked in any remedial measures.

Links between different domain models will be an essential component of the overall objective of achieving integration at a river basin scale. For example, nitrogen dynamics within a river basin systems will involve close integration between land based delivery models for nitrogen, river transport models and receiving waters impact assessment models such as those being evaluated for estuaries (WP7). Similarly, freshwater eutrophication will involve close liaison with impacts models for rivers (WP5) and lakes (WP6).

Groundwater

Groundwater is an important component of resource planning. Groundwater constitutes an important resource within the integral phase of the hydrologic cycle. In many catchments stored groundwater maybe greater by several orders of magnitude than surface water stored in reservoirs.

The recharge-discharge regime of aquifers has important interrelationships with the other components of the hydrologic cycle. Of special interest is the base-flow component of a stream and the influence of surface water in the subsurface system. The capability of surface-groundwater conjunctive use has been applied to many regions in the world. Quantification of these parameters requires the appropriate water balance describing the hydrologic regime in a catchment.

For the benchmark process the objective is to consider existing groundwater models that can be used in simulating scenarios of diffuse pollution (specifically nutrients) on spatial and temporal distributions of groundwater resources. The operational models for groundwater will benefit and complement the integrated model systems providing a tool for assessing scenarios and effectiveness of water management measures on groundwater, which can include economic considerations.

Simple 2-D transport models have been developed, a finite-difference groundwater flow model based in particle tracking, with automatic parameter estimation and a transport model for conservative and non-conservative compounds. Surface and groundwater interactions can be simulated by e.g. the coupled and modular, three-dimensional, finite-difference ground-water flow models.

The integration of the groundwater models into an integrated model system requires an interface between pressures occurring on surface soil and the state of the groundwater. This interface will be developed and tested for selected models with data from the test catchments. The coupled pairs of diffuse pollution – groundwater model will be provided to the application on river basin scale. That application will test whether various time patterns of forcing functions and management options (climatic conditions, field area, water balance, irrigation, nutrients application, etc) produce realistic outputs for groundwater (pumping, recharge, spatial and temporal distribution of nitrates and/or water level, etc).

River water

River water quality models have been usually designed to address a specific problem or to be applicable to a specific catchment area or region. Some examples of their uses in Europe have been to determine discharge consents for point sources, to predict changes in solute fluxes as a result of new point/diffuse discharges, and to predict fluxes of nutrients to estuaries. When coupled with appropriate models of diffuse pollution they have also been applied to assess the impact of changes in land use or land management.

Essentially, river water quality models differ from one another by their representation of four key attributes: dimensionality, time, hydrodynamics, and pollutant inputs. For example, most river models are one-dimensional and can be applied to ‘branching’ systems whereas two- and three-dimensional approaches can incorporate either longitudinal and lateral or longitudinal and vertical variations in flow and concentration and thereby model the movement and dispersion of pollutant ‘plumes’ downstream. A zero-dimensional formulation represents the simplest structure whereby the water body is represented as one or more fully-mixed tanks. These models have been shown to be particularly appropriate when water quality data for the river is limited.

Temporal resolution of the model is a crucial consideration. For example, eutrophication in an estuary is a response to the seasonal nutrient loads delivered from up-stream and the process advances over several months, whereas combined sewer overflows affect river water quality within minutes or hours and must, therefore, be modelled in detail. Clearly, these different time constants necessitate different water quality model formulations. Choice of time step also determines how the model represents

chemical and biological processes within the river, for example, steady-state models predict concentrations that do not vary in time. Dynamic models allow for concentrations to vary over time in response to time changes in pollutant inputs or driving variables.

The choice of a given model for a particular catchment, therefore, is dictated by the nature of the problem to be addressed and the resolution of the spatial and temporal data required to calibrate and test the model. The development of an appropriate procedure for testing all models against a 'benchmark' represents a significant step forward in ensuring model comparability across EU Member States and within Member States where different organisations use different models.

Lake water

Compared to other habitats such as terrestrial landscapes and coastal zones, lakes can more readily be considered spatially homogeneous systems with well-defined boundaries and boundary flows. Thus, the tradition of modelling lakes in terms of mass balances and input-output relationships in well-mixed reactors (box models) can largely be motivated from inherent physical properties. Box models have been successfully applied for describing many aspects relevant for the management of lake ecosystems.

The well-mixed reactor model principle can to some extent also be used for more structurally complex systems by linking inputs and outputs of a set of communicating compartments (such as series of lakes connected in a chain). In general, though, one would expect the assumption of spatial homogeneity to put strong restrictions on the attainable precision of box models. Thus, many recent publications deal with various aspects of increasing the spatial resolution of lake models.

In some models stratification and vertical exchange processes are described mechanistically as a 1-dimensional partial differential equation for temperature stratification, relating surface energy balance and wind-driven mixing. Many of the available models actually represent whole families of models that have evolved through several decades. The MINLAKE family deserves special interest for its focus on global or regional, but not local, calibration. This feature makes it possible to make good predictions on a regional scale of surface temperature, thermocline depth, and duration of stratification based only on lake morphometry and standard meteorological data.

The importance of horizontal gradients usually increases with lake size, and cannot be ignored in large and very large lakes. The implied partial differential equation representation of the full, 3-dimensional fields of density and velocity is computationally demanding, albeit within the reach of modern, desktop computers. There exists a range of mature software products for this kind of problems, both commercial and open. Perhaps the greatest obstacle to the general applicability of 3D circulation models in lakes is the high requirement for validation data. This entails synoptic, profiling instruments (undulating CTDs, ADCPs, etc), and the necessary ships to carry them, and such data are available only for a few very large lakes.

Estuary

River basin management will directly affect inputs of water and pollutants to coastal marine waters. Consequently, the Water Framework Directive (WFD) also considers coastal areas associated to the river basins. The WFD, however, defines the geographic extent of the coastal zone so that important flows related to coastal currents may not be included. As such, the WFD will perhaps be more relevant for estuaries than for open coastal zones in general. Due to the one-way coupling between land and coastal zone, estuary models need not always be an essential element of the model chains representing the river basin processes. As inputs generated from river basin model systems will be crucial in estuary models, there will nevertheless be a need for proper interfacing to models of this domain. Thus, the applicability of different estuary models as downstream recipients of river basin model outputs becomes an important aspect of benchmarking models for the WFD.

Estuary models are widely variable with respect to spatial and temporal resolution, and perhaps also more explicitly matched to characteristic topographical and hydrodynamical features of the locality. Simple or multiply connected box models will continue to have their use in estuary modelling, especially when interactions between different phases (e.g., air, water, and sediment) have to be considered, such as in models for persistent pollutants. Models with a 1- or 2-dimensional horizontal structure will often be efficient in estuaries with strong tidal mixing, while plume models might be more appropriate in open coastal waters with well-defined point sources. In other geometries, such as fjords with a shallow sill, structural representations in the length-depth dimensions will be more efficient. Finally, for complex topographies and demanding resolutions, there are several full 3D representations modelling the advection-diffusion dynamics of coastal waters.

An assessment of estuary models should consider (1) time resolution and seasonality, (2) depth/salinity gradient resolution, (3) geographical resolution, (4) type of dose/response and internal feedback relationships, and (5) statistical properties of output (min/max, distribution of concentration levels). Models can be classified according to which compartments the model contains (physical, chemical, and biological), how they describe transport and dispersion of suspended or dissolved matter, how they can describe water/particle/sediment interaction, and air/water interaction. Model properties can also be arranged into a matrix representing types of estuaries against major water quality issues. European coastal waters fall into 4 general types; open coastal areas, archipelago shallow estuaries with density stratification, vertically mixed river estuaries, and landlocked fjords with deep basins. Major water quality issues in these areas are typically related to eutrophication, heavy metals and persistent organic pollutants.

Cost-effectiveness and multi-criteria analysis

Within the Water Framework Directive there is therefore a requirement for a decision framework including social, economic and scientific aspects to be developed to assist in the management of water basins. The key challenge is to assess different mechanisms for determining cost-effective management strategies and to develop a framework for analysis. The latter will involve a mathematical approach that will model water use in relation to constraints imposed by quality or quantity criteria. It will also require a multi-criteria approach in order to advise stakeholder groups on the possible consequences of alternative river-basin management options to achieve water status targets.

The aim will be to evaluate existing modelling approaches against criteria contained within the Water Framework Directive and as such requires information on water users, their impacts on water quality and quantity, and the set of potential amelioration measures. This will provide a generalised decision framework which will be applied to specific case studies. Amelioration measures will not be restricted to those within the legal powers of the water authorities but will embrace a wider set of regulatory and economic instruments. For each scenario, and its associated set of instruments, the social and financial costs will be estimated together with the expected economic impacts on incomes and employment. This economic analysis will be used to contribute to a wider multi-criteria analysis of options in which the interests and responses of the full range of stakeholders will be examined.

3.5 Key linkages between domain models

Links between different domain models will be an essential component of the overall objective of achieving integration at a river basin scale. The existing models do not necessarily produce their output compatible with the required input of another domain model in terms of determinants (e.g. different fractions of nutrients) and spatial or temporal resolution. In addition, the quality of the model output often fails in extreme conditions, which on the other hand are important for ecology in the other domain. For example, if diffuse pollution models are calibrated to match the high flow period, they often fail during low flow causing a problem for river model in terms of oxygen concentration.

