STRATEGIC RESEARCH AGENDA

Water Research – A necessary investment in our common future

Water Supply and Sanitation Technology Platform

October 2006

Introduction

The Strategic Research Agenda (SRA) of the Water Supply and Sanitation Technology Platform (WSSTP) is a long-term strategy for a European water sector that has long been fragmented. This SRA is the second shared output produced by the Water Supply and Sanitation Technology Platform, the Vision Document[1] being the first output. Water and sanitation is a sector where services in Europe are provided by tens of thousands of public and private bodies of all sizes, with numerous organizations involved in research in all aspects of the water cycle. The WSSTP is mobilizing these enormous economic and human resources around a common vision and a common strategic research agenda. The WSSTP aims to create synergies between diverse water using sectors, and accelerate the implementation of new methods and technologies. The core of the WSSTP vision is that by 2030 the European water sector will be the leading international centre of expertise for providing safe, clean and affordable water services while protecting the environment.

To achieve sustainability Europe has to apply an integrated and participatory approach for water resources management. The solutions are integrated across individual sectors (intra-disciplinary) and disciplines (inter-disciplinary) and involve the civil society in the process of defining research goals and implementation strategies (trans-disciplinary) thus achieving more efficient and more economic solutions than possible within separate sectors. The strengths of all stakeholders in the sector will be combined to enable the European water sector to offer innovative and sustainable technologies to the world.

The Strategic Research Agenda describes the research which must be undertaken to realize our vision. The on-going stakeholder driven approach to developing a research agenda empowers all stakeholders (private and public) to define the future of research, and to share in the actual research and implementation activities. The WSSTP is a vital mechanism to increase investments in research to support the competitiveness of European water technology and services. The WSSTP believes that increased global competitiveness depends upon both economic growth and social responsibility. The WSSTP will therefore support both European economic growth and contribute to achieving the Millennium Development Goals as part of the EU Water Initiative.

[1] "Water Safe, Strong and Sustainable", European Vision for Water Supply and Sanitation in 2030, WSSTP, October; 2005.

Readers Guide

This merged SRA is the product of a long process which started with the development of specific research agendas produced by the thematic working groups of the WSSTP: Water Management (TWG1), Water for People (TWG2), Water in Industry (TWG3), Water in Agriculture (TWG4) and for building an enabling environment (Horizontal Working Group, HWG). The Member States Mirror Group contributed significantly to these SRA's. A first version of a merged Strategic Research Agenda was presented at a public Stakeholders Event in Budapest on October 17, 2005. Following this event a new version of the SRA was developed to accommodate comments made during and after the event.

The individual SRA's are available on the website: www.wsstp.org for more detailed background information.

- Chapter 1 details the four major European water challenges (though also of global relevance) as abstracted from the vision document.
- Chapters 2 and 3 detail the strategy and research needed to meet those challenges.
- Chapter 4 integrates the research through six pilots themes, where each pilot addresses a major European water problem with multiple water issues within the framework of Integrated Water Resources Management. Research needs and priorities are defined by the requirements of the pilots and so an overall research agenda is established.

Within the pilots, research needs are described at two levels: generic research and development, and enabling technologies. Each pilot will eventually result in a number of implementation cases addressing carefully selected, actual situations inside and outside Europe. The implementation cases will be chosen following an analysis of the research priorities detailed by the end user and market needs.

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1 Four Major Challenges

Worldwide, the water sector is facing a dramatic evolution because of three major 'drivers'. The related challenges, if addressed proactively and responsively, could offer tremendous opportunities. The 'drivers' triggering this development are:

- **Climate change** is predicted to cause significant changes in precipitation and temperature patterns, affecting the availability of water. Water scarcity especially in summer time, is particularly acute and often unpredictable.

- Existing **infrastructure is aging and deteriorating**. It is a technological and financial challenge to maintain and upgrade it in such a way that quality water can continue to be delivered to all sectors and wastewater can be adequately collected and treated.

- **Globalisation and population growth** are enforcing rapid changes (migration, urbanization, industrial activities, patterns of food production) leading to a dramatic increase in high-quality water consumption. Frequently, this demand for water cannot be satisfied by the locally available water resources, while the discharge of insufficiently treated wastewater increases costs for downstream users and has detrimental effects on the aquatic systems.

Looking at the water sector in 2006 and beyond, both within Europe and beyond, the implications of these drivers can be expressed in four major challenges for the next 25 years.

1.1 Challenge 1: Increasing Water Stress and Water Costs

Many areas suffer from water stress, and the severity of that stress is increasing. Water stress can occur in any geographical region where the demand for water exceeds the bearing capacity of available water resources. Water stress may be primarily a water quantity issue, but it can also occur as a consequence of a deterioration of water quality or lack of appropriate water management. Transboundary issues add complexity to the problem. Water stress can be long term or seasonal - as in the case of the Mediterranean coastal areas where a massive tourist influx puts even more pressure on the already limited resources during the summer season. In the Mediterranean region, the tourist industry has very demanding consumers who have high expectations for both the availability and the quality of the water. This situation can be aggravated by the demand of the agricultural sector which is the biggest water user. Inability to meet the demand for water can have strong economic implications. The very large seasonal fluctuations in demand, limited natural resources, and geographically isolated location of many tourist destinations demands innovative and flexible solutions.

The traditional solution to water stress has been to supply water from ever increasingly distant sources - the **civil engineering solution**. In many places this type of solution is neither economically nor politically acceptable. Since the middle of the 19th century the alternative solution to water stress has been to treat and use the locally available water resource - the **chemical engineering solution**. While incremental improvements continue to be made in treatment technologies these systems have reached the limits of their technological and economic effectiveness. This is also due to the increased number, complexity and variety of pollutants and the public's environmental expectations. Flexible and adaptable solutions to cope with water stress are needed to reduce vulnerability and ensure that the available water is used in the most efficient way. In the last 20 years there has been an increasing emphasis on demand management, and particularly in educational programmes to encourage public and private user

communities to conserve water and to improve the efficiency of water use. This **"social engineering" approach** has been supported by a variety of economic, legal and social incentives.

Water stressed areas need to be managed in such a way that the availability of good quality water is no longer a barrier to economic growth. This requires domestic, agricultural and industrial water users to be able to adapt their activities so that they can still function effectively and competitively without exceeding the limits of the available water resources, or compromising freshwater ecosystems. This requires innovation at all levels to produce and use water efficiently and to guarantee sustainable human intervention in the water cycle, by considering in a co-ordinated way all water uses and all potential water resources, including recycling. Considering the enormous water consumption in the agricultural sector it is obvious that securing water for food is the major water related challenge today.

Increasing water demand and higher quality standards increase the costs for all users. Water saving technologies and water recycling/ reuse technologies will become necessary.

For coastal zones, alternative water resources such as desalinated sea waters and treated brackish waters with proper residual management solutions will have to be included in the overall portfolio of water resources.

We need to improve the efficiency of water use, to develop new and effective solutions for water treatment and recycling to extend the availability of quality water to the various user requirements, improvements in performance of irrigation and of other locally important water uses will bring significant water savings and to develop advanced monitoring systems for water quality management.

1.2 Challenge 2: Urbanization

Rapidly increasing urbanization is one of the most distinctive changes of the 20th and early 21stcenturies. All over the world people are moving away from rural areas towards the cities. In many cases, this migration is triggered by poverty resulting from large scale destruction of natural resources e.g. deforestation, overgrazing and resulting erosion problems. The challenge of urban and peri-urban areas is the unpredictability and the rate of migration, which makes it difficult to plan and ensure appropriate water services. Again, flexible and innovative solutions are needed to cope with sudden and substantial changes in water demand for people and their associated economic activities.

The migration also raises issues about safe food supply and its associated water requirements, due both to the concentration and increase of demand, and to the competition for land in peri-urban areas where urbanisation pressure pushes away agriculture, even from areas with high agronomical potential. On the other hand, safe re-use of water by peri-urban agriculture could be of great interest. Turf and landscape irrigation is a very high water consumer, and is able too to re-use treated wastewater. In densely populated areas there are additional risks of accidental and deliberate pollution of water resources. Consumers in urban areas tend to be more critical and well informed, and expect a safer and higher quality of service. This requires increased security and monitoring as well as emergency systems.

Urban areas around the world suffer from old and deteriorating water infrastructures that are very vulnerable to failure due to aging, damage from excavations or over-loading. While existing water re-use options have to be further developed and implemented, the need for smaller scale, adaptable, local infrastructure systems is immense. Measures have to be taken to ensure the needed public acceptance of such innovative solutions.

1.3 Challenge 3: Extreme events

Climate change has an impact upon the average volume of available water resources, and upon the frequency and severity of extreme events (droughts, floods, heat waves or blizzards). These extreme weather events are devastating to humans and the economy as they threaten and disrupt normal life in vast areas and for long periods. The effects of the 2003 drought in Europe and of the 2005 New Orleans catastrophe, for instance, will have impacts for many years after the event. Systems are needed to provide appropriate, timely and readily applicable mitigation, warning, management and adaptation methods in case of extreme events not just in Europe, but globally. These need to provide advice at appropriate spatial and temporal scales, from minute for emergency services, to decades for effective adaptation to climate change.

Floods and droughts can be worsened by poor land management and the effects of climate change, and need to be tackled in an integrated way. Mitigation measures for floods will not induce any additional threat from droughts. Regions which are moving into conditions of long term perpetual water stress need solutions which are resilient to more frequent extremes and which enable the estimation of the full social and economic impacts so that the scale of the threat is quantified and appropriate mitigation strategies are adopted.

1.4 Challenge 4: Rural and under-developed areas

Many rural and under developed areas within and outside Europe lack any significant infrastructure for water services. Frequently, wastewater and agriculture water management have an adverse impact on water quality in small settlements without people being even aware of these hazards. It is estimated that more than 10% of the European population receives water from very small supplies that do not meet European drinking water standards. Most of these people are self-supporting and involved in small scale agricultural activity, since industrial activity is limited. The lack of basic infrastructure makes these areas less attractive for economic activity and development. Municipalities and regional or national government often lack the money and the know-how to initiate the needed development. Water supplies, wastewater treatment and re-use for public, industrial and agricultural water needs in such remote areas, need to be non-conventional, decentralised, easy to service and highly reliable. The technology needed must be affordable and manageable. Improvement of the water infrastructure may attract new developments in such regions and help to reduce migration to urban areas. Once such new technologies have been implemented and proven, they may have attractive export potential to developing countries. On the other hand, there is a challenge to protect the water resources in pristine landscapes.

2 The Strategy Chosen

The challenges are daunting, while at the same time the opportunities are enormous. Clearly a strategic approach is required. Research in support of radical and innovative solutions is necessary over a tremendously wide area, from natural sciences, engineering, to governance, economics and social sciences. Some of the research topics have to be addressed and solved soon, while others need much more time.

To provide appropriate solutions in a timely manner the WSSTP proposes a stepwise approach. The most urgently needed advances are to be available by 2010, with medium term objectives met by 2020, and by 2030 most of the goals described in the vision document will have been met.

In water stressed regions the different water users collaborate to maximize the benefits from their scarce water supplies. Strategically, WSSTP research will make a major break with previous approaches which predominantly dealt with just a single research issues. **The distinctive and key innovative feature of WSSTP research is that it will not address single issues in isolation, but will adopt a systems approach and develop integrated solutions which address all the major issues and relevant interfaces within the system.**

To address these problems an integrated approach based on the Integrated Water Resource Management (IWRM) concept will be used to establish a set of six pilot themes described in chapter 4. This overarching systems approach which considers water supply, sanitation, water use in agriculture and industry and river basin management needs to be embedded into the local framework of laws, regulations, and into customs. In an increasingly water stressed world, the WSSTP will deliver major advances in water use efficiency, pollution prevention and techniques to balance competing demands for limited water resources. To make this leap forward, the WSSTP will include research on water technologies in a social and economic context across all water users and their supply chains.

The WSSTP addresses the full spectrum of research, from basic to applied research through effective demonstration to successful commercialisation and will oversee efficient knowledge transfer along the whole knowledge chain. This will be realised through implementation cases within the six pilot themes. Generic research and development of enabling technologies will be carried out jointly among pilot members at a pre-competitive level followed by the development of competitive solutions by a commercial consortium of partners for each individual case.

The diversity of European climatic, social and economic conditions provides the European water industry with a competitive advantage when developing water systems for global markets. In Europe there is expertise in developing innovative solutions for wet and dry climates, for urban, peri-urban and rural regions, and for environments which will support technologically advanced or rugged simple solutions. This range of solutions will benefit strongly from the contribution of small and medium size enterprises (SMEs) involved in research, development and delivery of innovative systems solutions.

3 Research areas

Five areas of research have been identified to meet the major challenges the water sector faces

- Balancing demand and supply
- Ensuring appropriate quality and security
- Reducing negative environmental impacts
- Novel approaches to the design, construction and operation of water infrastructure assets
- Establishment of an enabling framework

3.1 Balancing Demand and Supply

WHAT IS THE GOAL?

Long term economic growth and quality of life is reliant upon the sustainable use of water by people, agriculture and industry. Together these users should not use more water than is naturally replenished and should not use water of a higher quality than needed. In areas with water resource constraints, balancing the demands for water between the various sectors will need to be accompanied by the use of new and alternative resources, by increased recycling of wastewater, or by a more economic allocation of resources among the different water users, or a combination of all the options.

WHAT RESEARCH IS NECESSARY TO ACHIEVE THIS GOAL?

- Water saving concepts and technologies
- Increased knowledge of water quality requirements for all applications and purposes
- Technologies which enable usage of new and alternative resources of water, including wastewater
- Aquifer recharge and recovery technologies
- Decision support systems and demand management systems to efficiently allocate and use water resources

Innovative technologies and demonstration projects will be developed for increased efficiency in water use and reuse and closing water cycle; research will include development of on-line monitoring for key parameters (trace pollutants, micro-organisms). The quality of the water should be tailored to the specific needs for human, industrial and agricultural consumption. By that, a more water-efficient allocation of resources can be achieved.

Research is needed to enable a sustainable reconciliation between the quantity and quality of available water resources with the demand for water from different sectors. In agriculture, there is a need for more accurate estimation of the temporal variation in crop water requirements to enhance efficiency of rainfed agriculture, better control of irrigation systems and use of alternative water resources. Wherever water is transported, early detection and control of leakages is needed, especially in urban water supply zones and agriculture. In industry, water quantity and quality control should be an integrated part of the process control. New technologies will become available that will result in less pressure on water resources, such as technologies that capitalize on soil moisture, allow a rapid response to rainfall and will contribute to the water holding capacity in agriculture.

Water saving concepts and technologies

Tools for the detection and management of unaccounted for water (detectors, sensors, on-line models) have to be further developed and brought into operation, both in municipal and industrial water distribution networks, sewer systems and in agricultural irrigation systems. Viable solutions should be available before the year 2010 since many necessary elements already exist today. In this context, a direct link has to be made with other technology platforms dealing with sensors, networks, nanoelectronics, manufacturing, materials (such as SUSCHEM, EUMAT, ENIAC, MANUFUTURE, FTC, NEM) that address related research and development.