One of the main objectives within the relevant Work Packages (WP3 – WP7) is, during the inventory of the domain models, to collate information of the suitability and compatibility of their output data to be used as input for the other domain models and produce a cross matrix of the output-input compatibility. During the calibration/validation process for the selected models/test catchments, the capabilities of models to produce valid input for the other domain models under changing and extreme conditions will be studied. These links will be developed and tested in close collaboration with the model developers.

The key linkages studied will be between the following domains:

- diffuse pollution models → river models
- diffuse pollution models → groundwater models
- river models → lake models
- river models → estuary models

3.6 Evaluating model characteristics and performance

The ability of the benchmark criteria to satisfy the requirements that are posed for models to be used for the implementing the WFD will be tested against two types of model analyses. First, the derived benchmark criteria will be compared against quantitative measures of model goodness-of-fit (MGF) to observed data. Second, the benchmark criteria will be compared to uncertainties related to model structures, assumptions, and specifications. Sensitivity analysis (SA) will be used to quantify response of model variables to changes in the inputs. Quantitative measures for MGF will be calculated for a few models in one domain, while the SA of a few models will be conducted for one model in each of several domains. The results of these analyses will be used to improve the derived benchmark criteria and to allow them to be compared with criteria related to evaluation of models' performance and sensitivity. The model evaluation is part of the WP9 – Integration and demonstration of integrated models.

Model goodness-of-fit (MGF)

The establishment of benchmark models requires quantitative measures of MGF that can be applied to all candidate models in an objective manner. Appropriately defined for the system under consideration, these measures of MGF provide a common metric for each model that can be unambiguously applied and directly compared for all models being examined. The use of quantitative measures allows comparison among models at a number of levels of increasing complexity. For instance, a simple comparison results when the measure of MGF is used to establish a "threshold value" to separate candidate models into two groups – those that function at least as well as some pre-determined criterion and those that do not. A more complex comparison may use the quantitative (and therefore continuous) nature of the measure of MGF to rank the models in some hierarchy of functionality.

Sensitivity analysis(SA)

Sensitivity analysis is the study of how the variation in the output of a model can be apportioned, qualitatively or quantitatively, to different sources of variation, and of how the given model depends upon the information fed into it.

A mathematical model is defined by a series of equations, input factors, parameters, and variables aimed to characterize the process being investigated. Input is subject to many sources of uncertainty including errors of measurements, absence of information and poor or partial understanding of the driving forces and mechanisms. This imposes a limit on confidence in the response or output of the model. Further, models may have to cope with the natural intrinsic variability of the system, such as the occurrence of stochastic events.

Good modeling practice requires that the modeler provide an evaluation of the confidence in the model,

possibly assessing the uncertainties associated with the modeling process and with the outcome of the model itself.

The use of modern techniques for model sensitivity analyses enable comparison of model structure and parameter-related criteria to the criteria and procedures introduced in the benchmarking process. Through the sensitivity analysis conclusions will be made in the BMW project on how well the benchmarking model uncertainties linked to model structures, variables and parameters could be taken into account in the benchmark criteria.

Moreover, the sensitivity analysis will provide information on whether the model under consideration is over-parameterised or dependent on highly uncertain or missing input data. In this project a systematic approach for tackling the parameter identifiability problem of large environmental models based on local sensitivity analysis is applied. Between others, the calculation of two identifiability measures that are easy to handle and interpret is used. The first (parameter importance indices) accounts for the sensitivity of model results to single parameters, and the second (collinearity index) accounts for the degree of near-linear dependence of sensitivity functions of parameter subsets

3.7 Integration of domain models; application to test river basins

A chain of domain models fulfilling the *a priori* benchmark criteria are coupled to form examples of integrated model systems. These integrated model systems will be tested by application to six European river basins representing a wide range of climate, water use and water pollution types. The rivers selected for the project are the Llobregat River (Barcelona, Spain), the Ythan River (Aberdeen, Scotland), the Humber basin (Southeast England, UK), the river Amstel (the Netherlands), the river Eurajoki (south-western Finland), and the Vansjø/Hobøl watercourse (near Oslo, Norway). This work will involve active participation by the local authorities at each river basin (the end-users).

There will very soon be a need for data sharing across the European test basins. Models within the same domain will need access to the same data, and also models from different domains will make use of the same data as input (e.g.. meteorological data). Consistency in the data, and easy access to the data will for this reason be a key point when the comparison of models within the same domain, and linkage of models are carried out. The use of a common database, which is accessible for all partners, will support and solve these issues. For the test applications all input data will be gathered into the information system ENSIS (Environmental Information and Surveillance System). All data will be stored in one and the same database, offering the user a system for storing, systematising and retrieving environmental data. The database will be accessible with use of the Internet and thin client technology (Citrix Metatrame).

ENSIS is a generic environmental surveillance and information system for air and water. The system consists of a database, which is integrated with models and a graphical user interface. The user interface is based on a geographical information system (GIS) from which geographically linked objects such as pollution sources, monitoring stations, measurements, rivers, lakes and model results can be presented. The map interface can be used to make queries to the database.

3.8 Toolbox for benchmark models

Modern information technology provides means for the development of tools for efficient information exchange and interaction. In this project an information system – the Toolbox – will be modified and adapted. The Toolbox is based on a relational database, web server and the internet connection. The users can easily search, edit and add information. The Toolbox has been tested in an Interreg II c project ‘Planning System for Sustainable Development’, PSSD. All project results, information of models and their applicability will be disseminated through the toolbox web page opened for the public at the end of the project. This will be one of the projects major deliverables.

The database of the Toolbox is an associative cross-referencing database. Information on benchmark models and their applications will be located in a relational database. Various attributes of each model can be related to underlying properties. By that way it will be possible to manage the substance of the models, e.g. their properties or benchmark criteria, and not to treat them as models only. The key item in Toolbox is simplicity and usability.

3.9 End users

End-users will actively participate in this project. The end-users are the authorities responsible for environmental protection and river basin management at each of the six test rivers. They are enthusiastic about the project and eager to begin. The end-users will be included as sub-contractors and will have a stake in the project. They will be actively involved in all stages of the project, and especially in the criteria setting including the socio-economic considerations of the models. In addition, they will actively participate in the formulation of management options and the setting of scenarios of measures within the testing phase of the integrated models.

End-users at each river basin will meet 4-6 times annually with scientists from the associated institute in each country. Contact will be most active between the end-user and the respective associated partner. The arrangements and financial support of the end-user to cover the costs of participating in the project will be formalised in the form of sub-contracts. Early in the project an internet based tool-box will be established and data and model information relevant for the project will be entered from the respective river basin, under the supervision of the main partners. The end-users will thus have opportunities for hands-on testing and evaluation of the models during all stages of further development. The end-users' needs and requests will thus be accommodated into the criteria and further development needs of the integrated models.

3.10 Project tasks, timetable, milestones and deliverables

The duration of the BMW project is 36 months. The work packages, and the specific tasks therein, are planned according to the timetable depicted in Figure 3-2. The flow of information is shown by arrows. The information is mainly fed to the stakeholder workshop, planned to be organised after the first year of the project, and back from that to the teams on domain models. Secondly the information is fed latest at the end of the project to the Toolbox.

The project milestones are listed in Table 3-1 and deliverables in Table 3-2 in which the number of each milestone (e.g. M3.1) and deliverable relates (D3.1) relate to the Workpackage where they derive from.

The tasks listed in Figure 3-2 and the work undertaken by each partner will be described in more detail in the deliverable D1.1 which will be made available within the first 6 months of the project.