The development of water saving equipment and technologies, including equipment that does not use any water, will be encouraged. For example, an approach which could be accomplished within a narrow time frame (by the year 2010) is a washing machine which accepts recovered water from the first washing cycle or which treat the effluent for direct re-use. Recirculation shower systems including heat recovery may be one solution which could contribute to a reduction of the overall water demand in municipalities, particularly tourist resorts. Also a completely closure of the water cycle and almost zero water use may be possible in some sectors.

Intelligent irrigation systems and integrated water management methods have to be developed (before the year 2010) to enable water saving in agriculture as well as in urban landscape as well as methods to increase the water retaining capacity of the soil.

A major long term challenge for research (until 2030) is to halt the over-exploitation of groundwater resources and to minimize pollution threats (e.g. by salinisation, diffusive agrichemicals, exfiltration from sewers). Research is necessary to integrate groundwater management concepts and to provide incentives to increase water harvesting and groundwater recharge.

Technologies which enable usage of new and alternative resources of water

Important new resources include brackish water, karstic water and seawater, wastewater, (grey or black) and rainwater (including runoff from hard surfaces and from agricultural fields). Cheaper and smarter technologies are needed to treat these sources to appropriate standards. Advances in membrane technology are expected to have a major role in the development of new methods of water treatment.

Increased knowledge of water quality requirements for all applications and purposes

The increased use of water fit-for-purpose needs information on the quality of the water required so that it can be matched with the needs of adequately treated water from optimal upstream water users and suppliers. In this context, specific research is needed on water quality demands for individual processes by modelling, simulation, predictive and process control tools to achieve sustainable water use in industry, and for cultivation of the various types of crop in agriculture horticulture and urban landscapes. The development of drought and salt resistant crops is an important part of this research. Significant improvements in achieving synergies between different users of water of different qualities will be available by 2010.

Aquifer storage and recovery technologies

Improved techniques based upon better understanding of overexploited aquifers will enable increased use of artificial recharge and the storage of excess winter surface water, treated waste-brackish or salted water. This reduces further overexploitation and increase resilience in times of drought. Available technologies consist of, amongst others: surface spreading (artificial recharge using basins), injection, induced recharge (river bank filtration), and Aquifer Storage & Recovery (ASR).

ASR may also yield economic benefits by reducing the peak factor in water production (and water treatment) and by raising the security of water delivery. In Europe, very few ASR-systems are currently in operation. Research will focus on quantification of natural aquifer storage and recovery including the dynamic processes of input-output relationship throughout the year followed by water resources management that takes these conditions into account.

Decision Support Systems to allocate and use water resources

The complexity of water supply and sanitation provides severe challenges to decision makers in all levels (water utilities, industry, agriculture, municipalities, and environmental authorities). In order to improve the decision making process specific research is needed in the following areas:

- Transparent and sustainable allocation and use of water resources.
- Spatial planning of water infrastructure and of land use in a rapidly changing world (e.g. impact of climate change, changes in population).
- Assessment and quantification of the impact of innovative concepts for water services.
- Development of integrated water management models to simulate the complex interactions in water basins and to forecast the impacts of new solutions.
  Significant outputs from this area of research will be available by no later than 2020.

WHAT WILL THE IMPACT BE?

Balancing water demand and supply will increase the availability of sufficient water of the right quality for people, industry and agriculture without adverse effects on any group of users. People in water stressed areas, like the Mediterranean region and some developing countries will have better access to safe water, reduced vulnerability to extremes and increased adaptive capacity. These achievements will make a significant contribution towards achieving the MDGs. This is even more important as water stressed areas increase due to climate and other global changes. Key objectives will include:

- Stopping the over exploitation of groundwater
- Farmers in water stressed regions adopting water efficient agricultural practices, with increased yields - "more crop per drop"
- Increasing economic competitiveness thanks to a more cost-efficient water use
- Decreasing dependency of the economic growth on the availability of quality water
- Access for all to water with the right quality and quantity
- Optimisation of maintenance, repair and rehabilitation cost for water supply and drainage systems
- Reduction of water leakage through pipes

As a result less water will need to be abstracted from the environment and so soil and groundwater will be protected. Damages due to droughts will be considerably reduced (as an example, the damage of the 2003 drought in Europe is valued at € 13 billion in the EU report 'Climate Change and the European Water Dimensions').

Links to relevant projects:

- Water saving concepts and technologies
  - Pilot 1 "Mitigation of water stress in coastal zones": General topic
  - Pilot 2 "Sustainable water management inside and around large urban areas": Generic Topic
  - Pilot 4 "Sustainable water management for industry": General Topic
- Usage of new and alternative resources of water
  - Pilot 1 " Mitigation of water stress in coastal zones"
  - Pilot 3 "Sustainable water management for agriculture": General Topic
- Decision support systems to allocate and use water resources

3.2 Ensuring Appropriate Quality and Security

WHAT IS THE GOAL?

One goal of the WSSTP is to develop synergies between different water users to enable treated water from one sector to be used by another, delivering cost benefits to both. With these objectives, it is essential that the quality and security of water supply and sewerage services are ensured, and users, particularly, domestic, have confidence in the water they are receiving.

WHAT RESEARCH IS NECCESARY TO ACHIEVE THIS GOAL?

- The management of risks at all levels of the water cycle (for instance using agricultural sites as flood mitigation areas)
- Availability of comprehensive water quality and nutrient monitoring tools, including early warning systems for pollution and pathogen detection
- Availability of emergency water supply systems
- Water management and protection on a river basin scale
- Understanding water quality requirements in all steps of the water cycle (supporting "water-fir-for-use purposes" approaches)
- Understanding water quality requirements in all steps of the water cycle
- Identifying potential synergies between different water users and developing the appropriate treatment and water use technologies for different types and uses of water

The management of risks at all levels of the water cycle

By the year 2010, more advanced methods for integrated risk assessment and risk management have to be developed, taking into account all aspects of the water cycle. This includes risk assessment and risk management tools for aquatic systems, agriculture and all water supply services including industry. The relation between water supply, sanitation and public health will be better understood to enable health based standards in Water Safety Plans.

Availability of comprehensive water quality and nutrient monitoring tools, including early warning systems for pollution and pathogen detections

By the year 2010, a set of monitoring systems are needed which deliver reliable information at a much faster pace than the classical laboratory methods, and which can be applied even for remote control. Systems are needed for timely warning and information on chemicals and pathogens derived from natural sources, accidents or malicious attacks. These systems must include on-line and 'at the site' monitoring and early-warning systems, as well as low cost, portable test kits for rapid and reliable determination of toxins, pathogens (including genomic and proteomic) and key contaminants.

Water Management and protection on River Basin Scale

Early warning systems are necessary to enable better forecasting of extreme weather conditions and the subsequent impacts, using information from satellites and from earth based monitoring stations. Existing flood forecasting systems need to be further developed to model pollution incidents and guide emergency response and remediation. Risk management systems will also be developed to reduce the vulnerability of water quality during droughts. Such integrated forecasting systems are under development, but will need to be fully tested before widespread implementation and use will be possible (by 2015 at the latest).

Remote sensing integrating in-situ monitoring through advanced telecommunication and global positioning systems will have a wide range of new applications in respect to water resources, supply, use and treatment. For example, these techniques are enabling the micromanagement of nutrients and water in agriculture and ecosystems. However, the new generation of low cost networks of smaller satellites to be launched over the next three-five years will enable a huge leap forward in high resolution, real time monitoring by 2010.

Understanding water quality requirements in all steps of the water cycle

Research and development into "intelligent sensors" will be very applicable in industrial water use where fast sensors for in-process monitoring and control of relevant industrial components (e.g. dyes, stickies, and micro-organisms, including pathogens) are important. The increasing use of industrial processes which operate at the molecular scale requires the development of water treatment and robust monitoring technologies to supply process water of an ultra-constant, adequate quality that is based on functional properties. Many of these new sensor techniques will have wider application and will enable water re-use and promote productivity by enabling traceability of water and control of water quality throughout the distribution and collection network.

Availability of emergency water supply systems

Cost-effective and sustainable **multi-barrier treatment schemes** in water supply systems are needed, providing safety against a broad spectrum of chemical and microbiological contaminants. Of particular importance are research and development initiatives focused on small scale, reliable and low cost treatment techniques needed to enable the decentralised production of water fit-for-use, and decentralized treatment of wastewater producing water ready for re-use.

Advanced separation techniques (for instance, micro-sieving, membrane separation, absorption, adsorption and ion-exchange, desalination) and conversion technology (biological treatment, advanced oxidation methods) have excellent potential to deliver the complex boundary conditions in different applications. The range of barrier techniques available to the water sector will be enlarged in the coming years as a result of advances in natural and engineering sciences. Very often, incentives are born outside of the water sector and we will liaise with other Technology Platforms, such as the European Sustainable Chemistry Technology Platform to monitor the development of these technologies (Biorefinery, Factory and Home of the future).

WHAT WILL THE IMPACT BE?

- All users are confident they will receive supplies of water that are of reliable quantity and quality
- There is a reduction in outbreaks of waterborne diseases (e.g. *Legionella, Cryptosporidium*)
- Accidental and deliberate contamination of water supplies will be detected promptly and trigger an adequate response (i.e. before water is used)
- Uninterrupted supply of water, especially in regions with limited water resources, and cost effective treatment of wastewater will boost local economic activities
- Emergency water supplies available within 24 hours following natural disasters
- The unit cost of water produced from new resources falls to existing levels
- More effective systems are implemented to ensure the continuation of adequate water services during extreme climatic events

The costs of down time and product fall-out in Europe, as a result of problems with water quality, are estimated at € 10 - 20 billion per year. This cost can be reduced if adequate monitoring and control systems for water quality are in place. Process water will have a quality fit-for-use. Industrial product quality will improve and less product fall-out, recalls and down-time of processes will occur. Injury and loss of life, due to extreme events, will be constrained.

Links to relevant pilots:

- Management of risks at all levels of the water cycle
  - Pilot 4 "Sustainable water management for industry"
- Availability of comprehensive water quality and nutrient tools
  - Pilot 3 "Sustainable water management for agriculture: Generic Topic
- Availability of emergency water supply systems
  - Pilot 2 "Sustainable water management inside and around large urban areas": Generic Topic
  - Pilot 6 "Proactive and corrective management of extreme hydro-climatic events"

3.3 Reducing Negative Environmental Impacts

WHAT IS THE GOAL?

A reduction in the negative environmental impacts that water users can have upon the water cycle. At different steps in the cycle, water will be considered as a valuable finite natural resource while wastewater is considered as a source of beneficial compounds. The goal is to ensure that the water demands of natural systems are environmentally balanced with people's commercial and domestic needs. Transformation of this approach to developing countries is considered a major step forward to overcome poverty, hunger and thirst, and thus to give a strong incentive to economic growth.

WHAT RESEARCH IS NECESSARY TO ACHIEVE THIS GOAL?

- Better methods and tools to set environmentally sustainable river flows
- Reduce water-based emissions
- Better technologies for monitoring, controlling and removing diffuse and point source pollution
- Develop usable products from sludge recovered during waste water treatment
- Reduce material and energy consumption and produce less waste
- Reduce soil erosion

Better methods and tools to set environmentally sustainable river flows

In the context of European legislation, a scientific basis is required to permit abstraction rates from surface and ground water sources to be consistent with the restoration of good ecological status, and in developing countries contribute to maintenance and sustainable livelihoods for those dependent upon, or affecting, freshwater ecosystems. Hydro-ecological modelling methods and tools will need to take account of predicted climate driven changes in flow regimes. Existing understanding needs to be extended to include more reliable modelling of the impacts of discharges to rivers including the impact of water quality changes upon ecosystems and environmental flows, including the impacts of short pulses of pollutants, temperature and seasons, including the ephemeral Mediterranean rivers.

Reduce water-based emissions

Water utilities, agriculture, water-using industry and communities need technologies and systems which allow them to meet the tightening regulations for the discharge of nutrients, harmful chemicals and thermal emissions to the water environment. Discharges of wastewater to the sewer system must have technologies available to them which will minimize discharges at source, or detect and intercept pollutants before they affect domestic or industrial wastewater treatment plant operations and the quality of sewage sludge. Combined water and energy management tools and technologies must be developed, especially for thermal power stations, to minimize thermal emissions to the aquatic environment.

Better technologies for monitoring and controlling of diffuse and point source pollution

A better understanding is needed of the mechanisms by which pollutants are generated, converted, transported and how they can be removed, both in the natural environment and within industrial and municipal water systems. By 2010 new technologies are needed to monitor these pollutants. In addition, new methods are needed to remove them, preferably at their source. Where this is not possible low cost and low input treatment will be applied to protect the environment. By 2020 chemicals released to the natural environment will be biodegradable products that do not harm the environment (Technology Platform on Sustainable Chemistry). Tools need to be developed to allow immediate response if accidental pollution from trade or households enters the sewer system.

These on-line measurement devices will be integrated to the new Information and Communication Technologies tools including next

generation Earth Observation satellites, opening the way to real time spatial representation of water quality and correlation with other spatial data (human and animal health, industrial and agricultural activities, biodiversity, etc) and better understanding of the links between land and marine water quality.

Develop usable products from sludge recovered during wastewater treatment

Wastewater from much industrial process, from sewage treatment and irrigation outflow is a valuable source of energy, organic matter, nutrients and minerals. During the treatment process many valuable compounds are concentrated in the sludge. Also at the production of process water and drinking water concentrated pollutants like brines are produced. These compounds need to be recovered for use in safe, high-quality products. Research is needed to address any unnecessary administrative and legal barriers to the use of these by-products of wastewater treatment and disposal. Techniques for selective removal or conversion of detrimental substances (salts, micro-pollutants, pathogens, heavy metals, colloidal materials, dyes, etc.) are needed. Advanced knowledge on socio-cultural and socio-economic concerns are necessary to make sure that cost-effective solutions find full acceptance by the public. Such studies will start very quickly but need to be continued until 2020, and beyond.

Reduce material and energy consumption and produce less waste

Large amounts of construction material are used to produce and install pipe works for domestic, industrial and agricultural water. Similarly, large amounts of energy are used for water and wastewater transportation and treatment. New technologies and equipment need to be developed which use less energy to pump and treat water and wastewater, with fewer added chemicals and which make better use of waste products such as water treatment sludge, the energy content of water and bio-gas. There is a need to reduce the energy used per kg of pollutant removed as well as maximise recovery of industrial water and raw materials. Conventional domestic water and wastewater systems serve large areas and thus require long transport conduits. Small scale local treatment and re-use systems need to be developed that can reduce the reliance on long pipelines and other large infrastructure.

Soil erosion reduction

Appropriate research will be conducted on the consequences of soil erosion and mechanism, to restore soil fertility, particularly using organic material from treatment processes and other sectors. Analysis of long term impact of organic waste application and adapted soil management techniques are needed, including on CO_2 balance.

WHAT WILL THE IMPACT BE?

In Europe, soil degradation due to erosion and compaction is probably the most important environmental problem caused by conventional agriculture, seriously affecting nearly 157 million hectares or 16% of Europe (www.ecaf.org). Research is needed into improved sewage treatment technologies and into the potential use of sludge to remedy the degradation of agricultural land. Better monitoring and control of discharges to sewage works will help improve the quality of sewage sludge, making it even more acceptable for recycling to agricultural land.