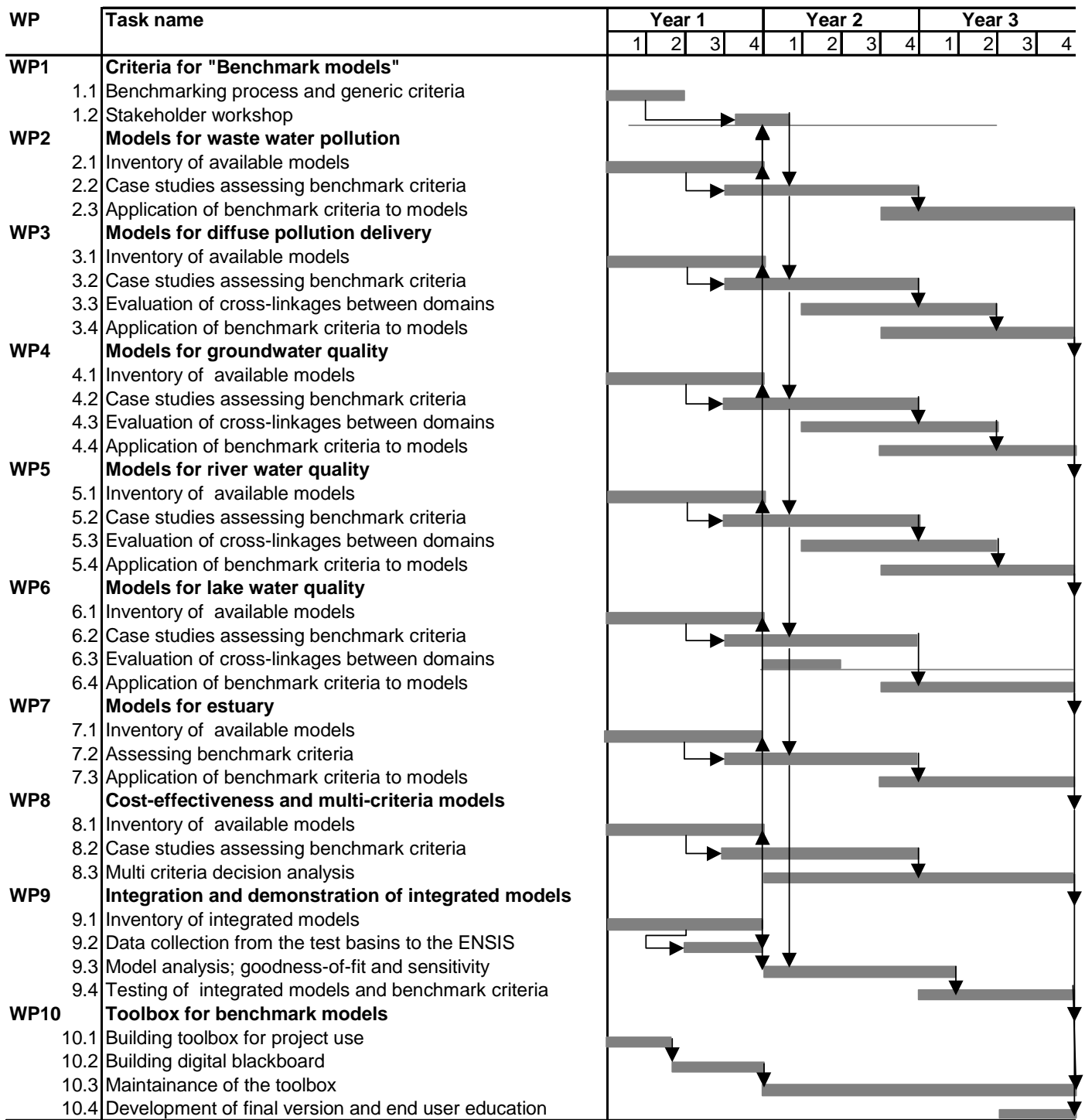


Figure 3-1. Project timetable (Gantt chart)

Table 3-2 List of milestones of the BMW project

Milestone No.	Description	Month
M10.1	Defining the user needs, functionality and opening of the Toolbox	5
M1.1	Define and document the concept and process of benchmarking models	6
M1.2	Workshop of stake-holders to assess the model inventory and benchmark criteria	12
M10.2	Launching the digital blackboard	12
M2.1	Inventory of wastewater pollution models completed	12
M3.1	Inventory of diffuse pollution models completed	12
M4.1	Inventory of groundwater models completed	12
M5.1	Inventory of river models completed	12
M6.1	Inventory of lake models complete	12
M7.1	Literature survey of estuary models completed	12
M8.1	Literature survey of economic modelling approaches completed	12
M9.1	Finalisation of the inventory of integrated model systems, including a report describing and formulating the initial set of benchmark criteria for integrated model systems	12
M9.2	Data on the case studies in the ENSIS system	12
M6.2	Specification of interface to and from the other domains complete	18
M7.2	Benchmark criteria completed	18
M8.2	Benchmark criteria completed	18
M2.2 M3.2 M4.2 M5.2 M6.3	Finalisation of case studies, assessing benchmark criteria and formulation of final set of benchmark criteria	24
M7.3	Classification of models completed	24
M8.3	Evaluation of economic impacts of scenarios in case-study catchments	24
M8.4	MCDA evaluation model set up and data collection from stakeholders	28
M5.3	Links for diffuse pollution > river > estuary models completed	30
M10.3	Toolbox opened for end-users	35
M2.3 M3.3 M4.3 M5.4 M6.4	Finalisation of application of benchmark criteria to all models included in the inventory with report and publication	36
M7.4	Evaluation of model properties against criteria	36
M7.5	Description of data input required for estuary models from observations and river models	36
M8.5	MCDA analysis and evaluation for selected catchments	36
M9.3	Demonstration and testing of linked domain models integrated over river basins	36

Table 3-2: List of deliverables of the BMW project

Deliverable No	Deliverable title	Delivery month	Nature ¹³	Dissemination level ¹⁴
D1.1	Description of project tasks and work undertaken by each partner	6	Re	PU
D10.1	Toolbox web site opened for project use	6	Other	CO
D10.2	Digital blackboard opened on web for project use	12	Other	CO
D1.2	The benchmarking process and generic criteria	18	Re	PU
D9.1	Inventory of integrated models with benchmark criteria	24	Re	PU
D2.1	Inventory of available wastewater pollution models with benchmark criteria	36	Re	PU
D3.1	Inventory of available diffuse pollution models with benchmark criteria	36	Re	PU
D4.1	Inventory of available groundwater models with benchmark criteria	36	Re	PU
D5.1	Inventory of river water quality models with benchmark criteria	36	Re	PU
D6.1	Inventory of river water quality models with benchmark criteria	36	Re	PU
D7.1	Inventory of estuary models with benchmark criteria	36	Re	PU
D8.1	Inventory of cost-effectiveness models with benchmark criteria	36	Re	PU
D9.2	Final evaluation of existing models, identification of missing links, recommendations for future model development, as illustrated by results from model applications to the case study river basins	36	Re	PU
D10.3	The second edition and the manual of the Toolbox	36	Other	PU

¹³Re=report; Other = website; ¹⁴PU=public; CO = confidential

3.11 Risks of failure

In this section those tasks are identified for which there is a significant risk of failure, and the fallback positions to be taken in the project should the tasks in fact fail are described. In the following

Task 3.2 Inventory of available models for diffuse pollution

Risks

For the diffuse pollution of eutrophying pollutants there exists a limited number of models which are fairly well tested. However, for pesticides and herbicides there is very large number of models in the market. In a recent inventory conducted in Finland, some 80 models were considered. In the project, it may thus be possible to assess of available models against pre-defined criteria.

Fallback position to be taken

If it turns evident that that it will not be possible to consider all available models in the market, those models will be left out from the inventory and model assessment which are least used, difficult to obtain and badly documented. The predefined criteria will thus include elements that justify the exclusion of a number of models.

Tasks 3.3, 4.3, 5.3, 6.3 Evaluation of cross-linkages between domains*Risks*

During the calibration/validation process for the selected models/test catchments, the capabilities of models to produce valid input for the other domain models under changing and extreme conditions will be studied. These links will be developed and tested in close collaboration with the model developers. This task has however proven in earlier EC funded projects (e.g. CHES) to be extremely difficult. In particular, the models for diffuse pollution delivery do not produce the necessary output for the river and lake models for all year round. Therefore, it is seen that the development of these links together with the model developers may not be possible for all models in the market during the project time span.

Fallback position to be taken

If it turns evident that the modelling teams do not see possible to make the required modifications for the models, an other approach will be taken. In that case the necessary model adjustments and further development needs will be carefully documented and disseminated to the modelling groups. Their comments for these further development needs will be collected and added to the documentation. This way it will be ensured that the modifications will be implemented to the models as soon as possible.

4 CONTRIBUTION TO OBJECTIVES OF PROGRAMME

The BMW project contributes to the Energy, Environment and Sustainable Development programme addressing in particular:

Key action 1: Sustainable Management and Quality of Water

Activity 1.1 Integrated management and sustainable use of water resources

Sub-activity 1.1.1 Strategic planning and integrated management methodologies and tools at the catchment scale

The BMW project addresses the issue of sustainable water management and technological development. Its focus is on the development of knowledge and harmonised tools to be used for rational management of surface and ground water resources. The newly adopted Water Framework Directive will mandate management of water resources organised by river basins with the associated near-shore marine areas.

This BMW project aims at developing common operational modelling tools for the evaluation of management options at the river basin or sub-basin scales, including river estuaries and coastal zones. These tools, benchmarked integrated model systems, can be used by river authorities in the implementation of the EC Water Framework Directive. The use of the tools is tested against real management and analysis needs for selected catchments and river basins in Europe with respect to all types of alternative land-use, pollution control policies, and socio-economic development.

BMW project will enhance the use of the integrated models by coming up with a selected number of 'European benchmark models' that can be used in the implementation of the EC Water Framework Directive for the various integrated water management requirements at river basin scales.

The project will actively involve river management authorities at six European river basins selected for case studies as sites where the established benchmark criteria and methodologies will be tested. For these basins long-term research and monitoring activities have been undertaken, and thus intensive high quality data for model evaluation is available. These test basins differ in natural characteristics, pollution sources and problems as well as in available management options.

This project will cluster *a posteriori* with other relevant projects. These will be sought co-ordinated through, among other measures, a large-scale concerted action on catchment/river basin modelling. The overall benchmark process and guidelines and criteria derived therein will lay a foundation for the inter-comparison and verification of various models being presently under construction.

5 COMMUNITY ADDED VALUE AND CONTRIBUTION TO EU POLICIES

5.1 European dimension of the problem

All European countries will face the same need for tools and methodologies appropriate for implementation of the Water Framework Directive. Because rivers commonly cross political boundaries such as municipal, county and national borders, existing management procedures will have to be re-assessed and adapted to accommodate the new Water Framework Directive. Management of river basins that cross national boundaries will clearly be facilitated if the individual countries use the same methods for evaluating the effectiveness of management options. The BMW project aims to harmonise tools and demonstrate their use for integrated river basin management at a wide range of basins in Europe differing in natural character and pollution problems.

River basin authorities in all European countries will have the need for modern and effective tools for the analysis and presentation of water quality and quantity data. In particular, the management of river basins and derivation of cost-effective, alternative mitigation measures call for integrative tools. Managers all across Europe will need to evaluate the implications of alternative measures to reduce pollution such that the requirements of the Water Framework Directive are met. The BMW project's major objective is to develop and test criteria for such tools, suitable for the wide variety of river basin types in Europe.