Links to relevant pilots:

- Reduction of water based emissions
  - Pilot 2 "Sustainable water management inside and around large urban areas": Generic topic
  - Pilot 3 "Sustainable water management for agriculture": Generic topic

3.4 Novel Approaches to the Design, Constructioin and Operation of Water Infrastructure Assets

WHAT IS THE GOAL?

Extensive water distribution, flood protection, irrigation, drainage and sanitation infrastructure has been built over the past two centuries, both above and below ground. Many assets are more than 100 years old, severely degraded, requiring rehabilitation or replacement. The cost of updating aging water infrastructure is a major issue throughout the world, resulting in leakages from both the water supply and waste water systems, and inflow of groundwater to sewers or to supply systems when pressure is low and reduction in service to water customers. A major goal is to develop technologies to allow the monitoring of the water infrastructure, and to design and implement solutions to optimise the costs and rate of infrastructure improvements.

The increasing re-use of treated wastewater and recovery of by-products from a wide range of properties, sources and applications (domestic, industrial and agricultural) poses major challenges in terms of technology development and public acceptance. In the case of agriculture for instance, the use of new types of intelligent variable permeability pipes would allow users to greatly improve the efficiency of irrigation.

An important goal is to manage the raw water, wastewater, floodwater, irrigation, drainage and sewerage infrastructure to optimise reliability and operational costs for longer periods, increase adaptive capacity, enabling water re-use while maintaining integrity, and with minimum disruption during rehabilitation. The result would be higher efficiency and reliability of the water related services.

WHAT RESEARCH IS NECESSARY TO ACHIEVE THIS GOAL?

- New innovative and integrated concepts for water distribution and re-use
- Smart asset management strategies
- Technologies and analytical methods to assess the condition and remaining life of assets
- Better understanding of deteriorating and disturbing processes
- Advanced methods to maintain, replace and renew existing assets

New innovative and integrated concepts for water distribution and re-use

Innovative and integrated concepts to enable smarter operation and maintenance of the assets with proper risk management especially for underground infrastructure with long life times (pipe and sewer networks). Existing infrastructure must become more adaptable to future demands. In addition to the need to optimise the timing and location of maintenance and rehabilitation, greater adaptive capacity must be built-in this upgraded infrastructure. This requires knowledge

on all possible effects of failures for consumers, industry, traffic and agriculture, and designs based on credible scenarios for the future. We need smarter inspection, maintenance and replacement technologies and better construction materials to ensure the integrity of systems. Links will be made to the European Construction Technology Platform to ensure the transfer of new construction techniques into the water sector, including the potential to use the water infrastructure for multi-sector services such as heat transport, communiation etc. New dual use systems which facilitate water re-use and recovery of waste products, new in-line treatment processes which reduce space and cost, decentralised or semi-decentralised systems which reduce the need for extensive transport networks and easily accessible underground pipe channels.

Smart asset management strategies

To improve the adaptive capacity of infrastructure to meet the changing demands, causing less interruption of services and disturbances to the public. There is a need to develop sensors, communication methods and data analysis techniques which in combination they will reduce leakage and groundwater intrusion and reduce the life-cost of systems, by enabling real time monitoring of system performance.

Technologies and analytical models will enable to assess the condition and remaining life of assets

They will ensure the prevention of damage due to failures in water services and to prolong the usability of water infrastructure, by enabling asset owners to predict disruptions to service and so take preventative actions.

Better understanding of deteriorating and disturbing processes

Methods will be developed to reduce and remediate processes such as scaling, bio-fouling and corrosion and also to improve our understanding of the impact of traffic and weather patterns on asset performance.

Advanced methods to maintain, replace and renew existing assets

Develop methods to find and reduce leakage from and ingress to pipelines. Non-disruptive methods of installing and replacing assets. Intelligent pipes (with pollutant sensors), with self alarming sensors to indicate close-to-failure status and self-”healing” pipe materials.

WHAT WILL THE IMPACT BE?

With a renewal rate of 1% per year (corresponding to a life expectancy of 100 years) at € 500 per meter, rehabilitation costs for water supply infrastructure in the Netherlands amounts to € 550 million per year. **This SRA will produce smart solutions for asset management, which will reduce the maintenance costs by at least 10%.** This means a cost saving for the Netherlands of € 55 million per year. Significant reduction of economic damages due to disruptive effect on third parties (traffic, shops, businesses etc) will also be achieved. The introduction of the Urban Waste Water Directive in new Member States is estimated to cost at least €25 billion. New methods and tools developed within the WSSTP to treat wastewater will reduce these costs by 20%.

Links to relevant pilots:

- Technologies and analytic models to assess the condition and remaining life of assets
  - Pilot 2 “Sustainable water management inside and around large urban areas”: Generic Topic

3.5 Establishment of an Enabling Framework

WHAT IS THE GOAL?

The goal is to establish an enabling framework for the smooth and efficient implementation of systemic integrated and site-specific integrated water solutions to the major water issues, in Europe, with potential applications worldwide.

The two targets are:

- to ensure the proper consideration, understanding and inclusion of social, economic, climatic, environmental, political, legal and regulatory concerns in the decision process used for selecting global and site-specific water solutions.
- to identify, understand and break the four major barriers for cross cutting issues impeding the deployment of integrated water solutions at the local, regional, national or translational level, namely: compliance with regulations and directives, public and political acceptance, financing of infrastructure and water value pricing.

KNOWLEDGE NEEDED TO ACHIEVE THIS GOAL

- **Knowledge on local conditions related to water systems:**
  - Trends in demographic evolution and its potential impact on the economical growth, quality of life and relationship between the various communities of users
  - Trends in rapid technology development and its potential impact of water systems, such as ICT and its effect on behaviour of communities (public, authorities, NGOs, economic and water systems stakeholders)
  - Trends in economic globalisation and its impact on water systems issues
  - Trends in climatic changes and their potential impact on the availability of quality water for all communities and the adverse effects of extreme events (storms, floods and droughts)
  - Specific environmental concerns and constraints, including legislation
  - Major driving forces governing political decisions and legal compliance
  - Overall expectations of every community of users in terms of availability and quality of water, environmental impact, affordability and economics provision
- **Inclusion of above knowledge into the data base management system** of IWRM/DSS for constraining and optimising the aid to the decision process
- **Scientific methods for analysing the knowledge metadata** and their interrelationship to optimise the decision process
- **Strategies to break the four cross cutting issues barriers** impeding the implementation of integrated water resource management solutions
- **Knowledge on factors influencing public and political acceptance**
- **Methods for education and knowledge transfer**

Box 3.5: Research needs to establish an enabling framework

- Knowledge on new methods of IWRM/DSS and data management
- Knowledge on risk management
- Standardisation of methodology, technology and process
- Knowledge on barriers for integrated water solutions implementation
- New knowledge transfer and Education methods

WHAT ARE THE RESEARCH NEEDS?

Knowledge on new methods of IWRM and data management

- **New methods of IWRM/DSS:**
  The methods and tools being developed for integrated water resource management are increasingly improved. More experiences on their feasibility in practice are available. A generic quality assurance assessment is needed in order to highlight the benefits of advanced IWRM/DSS approaches, such as hydro-economic models
- **Data collection and validation:**
  This is a major task given the non tangible character of the information, the need to go beyond the intra and interdisciplinary nature of the information towards the trans-disciplinary aspects,the vast diversity of information and the complex nature of social situations with the dependence on gender, language, culture, economy and geopolitics. Research should be undertaken to efficiently access the relevant data, make sure of their comprehensive coverage and guarantee their quality.
- **Data mining and analysis:**
  A methodology must be developed to map and format the collected relevant knowledge to make use of it as a set of tangible constraints in the modelling and simulating tools used in the water solution scenario builder system included in the IWRM/DSS system.
- **Data interpretation**
  Research should be conducted to develop the interpretation tools, the algorithms to be used in the scenario builders. This applies to the use of trends for the reference data, economics prediction, impact predictions, and compliance with constraints of social, environmental, political or legal nature. Given the urgency of this challenge, this research should provide the key results by 2010 in order to be used in the full scale implementation cases of the various pilot programs. All the processed information must support individual or collective decision processes, by representing present or future realities in ways that can be understood by all stakeholders: they must be able to participate, to make use of the information and to commit themselves to the resulting actions.

Knowledge on risk management:

Assessment of risk and risk mitigation strategies should be developed for each integrated water solution implementation case in order to ensure the optimisation of the solution selection process, the public and political acceptance and the compliance with legal constraints. Research should be conducted to develop a template methodology to assess the transdisciplinary risk. This methodology should be integrated in the DSS system. As the perception of risks and its impacts are extremely dependant of the local context, the methodology should be open enough to take into account the specific local social, environmental, economical and political aspects. In the IWRM /DSS output, the risk level will be used as a ranking qualifier constraint in the selection process. This functionality should be available by 2010.

Standardisation of methodology, technology and process:

This is a key requirement to federate the European water industry and make it more competitive worldwide. It is in addition an enabler to rationalize and facilitate the decision process It is of great importance to streamline the education and training process, key to break the public and political acceptance barrier. Research should be conducted in ways to ensure setting sound European standards for the new technologies and their operational process.

This will be a long and strenuous process but should be available by 2020 at the European level.

Note: on this topic there is a need to have a revision of standardisation procedures, as soon as the common interest is concerned, to ease participation in the process of all stakeholders and consideration of all stakes.

Knowledge on barriers for integrated water solutions implementation:

The implementation of integrated water solutions for major water challenges is facing four main barriers:

- Compliance with regulations and directives
- Public and political acceptance
- Financing for infrastructure
- Water value pricing

Those four barriers have to be overcome to ensure the smooth, efficient and well accepted deployment of the proposed systemic solutions relevant to the four major challenges as presented in Chapter 1.

PROCESS PROPOSED TO OVERCOME THOSE BARRIERS:

- **Compliance with regulation and directives:**
  Relevant regulations and directives data will have to be gathered and input to the IWRM/DSS data base management system for each specific case as a set of constraints for the solution simulation scheme (constrained scenario builder).
  The compliance of the solution alternatives will be assessed and, in case of noncompliance, special actions undertaken to demonstrate to authorities the added value (social, environmental and economical) for potential rework of the implementation and regulation scheme.
  As an example, let us illustrate the case of using a dual water distribution network for cities or villages with agricultural activities.
  The regulation is preventing the use of such a concept in a lot of locations. It will be necessary to demonstrate the added value in terms of quality water availability, fresh water saving and mitigation of aquifers overdrafting while still securing health protection. Revisiting the regulation will then be initiated to permit the use of dual networks.
  In the case of the use of new technologies, the requirements of changing the implementation process and input of new standards and best practices, respectively with their benefits and impacts will be provided to authorities to set new regulations and directives.

- **Public and political acceptance:**
  Integrated water solutions proposed for mitigating water challenges will use a systemic approach combining existing technologies not widely deployed and new technologies. This portfolio of technologies might not receive an a priori acceptance from the public and political communities.
  As an example, let us illustrate the case of the treated waste water re-use for irrigation purposes. For the technologies and processes used for the given systemic solution, the complete set of training material (technologies, processes, economics, and impacts) will be designed and made available to the various communities of users, regulators, agencies, operators and general public users.
  A dissemination campaign for the results of the systemic solution implementation will be conducted (interactive website, leaflets, local and regional conferences, training the trainer's campaigns). Special attention should be paid to the education especially for Small and Medium sized Enterprises (SME) and less developed countries.

- **Financing systemic water solutions infrastructure:**
  For European applications where water pricing is accepted, the financial engineering will be using grants and debts financing mechanisms as per the guideline prepared by the European technology platform (ETP) workgroup on financing ETP projects, namely:
  - Grants and subsidies for high technical risk generic research projects and key technology enablers: member states national research programs, transnational research programs (EUREKA projects and clusters), European Commission Framework Programs (FP7 and beyond), venture capital funds (EIF) and industry own research programs.
  - Debt financing for pilot implementation cases (low technical risk but high financial risk) by direct project co-financing, use of regional structural funds and use of loans from local banks, EIB and other development banks for third world countries. A special attention should be paid to the possibility to help financial small R&D activities of SMEs (e.g. amounts below 200 k€) with limited numbers of partners, as this may be difficult at present. Small communities also may meet difficulties to cover financially investment peaks corresponding to long life assets which are important within their global legacy. Long term financial tools and/or mutualisation and solidarity procedures are to be implemented to allow those investments.

- **Water value pricing:**
  Sociological, technical and economic barriers have to be overcome among which:
  - Acceptance of water pricing, or of water price increase, which may meet cultural and institutional barriers
  - Social necessity to secure a minimum social access to water
  - Insufficient knowledge of part of the present or future costs (externalities, resource costs, mid term investments), and of demand in relation to price
  - Need to implement metering or to consider meaningful and representative pricing parameters; need to implement pricing systems which are affordable and efficient, and which comply with income timing of water users

Resilient cost coverage and efficient water demand management can be obtained through adequate water consumption pricing. Costs to be considered are – in totality or in part - those corresponding to the provision of a water service (supply, collection and treatment, with both operation and investment costs), and those representing externalities and resource costs (the economic value of natural water resources). They include a high percentage of fixed costs.
Research and innovative experiments are to be co-ordinated on understanding better: the cultural and institutional barriers, willingness to pay and demands on ways to combine economic efficient pricing and social access to water. In addition research is needed on demands for smart and stable tariff structures being able to combine cost coverage (fixed and variable costs) and demand management, which includes ad-hoc pricing systems (in technical, organisational and financial terms). Further economic incentive systems, such as water trading, are to be explored as well provided it is consistent with constitutional principles and provisions.

WHAT WILL THE IMPACT BE?

Embedding technical solutions into a political, economic and social framework will allow appropriate water supply and sanitation technology to contribute to sustainable development and to reaching the Millennium Development Goals.

The users of water supply and sanitation technology and the consumers of water services will be able to deal with water issues effectively, wisely and consciously to the benefit of the ecological balance, the economy as a whole, and to social harmony in a rapidly changing world.

Europe's ability to propose tailored solutions of water problems and to get them established - within Europe and outside - will be tremendously enhanced.

Europe will become uniquely positioned in water supply and sanitation in the world, due to its technological competence its well established understanding of needs and concerns of stakeholders on the local regional and river basin level, and due to its efficient water management and governance of water-related problems.

Links to relevant projects:

- Knowledge on new methods of IWRM/DSS and data management
  - Pilot 1 "Mitigation of water stress in coastal zones"
  - Pilot 3 "Sustainable water management for agriculture": Generic Topic
  - Pilot 4 "Sustainable water management for industry": Focus at SME

4 Integration - Pilots

4.1 The Concept of a Pilot

The Strategic Research Agenda of the Water Supply and Sanitation Technology Platform will be implemented through so-called Pilot Themes or Pilot Programmes. The 'Pilot Theme' concept is illustrated in Figure 4-1 and the key elements are defined and explained below.

A pilot programme is defined as an organizational structure that embraces the whole conceptualisation, feasibility, (including generic research and enabling technology development), prototype development, piloting, demonstration and deployment of cases; a structure set up to carry out precisely targeted and prioritized research that is defined by and tested in a number of real-life applications. The ultimate objective of a pilot programme is to develop new and innovative contributions to solving a major European water problem through the formation of multi-facetted, multi-sectoral and highly competitive consortia.