For river basins that lie in more than one country, it is clear that the managers are best served by use of a common analytical and management tool. The overall objective of the BMW project is to establish a common basis for the selection of such tools. Moreover, data and document transfer by internet is facilitated by the development of common software, such as the Toolbox. In the same way will widespread use of a common GIS/database presentation and management tool such as ENSIS greatly aid in rational evaluation of management options for multi-national river basins.

The joint execution of this project by institutes in several European countries entails clear benefits. By including as demonstration and testing rivers differing in character -- groundwater and drought problems in Spain, agricultural pollution in the UK, and mixed water use conflicts in Finland and Norway -- the robustness and general applicability of the derived criteria for benchmark models can be documented. This spectrum of characteristics is not available in any one country.

5.2 European added value for the consortium

The project will draw upon the expertise of several European groups, which together represent combined expertise not readily available in any one of the countries. Because water supply and pollution problems are different in different regions of Europe, each country has developed specialised modelling expertise. BMW will draw upon expertise on multi-source water pollution and model integration from the Netherlands, expertise on groundwater resources and flood control from Spain, expertise on water routing and catchment hydrology from France, expertise on diffuse sources of pollution and in-stream processes from the UK, expertise on socio-economic assessment methods from the UK, and expertise on systems analysis and in-lake processes from Finland and Norway.

To move forward from single models to an integrated model systems with analytic capability and capacity to allow assessment of cost-effectiveness of management options is a major undertaking and requires joint efforts by scientists from a variety of disciplines. The necessary diversity in experience and expertise is available in Europe. The BMW project will bring them together.

The Water Framework Directive will necessitate development of new technologies for integrative modelling, assessment and management of river basins. The BMW project aims to develop a methodology towards a harmonised tools that can be used at river basins throughout Europe.

5.3 European policies

This project is directly aimed at facilitating implementation of the EU Water Framework Directive COM (99) 271 across Europe. The project will provide a systematic overview of models and formulate and test multiple criteria as needed for the implementation of the Water Framework Directive. BMW will further demonstrate a methodology for analysing the cost effectiveness of various scenarios of management measures that can be taken to improve water quality such that the objectives of the Directive are achieved. The software tools developed within the project (ENSIS and Toolbox) are designed to provide authorities insight into the models and the management options available such that the objectives of good water quality can be achieved with respect to drinking and bathing water, ecological protection and water supplies for the users.

Major rivers in Europe supply a significant fraction of pollutants to coastal zones. Large stretches of coastal zones and marine seas in the Mediterranean, Atlantic, North Sea and Baltic Sea suffer from degradation and pollution. The Water Framework Directive includes coastal marine areas associated with river basins. EU policy on protection of coastal zones is forthcoming COM (95) 511 and will require integrated management of river basins coupled with coastal zones. The EU is already party to conventions to protect the North Sea ((Paris and Oslo Commissions), the Baltic Sea (Helsinki Commission), and the Mediterranean Sea (Protocol for Protection of the Mediterranean Sea against Pollution from Land-based Sources). Through these agreements the EU is committed to major reductions in pollution from land to sea within the next 10-20 years. Achievement of this will require significant reduction of pollutant loadings from rivers discharging into the sea. The BMW project will provide an in-depth analysis of the tools available by which managers of river basins can determine cost-effective priorities of measures to reduce such pollution.

6 CONTRIBUTION TO COMMUNITY SOCIAL OBJECTIVES

6.1 Quality of life, health and safety

Environmental protection and sustainability are cornerstones in EU social policy. The Treaty of Amsterdam (adopted 1997, entered into force 1999) places protection of the environment as a core objective of the EU. Sufficient quantities of high quality water are essential elements for human health. And a clean environment with high ecological status of surface water is an important element contribution to the quality of life. The goal of the Water Framework Directive is to insure that both water quality and quantity are optimal for all Europeans. The BMW project will develop criteria and guidelines for the development of harmonised modelling tools that will aid managers and decision-makers in fulfilling the requirements of the Water Framework Directive and thus contribute towards enhancing the quality and life and health.

6.2 Increasing employment and skills

The project will further develop and produce two software products (ENSIS and Toolbox) that have potential for commercial exploitation. These tools will facilitate cost-effective measures to be taken by river basin authorities and thus promote more rational and effective water use. The tools will aid in achieving good water quality and thus set the terms for sustainable agriculture and forestry in river basins in Europe. The products potentially can be marketed globally. Indeed the current version ENSIS 2.0 is already in use in projects, for example, in China.

6.3 Preserving the environment and natural resources

Sustainable use of water resources is a basic goal of the Water Framework Directive. Tools and methodologies that can assist managers and stakeholders in river basins in the EU and associated states in achieving sustainability of water resources will be a step towards preserving and restoring the environment.

The project will contribute to enhancing the environment and to rational use of water resources. The benchmarking process developed within the BMW project will establish a common platform for evaluating cost effectiveness of various measures in order to achieve the multiple objectives of the EU Water Framework Directive. The objectives include rational water use and achievement of good water quality for ecological protection, drinking water and bathing water.

The EU is committed to several international agreements regarding prevention of pollution from land to marine areas, most important of which are the North East Atlantic, the Baltic Sea and the Mediterranean Sea. The Paris and Oslo Commissions (PARCOM, OSPAR) are regulatory agreements for prevention of pollutants in the maritime area of the North East Atlantic (signed 1992, ratified 1998). Under this convention (the Esbjerg declaration of 1995) the EU is committed among other thing to take “ long term action to maintain and improve the state of the North Sea including:

- management and assessment tools to set priorities
- means of assessing progress”

The Helsinki Commission (HELCOM) (signed 1974, entered into force 1980, signed by the EU 1992) is an agreement to cover all sources of pollution to the Baltic Sea. The Baltic Sea Environmental Declaration of 1992 launch3d the concrete effort to “assure the ecological restoration of the Baltic Sea, ensuring the possibility of self-restoration of the marine environment and preservation of its ecological balance”. The measures should be implemented by 2012.

The Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (adopted 1980, entered into force 1983, amended 1996) binds signatory parties (among

them the EU) to ensure that point source discharge and air emissions from industrial installations shall be in conformity with the provision of the protocol by the year 2025.

The Water Framework Directive aims at reducing the flow of pollutants from river basins to the sea, and the BMW project will develop harmonised criteria for tools by which flow of pollutants and management options for measures to reduce pollution can be assessed and the cost-effectiveness evaluated. Such tools will be of aid in fulfilment of the international commitments on environmental protection of marine areas.

7 ECONOMIC DEVELOPMENT AND S&T PROSPECTS

7.1 Contribution to growth

The BMW project will produce inventories and scientific and technical assessment of existing models that can be used for river basin management as mandated by the WFD. As end-users for the produced information will be all river basin authorities in the EU member states and associated states in the European Economic Region, and in addition other States which lie in river basins that cross international boundaries.

This project will evaluate several models that have potential commercial importance for their producers. The commercial value will not, however, be in any instance a criterion within the benchmarking process. Nevertheless, the benchmark models can be expected to be put to wide use in the implementation of the WFD; the potential number of customers for integrated river basin models is greatly increasing.

As an additional important deliverable BMW will provide an identification of modelling needs for implementation of WFD. Coupling of physical-chemical-biological models with socio-economic models will be necessary for optimal economic implementation of pollution reduction measures in river basins. This coupling is a crucial part of this project.

7.2 Strategic impact and potential end-users

End-users will actively participate in this project. The end-users are the authorities responsible for environmental protection and river basin management at each of the six test rivers. The end-users will be included as sub-contractors and will have a stake in the project. They will be actively involved in all stages of the project, and especially in the criteria setting including the socio-economic considerations of the models. In addition, they will actively participate in the formulation of management options and the setting of scenarios of measures within the testing phase of the integrated models.

End-users at each river basin will meet 4-6 times annually with scientists from the associated institute in each country. Contact will be most active between the end-user and the respective associated partner. The arrangements and financial support of the end-user to cover the costs of participating in the project will be formalised in the form of sub-contracts. Early in the project an internet based tool-box will be established and data and model information relevant for the project will be entered from the respective river basin, under the supervision of the main partners. The end-users will thus have opportunities for hands-on testing and evaluation of the models during all stages of the project. The end-users' needs and requests will thus be accommodated into the criteria and further development needs of the integrated models.

Table 7-1. BMW project. Test river basins, end-users, and associated partners.

River Basin	End User	Associated Partner
River Eurajoki, Finland	S-W Finland Environment Centre	FEI (01)
Vansjø-Hobøl, Norway	MORSA	NIVA (02)
Amstel river, the Netherlands	Amstel Waterboard	Delft (07)
River Ythan, UK	Scottish Environment Protection Agency	MLURI (03)
Humber River, UK	UK Environment Agency	CEH (05)
Llobregat River, Spain	Junta d'Aigües de Catalunya	UPC (06)

As can be seen from Table 7-1 the end-users in this project represent river basins in a wide range of regions and environmental conditions in Europe.

The project will clearly strengthen European science of water quality modelling. The participating scientists at the research institutes will increase their expertise on basin scale modelling and water resources planning. As a result, they will be better poised to obtain new research contracts nationally, in Europe and worldwide.