Six pilots have been defined, each with a different issue in focus. The six pilots will not provide the solution to all European water problems but together they should cover a large portion of the spectrum of water problems. Each pilot has a number of real-life implementation cases in various parts of Europe (some with a twinning outside Europe), where system solutions within the framework of IWRM are demonstrated and tested.

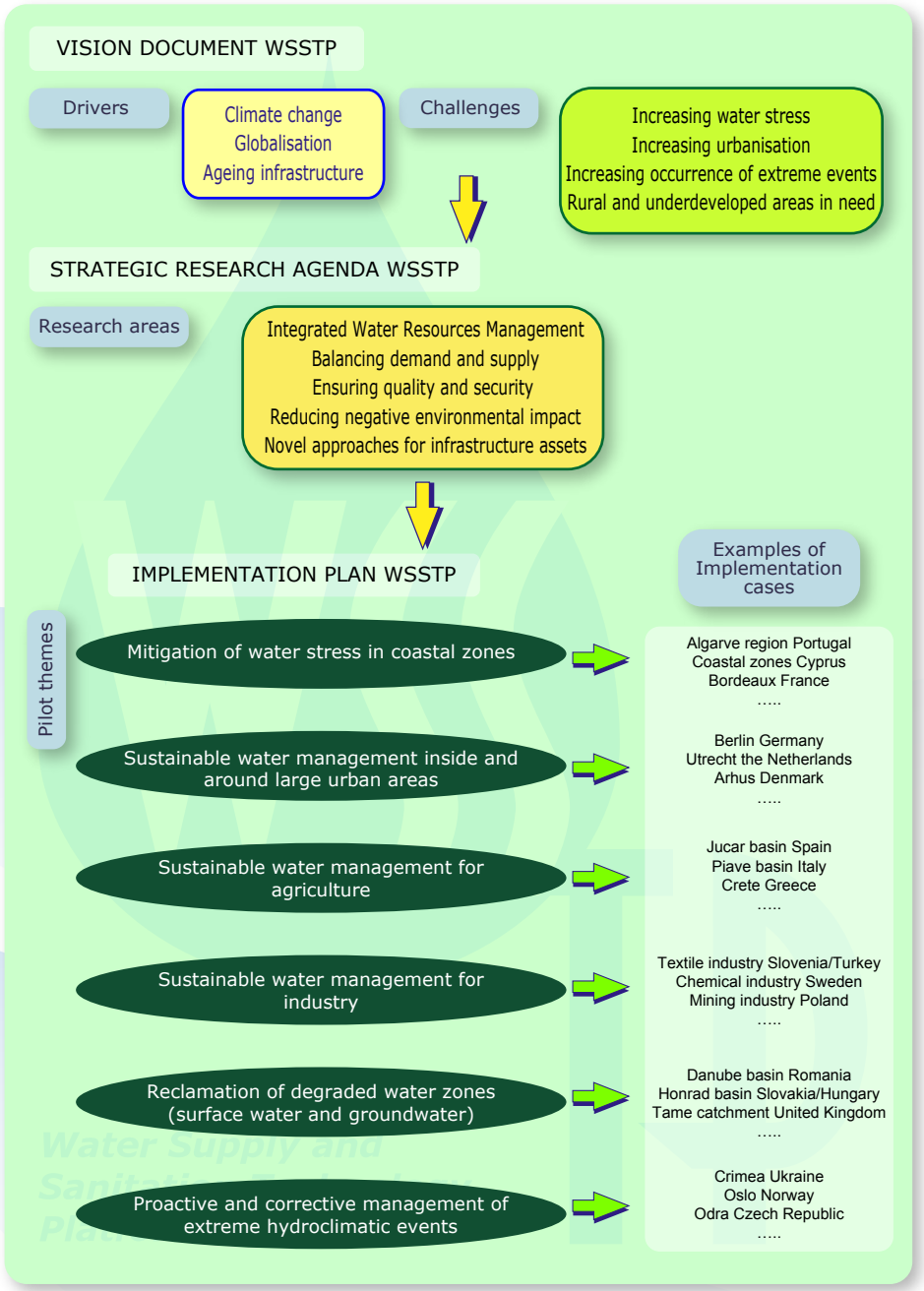
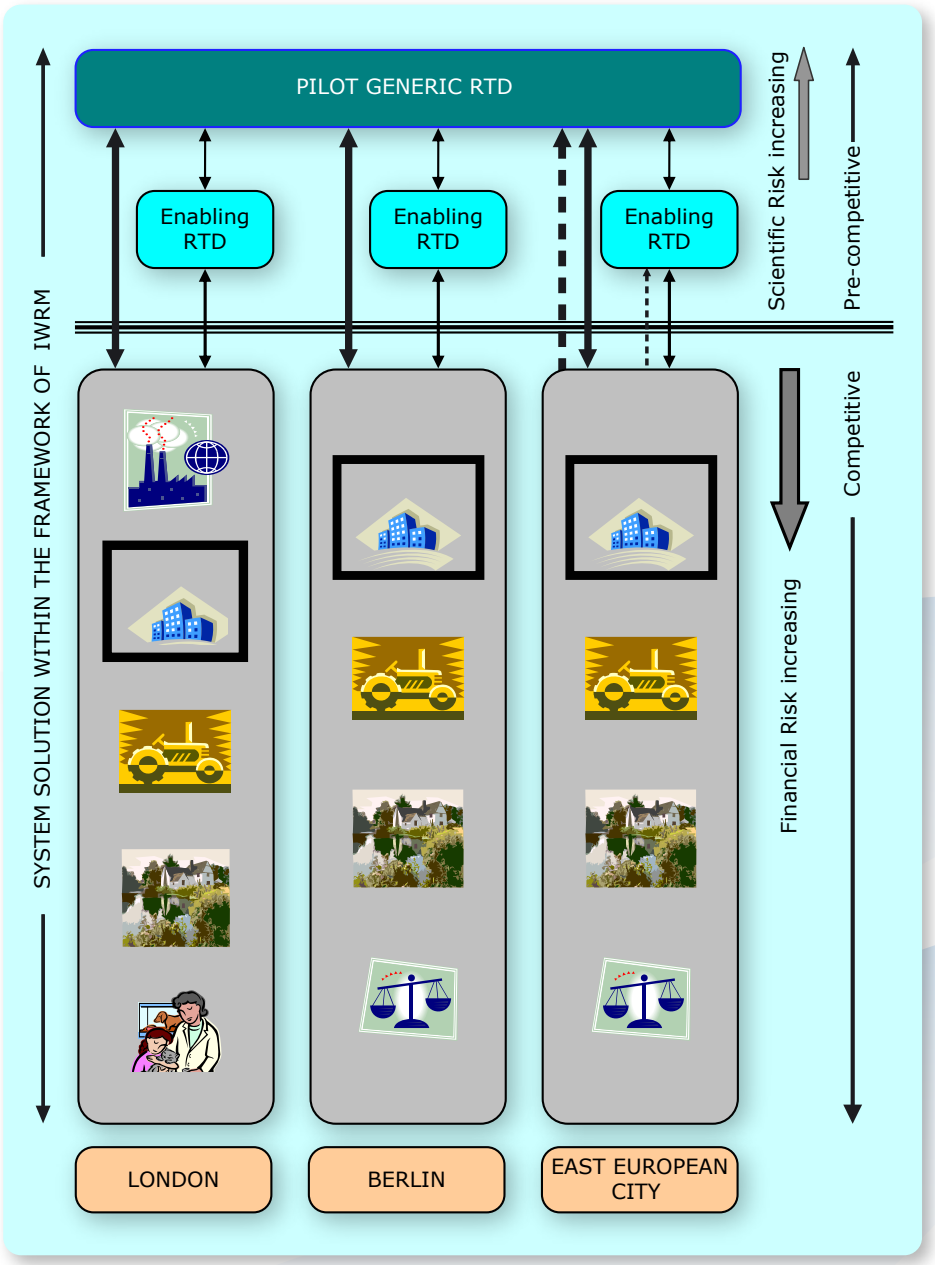


figure 4-1 Pilot Framework



Pre-competitive and competitive phase

Within a pilot programme a pre-competitive and a competitive phase can be distinguished. The RTD in the pre-competitive phase will be carried out by a variety of organisations under various RTD programs but organized as part of a whole integrated programme. This task will be further detailed in the WSSTP Strategic Deployment Document (SDD).