7.3 Dissemination of results

A Technological Implementation Plan to be produced by the end of the project, a draft version to be made available at month 33 of the project, will outline the main project output and contractor specific exploitation plans.

The Internet will be a major channel for dissemination. A home page for the project will be founded at the very beginning of the project. The home page will be updated as the project progresses. The Toolbox located at the home page will offer a flexible tool for interactively searching real time information related to project results. Toolbox will greatly enhance information exchange and transferability of integrated models. The database of the Toolbox is an associative cross-referencing relational database being able to store any kind of information: e.g. text, programs, links, pictures, spreadsheets. All project results, information of benchmark models and their applications will be disseminated through the toolbox web page opened for the use of the end-user and scientific community at the end of the project.

Brochures describing the benchmarking process, the benchmark criteria and their test applications will be produced with updates during the project. Both the home page and the brochures have a wide set of target groups:

- potential end-users such as river basin authorities, public authorities at the local, regional, national and international levels world-wide
- scientific and technical advisors to these authorities
- consulting firms who might use the products as tools in their projects dealing with water use and water pollution management
- national and international organisations dealing with water related projects worldwide
- The Environment Directorate General at the EC Commission responsible for the implementation of the WFD

The results will also be sought published in the international scientific literature and presented at scientific conferences. Here the target group is scientific peers in the fields of hydrology, hydrochemistry, geohydrology, and water resource planning. We foresee high quality scientific output in particular on the model inventories, model linkages, and also on the process and methodology of benchmarking, as well as on the analyses of model goodness-of-fit and sensitivity vs. benchmark criteria.

8 THE CONSORTIUM

The consortium consists of 8 partners, all of which are research organisations. The research institutes are from six countries: Finland, Norway, the UK, the Netherlands, France and Spain. The project coordinator is the Finnish Environment Institute, located in Helsinki, Finland.

01 FEI Finnish Environment Institute, Helsinki, Finland

Sub-contractors:

South-West Finland Regional Environment Centre (River basin authority; WP1 and WP9)

HN-soft Co. (SME on software development; WP10)

02 NIVA Norwegian Institute for Water Research, Oslo, Norway

University of Reading, Dept of Geography, Reading, UK (WP6)

MORSA, Oslo, Norway (River basin authority) (WP1 and WP9)

Norwegian Meteorological Institute (DNMI) (WP7)

03 MLURI Macaulay Land Use Research Institute, Aberdeen, Scotland, UK

Sub-contractor: Scottish Environment Protection Agency

(River basin authority; WP1 and WP9)

04 Cemagref, Centre national du machinisme agricole du génie rural, des eaux et des forêts,
Paris, France

05 CEH Centre for Ecology and Hydrology, Wallingford, UK

Subcontractor: Environment Agency, Wallingford, UK (River basin authority; WP1 and WP9)

06 UPC Universidad Politecnica de Catalunya, Barcelona, Spain

Sub-contractor: Junta d'Aigües de Catalunya (River basin authority; WP1 and WP9)

07 Delft WL | Delft Hydraulics, The Netherland

Subcontractor: Amstel-Gooiland-Vecht Waterboard, Hilversum;

(River basin authority; WP1 and WP9)

08 UPM Universidad Politecnica de Madrid, Madrid, Spain

The consortium comprises scientific expertise in all the key areas required to tackle the challenges of the project. Ecological expertise is provided by partners FEI and NIVA; hydrology and water quality modelling expertise is provided by partners FEI, NIVA, Cemagref, CEH, and Delft WL; groundwater expertise is provided by partner UPC; water resources planning and economic analysis expertise is provided by partners MLURI, FEI and UPC; systems analysis and programming expertise is provided by partners UPM, NIVA and FEI. In the enclosed table a closer overview of the expertise is provided.

The end-users (water authorities) at the 6 river basins have confirmed their participation and are formally included as sub-contractors. Their participation will help 1) to fully integrate user requirements and 2) to exchange information on the possible effects of the implementation of EU water-related policies under the different socio-economic conditions of the test sites.

Table 8-1. Expertise and types of personnel of project partners

Expertise	Partner	FEI	NIVA	MLURI	Cemag ref	CEH	UPC	Delft	UPM
Modelling principles and criteria		X	X	X	X	X	X	X	X
Waste waters, engineering, modelling			X					X	
Ecology, water biology		X	X						
Hydrology				X	X	X			
Diffuse pollution, modelling		X	X	X	X	X		X	
River and lake water quality, modelling		X	X		X	X		X	
Groundwater, modelling						X	X		
River basin management		X	X	X		X		X	
Estuary models		X	X					X	
Socio-economics; cost-effectiveness		X		X					
Integrated model applications		X	X	X		X	X	X	
Sensitivity and uncertainty analysis		X							X
Data base and information technology		X	X						
Connections to end-users		X	X	X		X	X	X	
Type and number of personnel									
Senior scientist		2	2	1	3	1	1	2	1
Scientific manager								3	
Scientist		6	3	2		3	3	1	2
Research assistant			2						
Total number of persons working		8	7	3	3	4	4	6	3

Table 8-2. Roles and functions of the partners in the BMW project. All partners participate in the formulation of criteria for benchmark models (WP1).

01 FEI

- project co-ordinator
- lead partner for criteria Benchmark models (WP1) and Toolbox (WP10)
- major role in lake waters (WP3) and integration (WP9)
- participating on diffuse pollution (WP3), estuaries (WP7) and cost-effectiveness (WP8)
- testing at Eurajoki river basin (with sub-contractor SW-REC) (WP9)

02 NIVA

- lead partner for lakes (WP6) (with subcontractor Univ. Reading) and estuaries (WP7) (with subcontractor DNMI)
- major role in wastewaters (WP2) and integration (WP9)
- provide and operate ENSIS GIS-database system for data from the test basins (WP9)
- testing at Vansjø-Hobøl river (with sub-contractor MORSA) (WP9)

03 MLURI

- lead partner for diffuse pollution delivery (WP3) and cost-effectiveness and multiple criteria analysis (WP8)
- participate in waste waters (WP2)
- testing at River Ythan (with sub-contractor Scottish Environment Protection Agency) (WP9)

04 Cemagref

- responsible for hydrological models under WP3 (diffuse pollution delivery)
- participating on river modelling (WP5)
- assistant contractor to MLURI

05 CEH

- lead partner for rivers (WP5)
- major role for Demonstration and Integration (WP9)
- participating on diffuse pollution (WP3) and groundwaters (WP4)
- testing at River Humber (with end-user) (WP9)

06 UPC

- lead partner for WP4 (groundwater)
- testing at Llobregat River (with sub-contractor) (WP9)

07 Delft

- lead partner for WP2 (wastewaters) and WP9 (integration)
- participating on diffuse pollution (WP3), rivers (WP5), estuaries (WP7), and cost-effectiveness and multiple criteria analysis (WP8)
- testing at Amstel River (with sub-contractor Amstel Catchment Waterboard) (WP9)

08 UPM

- overseeing model sensitivity analyses (WP9)
- major role for model goodness-of-fit testing (WP9)

9 PROJECT MANAGEMENT

9.1 Clustering

In order to support the implementation of the Water Framework Directive, the European Commission is proposing to establish a cluster on Integrated Catchment Water Modelling (CATCHMOD). The objective of this cluster is the development of common harmonised modelling tools for the integrated management of water at river basin or sub-basin scales, including the interface to the coastal zone, in order to achieve a selected number of « European benchmark models » for the various integrated water management requirements at that scale.

This requires a close cooperation and synergy between different ongoing EC projects funded under Key Action that address comparable and complementary issues and research questions. This project will form part of this cluster. The other projects in the cluster:

The Tisza River Project - Real-life scale integrated catchment models for supporting water- and environmental management decisions - TISZA RIVER PROJECT

Towards Harmonised Procedures for Quantification of Catchment Scale Nutrient Losses from European Catchments – EUROHARP

Harmonising Quality Assurance in model based catchment and river basin management – HARMONIQUE IT Frameworks – HARMONIT

Additional projects could also be considered by the European Commission in a later stage.

The primary aim of the cluster is to enhance the complementarity and synergy between the above projects, to avoid unnecessary overlaps in project activities and to help the co-ordination and dissemination of research results. The secondary aim is to provide support to EU policy in the area of developing strategies facilitating the implementation of the Water Framework Directive in the field of basin management plans.

Actions in support of the research cluster are detailed below.

1. A steering committee, composed of the five project co-ordinators, will manage and oversee the implementation of the common tasks. The chair of the committee will be agreed at its first meeting, and will rotate on an annual basis. The Commission will be invited to attend meetings of the committee. The committee will provide a report to the Commission on progress on the common tasks every 12 months. The first meeting of this steering committee will take place after 6 months of the starting date of the latest signed contract.
2. A web site to support the clustering activity will be established. This will hold information about the projects and provide updates on research progress, dissemination events etc.
3. Where there are clear overlaps between the projects' workpackages in terms of methodology or research objectives, more involved forms of collaboration will be explored. This is particularly relevant to the work being undertaken on various model domains (e.g. diffuse pollution, ecology, socio-economic issues, etc.) software tools for linking models, proof of concept, database design and harmonisation of terminology, evaluation of models performance, common sites for model and tools evaluation and testing.
4. Each of the above projects will extend an open invitation to the members of the other consortia to attend their project meetings and they will try where appropriate to arrange common meeting to discuss complementary issues.
5. Where appropriate the above projects will work to identify and exploit common dissemination and exploitation opportunities (e.g. publications).

The terms of reference of the steering committee, including a description of how the common tasks will be implemented, will be finalised and delivered to the Commission in draft form, after the first meeting of the steering committee. The final version will take account of any comments of the Commission.

Each project commits to contribute at least 1% of their respective EC contribution towards the common tasks of the cluster. Opportunities for additional funding to support further collaborative activities will be explored.

9.2 Management and decision making

The overall co-ordination of the project will be at the Finnish Environment Institute. FEI will co-ordinate the development of the benchmarking process and the derivation of benchmark criteria. The project co-ordinator will quality control all written documentation originating from the project.

Application and testing of established benchmarking criteria and procedures will be tested for entire integrated systems of domain models at the 6 river basins will directly involve the water authorities (end-users). The authorities have confirmed their participation in the project thus having a stake in the work and will receive financial resources to fund extra work involved in the data collection, development and testing of benchmark criteria.

Decision-making within the project will follow a hierarchical structure with delegated authority. Overall decisions will be made by the project co-ordinator at FEI, in consultation with the management team comprised of one representative from selected the contract partners. Each member of the senior group will have primary responsibility for one aspect of the project.

Table 9-1. Decision-making and responsibilities within the project. Decision makers comprise the management team

research area	decision maker
Overall project, benchmark process, criteria, toolbox, dissemination	01 FEI (Kämäri)
Lakes, estuaries	02 NIVA (Wright)
Groundwaters	05 UPC (Candela)
Rivers, model evaluation	05 CEH (Jenkins)
Socio-economics	04 MLURI (Ferrier)
Integration	07 Delft (Groot)

In addition the institute most closely related to each river (FEI – Eurajoki; NIVA --Vansjø-Hobøl; CEH – Humber; MLURI -- Ythan; Delft WL – Amstel; UPC -- Llobregat) will make decisions regarding the application and testing at each of the 6 rivers. These institutes will also be responsible for joint activities with the respective water authorities (end-users).

No new water quality data will be collected as part of the project. Existing data will be quality controlled with respect to use in application and testing of ENSIS at the 6 river basins. The institute closest to each river (see above) will do this quality assurance. Similarly the data on human activities and pollution sources will be quality controlled by the member of the economics sub-group from the institute closest to the particular river.

As laid out in the Gantt diagram (Section 3) the scheduling of tasks specifies the nature and timing of the deliverables. Special attention will be paid to deliverables necessary for initiation or continuation of subsequent tasks. Annual project meetings and more frequent meetings involving pairs of partners (development of domain links) and sub-groups will enhance communication between partners.

9.3 Project manpower

The number of staff months each project will invest in each of the workpackages of the project is shown in Table 9-2 below.

Table 9-2 Number of staff months for each workpackage and institute

Work-Package No	FEI Coordination	FEI	NIVA	MLURI	Cemagref	CEH	UPC	Delft	UPM	Total Man Power	Total without coord.
WP1	2.2	10.0	2.4	2.0	3.0	3.0	0.0	4.0	4.0	30.6	28.4
WP2	2.2	0.0	6.4	2.0	0.0	0.0	0.0	14.0	0.0	24.6	22.4
WP3	2.2	4.0	2.4	24.0	10.0	6.0	0.0	3.0	0.0	51.6	49.4
WP4	2.2	0.0	0.0	0.0	0.0	3.0	30.0	0.0	0.0	35.2	33.0
WP5	2.2	0.0	0.0	0.0	3.0	29.5	0.0	3.0	0.0	37.7	35.5
WP6	2.2	10.0	18.6	0.0	0.0	0.0	0.0	0.0	0.0	30.8	28.6
WP7	2.2	4.0	8.3	0.0	0.0	0.0	0.0	6.0	0.0	20.5	18.3
WP8	2.2	8.0	0.0	18.0	0.0	0.0	0.0	4.0	0.0	32.2	30.0
WP9	2.2	15.5	20.3	8.0	0.0	10.0	13.0	18.0	28.0	115.0	112.8
WP10	2.2	18.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0	22.7	20.5
Total Person Months	22.00	70.00	60.40	54.00	16.00	51.50	43.00	52.00	32.00	400.9	378.9

9.4 Reporting

- On 6-monthly intervals from the project's starting date the project will provide the Commission services with a short Management Report, outlining the practical implementation of the project in accordance with the time schedule indicated in the Description of Work
- A draft of the Technological Implementation Plan (T.I.P.) should be submitted with the 1st Periodic Report. This document will be revised and updated at the interim Periodic Reports, and finalised on project completion with the Final Report.
- The co-ordinator will notify the responsible officer in the Commission of meetings of the project partners. The notification will be given well in advance of the meetings to enable the Commission to be represented.
- During the first year of the project, a meeting will be organised with the co-ordinators of complementary projects funded by different EU RTD activities, to consider the possibilities for integrating the work of these projects with a cluster. If appropriate and on the basis of the outcome of this meeting, a list of specific activities will have to be decided and implemented according to the participation rules of FP5.

SUPPLEMENT 1: Description of Work Packages

Work package list

Work-Package No	Workpackage title	Lead Contractor No	Person months	Start month	End month	Deliverable No
WP1	Criteria for 'Benchmark models'	01	28.4	1	36	D1.1 D1.2
WP2	Models for wastewater pollution	07	22.4	1	36	D2.1
WP3	Models for diffuse pollution delivery	03	49.4	1	36	D3.1
WP4	Models for groundwater quality	06	33.0	1	36	D4.1
WP5	Models for river water quality	05	35.5	1	36	D5.1
WP6	Models for lake water quality	02	28.6	1	36	D6.1
WP7	Models for estuaries	02	18.3	1	36	D7.1
WP8	Models for cost-effectiveness and multi-criteria analysis	03	30.0	1	36	D8.1
WP9	Integration and demonstration of integrated models	07	112.8	1	36	D9.1 D9.2
WP10	Toolbox for benchmark models	01	20.5	1	36	D10.1 D10.2 D10.3
	TOTAL		378.9			

WP1: Criteria for 'Benchmark models'

Start date or starting event: month 1

Lead contractor: FEI

Person-months per partner:

Partner	FEI	NIVA	MLURI	Cemagref	CEH	UPC	Delft	UPM	Total
Months	10.0	2.4	2	3	3	0	4	4	28.4

Objectives

- Describe the benchmarking process
- Derive generic criteria for benchmark models
- Define questions to be posed to the test applications of the model systems integrated to river basins

Description of work

The benchmarking process will start in close collaboration with the end users. Those responsible for model evaluation (benchmarking) and those for model use (application at case study rivers) will join to define the benchmarking process that leads to harmonisation of models to be used in different countries.

Two types of criteria will be identified:

- criteria that apply to all models (generic criteria),
- criteria that apply to the integration of the domain models into an integrated model

The generic criteria will assess the models'

- relevance to account for socio-economic questions
- validation status
- documentation of the model and changes with new versions

Domain-specific criteria will be derived and tested to evaluate the models' capability to incorporate:

- dose-response relationships
- changes in response
- desired spatial and temporal scales and resolution
- water quality parameters relevant for key organisms
- models sensitivity to key forcing functions

A workshop will be organised by the project bringing together project scientists and end-users to;

- assess the developed criteria reflecting the requirements of the Water Framework Directive
- assess the inventory of models from each domain against the established criteria;
- and based on these assessments to;
- define the key characteristics of models in each domain with respect to the requirements of the Water Framework Directive
- define benchmarks or standards with respect to temporal and spatial scale of operation within each domain and between domains
- define key questions that might be asked of models within the scope of testing programmes of measures with which to achieve good status

Deliverables

D1.1 Description of project tasks and work undertaken by each partner (month 6)

D1.2 Document the benchmarking process and generic criteria for benchmark models (month 18)

Milestones

M1.1 Define and document the concept and process of benchmarking models (month 6)

M1.2 Workshop of stake-holders to assess the model inventory and benchmark criteria (month 12)

WP2: Models for wastewater pollution

Start date or starting event: month 1

Lead contractor Delft

Person-months per partner:

Partner	FEI	NIVA	MLURI	Cemagref	CEH	UPC	Delft	UPM	Total
Months	0	6.4	2	0	0	0	14	0	22.4

Objectives:

- define benchmark criteria for wastewater pollution models
- provide an inventory of existing modelling approaches for wastewater pollution and assess the weaknesses and strengths of the various models with respect to implementation of the Water Framework Directive
- undertake testing and evaluation of selected approaches on an appropriate test basin,
- demonstrate potential impacts of alternative measures on wastewater loading.

Description of work

Work Package 2 (WP2) deals with wastewater pollution models. These models describe the point-source emission of pollutants to water systems. As the generation (or production) of wastewater and pollution is closely connected to human activities, socio-economic developments are implicitly included in wastewater pollution models.

The first activity of WP 2 encompasses a literature search and review to build an inventory of existing wastewater pollution models. The key characteristics of each model will be summarised, and some example applications of each model, in combination with the questions addressed by the model, will be gathered. Based on the information made available the wastewater pollution models will be categorised by the spatial and temporal resolution, the possible fields of application, and linkage to other domains. The summarised results of the inventory will be sought published in the international scientific literature.

One or more examples of wastewater pollution models will be demonstrated in selected case study areas. The compliance of the models to the initial benchmark criteria, formulated in WP1, will be demonstrated in the case studies. Benchmark limitations will be documented and highlighted, and recommendations for adjustment of the benchmarks will be formulated.

The wastewater pollution models included in the inventory will be assessed with respect to the final benchmark criteria.

The models included in the selected case study areas will be provided to WP8 on whole catchment integration.

Deliverables

D2.1 Inventory of available wastewater pollution models and formulations of the benchmark criteria (month 36)

Milestones and expected result

M2.1 Inventory of wastewater pollution models completed (month 12)

M2.2 Finalisation of case studies, assessing benchmark criteria and formulation of final set of benchmark criteria (month 24)

M2.3 Finalisation of application of benchmark criteria to all models included in the inventory with report and publication (month 36)

WP 3: Models for diffuse pollution delivery

Start date or starting event: month 1

Lead contractor MLURI

Person-months per partner:

Partner	FEI	NIVA	MLURI	Cemagref	CEH	UPC	Delft	UPM	Total
Months	4.0	2.4	24	10	6	0	3	0	49.4

Objectives:

- define benchmark criteria for models of diffuse pollution
- provide an inventory of existing modelling approaches for diffuse pollutants and assess the weaknesses and strengths of the various models with respect to implementation of the Water Framework Directive
- undertake testing and evaluation of selected approaches on an appropriate test basin,
- demonstrate potential impacts of EU legislation and policies on diffuse pollutant loading.

Description of work:

This WP will focus on the evaluation of published and available diffuse pollution models for the nutrients, phosphorus and nitrogen. During the first phase of the WP bench marking will be undertaken in a manner consistent with that of other domains in WPs 2 and 4-7. This will provide a detailed inventory of existing empirical, stochastic and process-based models, including information on model complexity, structure, temporal and spatial resolution, and data requirements. This will be circulated to the specified end-users for comment and to ensure inclusivity. Following on from this evaluation, appropriate representative models will then be selected and evaluated against data collated from the test basins in WP9. In particular, the evaluation will focus on the nature and availability of data, and the temporal and spatial requirements of the models

A key element of the third objective of the WP will be to evaluate linkages between different domain models. Nitrogen dynamics within catchment systems will involve the integration of land based delivery models for N, groundwater (WP4) river transport models (WP5) and receiving waters impact assessment models such as those being evaluated for estuaries in WP7. This will be a task of the second year of the project. Similarly, freshwater eutrophication impacts will be assessed through the integration of delivery models and impacts models for rivers and lakes (WP6). This will require regular meetings between the groups in those particular WP's. Model integration and domain linkages will be evaluated and documented by the end of year 2.

The third task will ensure that the approach adopted in linking between domain models meets the requirements of end users, with the emphasis being placed on both the flexibility of the approach and on the quality of the decision support capability. This will involve the identification of appropriate targets based on both ecological and socio-economic criteria.

Deliverables

D3.1 Inventory of available diffuse pollution models and formulations of the benchmark criteria (month 36)

Milestones and expected result

M3.1 Inventory of diffuse pollution models completed (month 12)

M3.2 Finalisation of case studies, assessing benchmark criteria and formulation of final set of benchmark criteria (month 24)

M3.3 Finalisation of application of benchmark criteria to all models included in the inventory with report and publication (month 36)

WP4: Models for groundwater quality

Start date or starting event: month 1

Lead contractor: UPC

Participation and person-months per partner:

Partner	FEI	NIVA	MLURI	Cemagref	CEH	UPC	Delft	UPM	Total
Months	0	0	0	0	3	30	0	0	33.0

Objectives:

- define benchmark criteria for groundwater models
- build an inventory of existing models for groundwater
- test selected models on groundwater in the case study river basins
- use models to assess scenarios of change in key driving variables (climate, land use, point sources and diffuse sources)
- specify linkages between models for surface waters (diffuse pollution) and groundwater

Description of work

The first step in WP4 will be compilation of inventory of existing models for groundwater. Models of all types relevant for use with the Water Framework Directive and relevant for all major pollution problems in river basins in Europe will be included. Sets of necessary and desirable criteria for groundwater models will be compiled, and the existing models evaluated with respect to these criteria. Shortcomings of the individual models and general lack of necessary models necessary for management of specific pollution problems will be identified. This information will feed into WP9.

Next selected models that satisfy a minimum of criteria (benchmark criteria) will be applied to groundwater aquifers in the case study river basins (input to WP9). The explanatory capability of the models will be evaluated relative to a standard (benchmark).

Selected models will be used to evaluate their predictive capability of response to various forcing functions in groundwater. Drivers to be assessed will be climate, land-use, and diffuse pollution. The effects of scenarios of change in each of these will be made using the model and compared with data from groundwater aquifers with suitable long-term data sets.

The individual models will be evaluated with respect to their data requirements in time and space relative to the integration into river basins (input to WP9). The information delivered by models from the other domains (diffuse sources WP3) as well as the delivery of information to the next domain downstream (river model WP5) will be specified and each model evaluated as to its utility and relevance. As set of objective criteria to this end will be developed.

Deliverables

D4.1 Inventory of available groundwater models and formulations of benchmark criteria (month 36)

Milestones and expected result

M4.1 Inventory of groundwater models completed (month 12)

M4.2 Finalisation of case studies, assessing benchmark criteria and formulation of final set of benchmark criteria (month 24)

M4.3 Finalisation of application of benchmark criteria to all models included in the inventory with report and publication (month 36)

WP 5: Models for river water quality

Start date or starting event: month 1

Lead contractor: CEH

Person-months per partner:

Partner	FEI	NIVA	MLURI	Cemagref	CEH	UPC	Delft	UPM	Total
Months	0	0	0	3	29.5	0	3	0	35.5

Objectives:

- define benchmark criteria for models of river water quality
- provide an inventory of river models describing key characteristics and examples of uses
- test appropriate models at selected case study areas to assess compliance with agreed benchmarks
- identify and develop key linkages with appropriate models of diffuse pollution and estuaries for testing at selected case study areas to assess compliance with the agreed benchmarks
- use river models and linked diffuse-river-estuary models to assess scenarios of catchment management and climate change

Description of work

An inventory of river water quality models will be compiled. The models identified in the inventory will be classified according to their structure, e.g. distributed or lumped, stochastic or deterministic, dynamic or steady state, mechanistic or empirical. Each type of model has data requirements, assumptions and calibration requirements that will make them more or less useful for a given catchment and to address a specific management question. For key management issues, appropriate models of different types developed and used by the project partners will be applied at selected case study areas to demonstrate compliance with the agreed benchmark (WP1) and to highlight the benefits/limitations of the models given the available data.

To be most effective in terms of catchment management, river models need to be coupled with models of non-point sources (WP3). Using the most appropriate river water quality model for a given data availability and management requirement, appropriate diffuse pollution models will be ‘linked’ and applied at selected case study sites to demonstrate compliance with the agreed benchmark (WP1). Further linkage with estuary models (WP7) will be developed, demonstrated and assessed against the agreed benchmark (WP1).

The river water quality models and linked diffuse-river-estuary models will be used to assess the broader influence of potential future climate change using best available data from GCMs.

Deliverables

D5.1 Inventory of river water quality models and formulations of benchmark criteria (month 36)

Milestones and expected result

M5.1 Inventory of river models completed (month 12)

M5.2 Finalisation of case studies, assessing benchmark criteria and formulation of final set of benchmark criteria (month 24)

M5.3 Links for diffuse pollution > river > estuary models completed (month 30)

M5.4 Finalisation of application of benchmark criteria to models included in the inventory with report and publication (month 36)

WP6: Models for lake water quality

Start date or starting event: month 0

Lead contractor: NIVA

Person-months per partner:

Partner	FEI	NIVA	MLURI	Cemagref	CEH	UPC	Delft	UPM	Total
Months	10	18.6	0	0	0	0	0	0	28.6

Objectives:

- build an inventory of existing models for lakes
- test selected models on lakes in the case study river basins
- use models to assess scenarios of change in key driving variables (climate, land use, point sources and diffuse sources)
- specify linkages between models upstream and downstream the lakes

Description of work:

The first step in WP6 will be compilation of inventory of existing models for lakes. Models of all types (flushing, stoichiometric, process-based) relevant for use with the Water Framework Directive and relevant for all major pollution problems in river basins in Europe will be included. Lakes of all types important in Europe will be considered (e.g. small headwater lakes, large lowland lakes, and reservoirs). Sets of necessary and desirable criteria for lake models will be compiled, and the existing models evaluated with respect to these criteria. Shortcomings of the individual models and general lack of necessary models necessary for management of specific pollution problems will be identified.

Next selected models that satisfy a minimum of criteria (benchmark criteria) will be applied to lakes in the case study river basins (input to WP9). The explanatory capability of the models will be evaluated relative to a standard (benchmark).

Selected models will be used to evaluate their predictive capability of response to various key drivers of change in lakes. Drivers to be assessed will be climate, land-use, point source, and diffuse source. The effects of scenarios of change in each of these will be made using the model and compared with data from key lakes with suitable long-term datasets. Eutrophication, acidification and pollution with one or more dangerous substances will be assessed.

The individual models will be evaluated with respect to their data requirements in time and space relative to the integration into river basins (input to WP9). The information delivered by models from other domains (point sources WP2, diffuse sources WP3, and inflowing streams WP5) as well as the delivery of information to the next domain downstream (river model WP5) will be specified and each model evaluated as to its utility and relevance. A set of objective criteria to this end will be developed.

Selected models for lakes will be tested for one pollutant at one case lake with respect to goodness-of-fit, and the performance evaluated relative to the benchmark.

Deliverables

D6.1 Inventory of river water quality models and formulations of benchmark criteria (month 36)

Milestones and expected result

M6.1 Inventory of lake models completed (month 12)

M6.2 Specification of interface to and from the other domains complete (month 18)

M6.3 Finalisation of case studies, assessing benchmark criteria and formulation of final set of benchmark criteria (month 24)

M6.4 Finalisation of application of benchmark criteria to models included in the inventory with report and publication (month 36)

WP7: Models for estuaries

Start date or starting event: month 1

Lead contractor: NIVA

Person-months per partner:

Partner	FEI	NIVA	MLURI	Cemagref	CEH	UPC	Delft	UPM	Total
Months	4	8.3	0	0	0	0	6	0	18.3

Objectives:

- build an inventory of existing models for estuaries
- describe model characteristics and classify the models in relation to the type of estuary forming the discharge area of the case study river basins.
- describe how the models may be used to assess scenarios of change in key driving variables (climate, land use, point sources and diffuse sources)
- specify the link between river model and estuary model

Description of work:

The Work Package on estuary models will mainly consist of a literature study of existing models, resulting in a description of how different estuary models can be used in the river basin management under the Water Framework Directive. The description will include an assessment of models relative to a set of criteria defined as part of the project.

The work package will also include a description of how the different models can be used in conjunction with the river basin models. Specifically, the work package will describe the data input from observations or river basin models that are required or can optionally be handled in different estuary models, both in content and general format.

Deliverables:

D7.1 Inventory of estuary models, including benchmark criteria, and evaluation of the models (month 36)

Milestones:

M7.1 Literature survey of estuary models completed (month 12)

M7.2 Benchmark criteria completed (month 18)

M7.3 Classification of models completed (month 24).

M7.4 Evaluation of model properties against criteria (month 36).

M7.5 Description of data input required from observations and river models (month 36).

WP8: Models for cost-effectiveness and multiple criteria analysis

Start date or starting event: month 1

Lead contractor: MLURI

Participation and person-months per partner:

Partner	FEI	NIVA	MLURI	Cemagref	CEH	UPC	Delft	UPM	Total
Months	8	0	18	0	0	0	4	0	30.0

Objectives:

The objective is to use evaluate and benchmark decision modelling approaches to assist in the management of water basins under the Water Framework Directive. The key contribution is to assess; (1) economic cost-effectiveness frameworks for examining management strategies and, (2) multi-criteria decision analysis (MCDA) that extend the framework by incorporating economic, social and environmental objectives thereby taking into account the interests of major stakeholders. The aim is to provide a generalised decision framework incorporating the goals of different groups and apply it to water management issues in selected case study contexts.

Work Description:

WP8 will conduct a literature search and review which will provide an inventory of existing approaches to cost-effectiveness evaluation and multiple criteria analysis. This will be undertaken in a way consistent with that in WPs-2-7, such that attributes of different approaches will be evaluated against the objectives contained in the Water Framework Directive. Selected approaches will then be evaluated ensuring that economic modelling approaches incorporate cost functions for major users/polluters in relation to quality/quantity criteria. Analysis will also differentiate between point and non-point sources and include those regulatory and economic instruments that are relevant at a catchment scale. Therefore, a key element will be the synergistic integration of cost effectiveness approaches with the different domain models, targeted towards end-user requirements.

Subsequently, the cost-effectiveness of potential amelioration strategies will be assessed at appropriate test basins included in WP8. This will form the normative baseline in analysis. Moving beyond that we will implement a multi-criteria approach so that social and environmental objectives and the preferences of different interest groups can be incorporated. Two MCDA methods will be explored – compromise programming and NAIAD (Novel Approach to Imprecise Assessment and Decision Environments). The NAIAD MCDA approach to stakeholder appraisal will be explored, as it is able to operate in a crisp, fuzzy or stochastic environment thereby providing greater flexibility in analysis. The end-point will be a positive analysis of decision criteria and their implications, and a route towards conflict resolution within the overall goal of sustainable ecological development.

Deliverables

D8.1 Inventory of cost-effectiveness models, including benchmark criteria, and evaluation of the models (month 36)

Milestones and expected results

M8.1 Literature survey of economic modelling approaches completed (month 12)

M8.2 Benchmark criteria completed (month 18)

M8.3 Evaluation of economic impacts of scenarios in case-study catchments (month 21)

M8.4 MCDA evaluation model set up and data collection from stakeholders (month 28)

M8.5 MCDA analysis and evaluation for selected catchments (month 36)

WP9: Integration and demonstration of integrated models

Start date or starting event: month 1

Lead contractor: Delft

Person-months per partner:

Partner	FEI	NIVA	MLURI	Cemagref	CEH	UPC	Delft	UPM	Total
Months	15.5	20.3	8	0	10	13	18.0	28	112.8

Objectives:

- evaluate the potential of existing integrated river basin model systems and formulate benchmark criteria. The evaluation will include socio-economic aspects
- demonstrate the applicability of selected models to the case study rivers
- evaluate the potential of the model system to account for socio-economic considerations

Description of work

WP 8 will inventory existing integrated model systems. The key characteristics of each computational framework will be summarised, and example applications will be gathered, in combination with the questions addressed. Attention will be paid to the level of detail in time and space, the possible fields of application, and linkage among domains.

A chain of domain models fulfilling the *a priori* benchmark criteria will be coupled to form examples of integrated model systems. These integrated model systems will be tested by application to six European river basins. (These are described in Appendix A). The compliance of the overall integrated model system with the benchmark criteria will be tested. A set of example management scenarios will be run for each test basin and be evaluated with respect to models' capability to serve as management tool in the implementation of the Water Framework Directive. This part will involve active participation by the local authorities (end-users) at each river basin.

The shared, central database (ENSIS) will handle the collection of data from the test basins and store typical results from model runs. A common database is crucial for the comparison of the models within the same domain. ENSIS will facilitate the evaluation of the possibilities to integrate models from different domains, since output from one model might provide input to the next.

Sensitivity analysis will be conducted on one model from each of several domains. Screening designs based on the Morris OAT designs (1991) and global SA will be applied using two techniques: Monte Carlo Analysis based on the Latin hypercube sampling, and Variance-based methods such as the Fourier amplitude sensitive test (FAST) (1973).

Deliverables

D9.1 Report on the inventory of integrated models, including a description of the key characteristics, example applications and questions that can be addressed, and recommendations for benchmark criteria for integrated models (month 24)

D9.2 Report with final evaluation of existing models, identification of missing links, recommendations for future model development, as illustrated by results from model applications to the case study river basins (month 36)

Milestones:

M9.1 Finalisation of the inventory of integrated model systems, including a report describing and formulating the initial set of benchmark criteria for integrated model systems (month 12)

M9.2 Data on the case studies in the ENSIS system (month 12)

M9.3 Demonstration and testing of linked domain models integrated over river basins (month 36)

WP10: Toolbox for benchmark models

Start date or starting event: month 0

Lead contractor: FEI

Person-months per partner:

Partner	FEI	NIVA	MLURI	Cemagref	CEH	UPC	Delft	UPM	Total
Months	18.5	2	0	0	0	0	0	0	20.5

Objectives:

- Offer an operational tool for project work and for result delivery
- Offer a real-time internet-based international planning and discussion blackboard
- Give an interactive document drafting platform
- Give an associative cross-reference database for managing the models and their attributes

Description of work

This work package consists of the development of an information system aimed to serve the project and the end-users. The information system – called the Toolbox – is based on a relational database, web server and the internet connection. The Toolbox located at the home page will offer a flexible tool for interactively searching real time information related to project results. Toolbox will greatly enhance information exchange and transferability of integrated models. The database of the Toolbox is an associative cross-referencing relational database being able to store any kind of information: e.g. text, programs, links, pictures, spreadsheets. All project results, information of benchmark models and their applications will be disseminated through the toolbox web page opened for the use of the end-user and scientific community at the end of the project. The principles of the Toolbox have been tested in an Interreg II c project ‘Planning System for Sustainable Development’, PSSD.

As the first step will be to define the elements to be included and implement the consequent structure of Toolbox. The structure and functionality of the system will reflect the project and end-user needs. The database will be an associative cross-reference database of information. Information on benchmark models and their applications will be located in a relational database. Splitting complexes into entities allows linking various attributes of the model to its underlying properties. By that way it will be possible to manage the substance of the models, e.g. their properties or benchmark criteria, and not to treat them as models only. The free linking of the entities enables seeking of information independently of the hierarchical structure of the substance. The Toolbox will also include a discussion forum and a bulletin board for the project.

Secondly we plan to develop the document management utility for the Toolbox. The aim is to offer a tool for developing documents in international real time co-operation. The users can add and edit text, insert objects like pictures into the document as paragraphs and so on. The other users can see the results simultaneously. The result of the work will be stored into the database. Finally, the development of the digital planner’s blackboard is carried out. This is necessary for encouraging the interaction between partners, arranging e-meetings and having common working sessions between partners.

Deliverables

D10.1 Toolbox web site with database and the document management opened for project use (month 6)

D10.2 The digital blackboard opened on the web for project use (month 12)

D10.3 The second edition and the manual of the Toolbox for benchmark models opened (month 36)

Milestones

M10.1 Defining the user needs, functionality and opening of the Toolbox (month 5)

M10.2 Launching the digital blackboard (month 12)

M10.3 Toolbox opened for end-users (month 35)