The implementation cases will be executed by consortia of commercial partners; this is the competitive phase. It is expected that this work will be done under normal commercial terms.

Linkage

The pre-competitive and the competitive phase are linked and must be seen as part of a whole. The research in the pre-competitive phase must be defined and prioritized by the requirements of the implementation cases. The stakeholders in the implementation cases will also become involved in the research phase to ensure smooth transition from research to implementation.

Time Line

Although Figure 4-1 shows the pre-competitive and competitive phases as separated, in reality there will be a continuous process.

Risk

The pilot framework will also provide a structure to tackle scientific risk and financial risk. In the pre-competitive phase the scientific risk is high but the financial risk is low. The converse is true in the implementation phase. The distribution of these risks is also reflected in the type of participants in each phase and in the degree of sharing of the financial burden. In the pre-competitive phase the main participants are likely to be scientific organizations, and a combination of public and private entities. The competitive, execution phase is clearly for robust consortia (including SMEs) who can balance such financial risks to eventually reach a meaningful return on investment.

Financial Engineering
The Strategic Deployment Document will discuss the engagement of consortium partners and stakeholders in co-financing whilst maintaining at the same time an open, transparent procedure in the competitive phase.

Pilot generic rtd
The research supporting all implementation cases within a particular pilot has been labelled as pilot generic RTD. It covers multiple issues. It is defined, targeted and prioritized by the needs of the implementation cases as identified by the stakeholders. Possible examples are: multi-parameter/ multi-user monitoring, data handling, data analysis and information presentation systems, scenario builders, risk management systems and decision support systems. The main difference from previous research plans is that these systems are truly integrated and serve multiple users over the whole spectrum of water issues in the particular pilot.

In principle this research is generic for a specific pilot. But will be made available to other pilots as appropriate.

Enabling technology development
There are many important research issues which do not integrate over several water issues, such as a better treatment process. In this case the needs are defined, targeted and prioritized by the implementation cases in a particular pilot. The technologies are building blocks necessary to realize effective water treatment and management, they have an enabling function. They could also serve other pilots.

Implementation cases (demonstration sites)
Each pilot has a number of implementation cases. The implementation cases of a pilot must address all major water issues in a region, such as a river basin. Each pilot will have a particular focus, and all cases within the pilot have this same focus. For example, water problems in and around a big city.

For example, as a way of optimization of water usage, re-use of city effluent for irrigation could be considered. Similarly a pilot on industrial water use, will consider the needs of other water users in the vicinity of the plant such as another industry or agriculture applications and so review options for water reuse.

The principal characteristics of an implementation case are:
1. Systemic integrated solutions for large multiple issues, within the framework of IWRM.
2. Real-life situations, such that technologies and methods to be developed can be based on realistic situations and realistic data.
3. Geographically transferable, the technology and methods developed for the particular case will be - transferable to similar situations elsewhere.
4. Addresses urgent social/economic problems with potential for system optimization, i.e. problems that can benefit from optimization across the whole water system, rather than just optimizing for a single user.

4.2 Integrated Water Resource Management (IWRM) – the Framework for Pilots

What is the goal?
Integration is a strategic goal of WSSTP which will be implemented, through the pilot themes. These will use Integrated Water Resources Management (IWRM) as the guiding framework to manage water as a resource to meet society's needs while protecting the environment. These processes must take account of future global changes such as climate change, demographics, migration and domestic and industrial activities.

What do we need to achieve this goal?
- Monitoring systems based on advanced ground-based and remote sensing, telemetry and understanding of physical and social processes

- New models to provide comprehensive, integrated information on technological and economic adaptability of a water system
- Decision Support System (DSS) to guide stakeholders towards optimal system solutions

All of this information must be accessible to planners, managers, and citizens in a format that can be understood by a variety of disciplines and -also by a non-technical audience.

What are the research needs?
Much research on monitoring and modelling has already been done or is presently being done in ongoing programs, but the focus is often on the needs within one particular sector. The focus of the research on IWRM must have a much broader scope and be focused on integration, across water sectors, across disciplines, within a basin and throughout the whole upstream - downstream water cycle.

Monitoring and sensors should serve multiple stakeholders; models should serve multiple disciplines and sectors. The analysis of research needs also revealed that there is still a lot of research needed to get a better understanding of processes, such as the impact on the environment of releases of domestic, industrial and agricultural (by-) products and the response of the natural system to such releases. Furthermore the impact of climate change and of extreme events, on a complex system, needs to be researched further.

Public awareness is crucial for a successful integration of IWRM, and there are important non-technological barriers, e.g. social, political, economic, and cultural, that need to be identified and possibly removed for a successful implementation This will require an enabling framework to be established.

Box 4.1 Research needs in support of IWRM in pilots

- Integrated approach: cross-sectoral aspects, valuation, 'reverse design', indicators
- Information for integration: monitoring, sensors, data analysis, coupling of models, uncertainty analysis
- Process understanding: impact of all aspects of climate change extremes, land use change, fate of (by-) products
- System knowledge and modeling: coupling an integration of models, uncertainty in models and decision support systems
- Model application in IWRM: integrated system management and environmental management, decision support systems, rapid assessment, risk management, methods for presentation to the general public
- Adaptive systems: planning in a changing world
- Dissemination and uptake

4.3 Pilot themes of the WSSTP SRA

Six pilot theme programmes have been identified to address the four major challenges for sustainable water management for Europe.

Pilot 1:	Mitigation of water stress in coastal zones
Pilot 2:	Sustainable water management inside and around large urban areas
Pilot 3:	Sustainable water management for agriculture
Pilot 4:	Sustainable water management for industry
Pilot 5:	Reclamation of degraded water zones (surface water and groundwater)
Pilot 6:	Proactive and corrective management of extreme hydro-climatic events

All pilot themes are based on IWRM principles and have a significant potential to contribute to the achievement of the global Millennium Development Goals (MDGs).

4.4 Pilot 1: Mitigation of water stress in coastal zones

Coastal zones occupy less than 15 % of the earth's surface but accommodate over 70% of the world's population (at less than 100 km from the shore). The coastal ecosystems are threatened by unsustainable development as a result of rapid demographic growth and agriculture, industry and tourism developments.

A number of issues need to be addressed; serious water stress (quantity and quality) and large seasonal effects due to the wide variety and groundwater variability of users needs, such as tourism and agriculture. Most coastal areas are affected by over-abstraction of groundwater inducing both land subsidence (deltaic zones), salt-water intrusion and in some cases shore erosion. There may be restricted accessibility to water resources due to urbanization, variability of climate water contamination from inadequate – sewage services.

What is necessary to mitigate water stress in coastal zones?

- Prevention of deficit, use of alternate water resources and artificial recharge
- Mitigation of salt-water intrusion
- Monitoring network, prevention and control of pollution and contaminants, forecasting network
- Optimization of borehole infrastructure for ground water abstraction and prevention of saline water intrusion (positioning, design and operation)

PILOT TITLE: Mitigation of water stress in coastal zones		
Generic RTD		
	Research items	**Time for completion**
Knowledge capture	• Demand: communities of users, needs and expectations, seasonal fluctuations (industry, agriculture, domestic, tourism) • Supply: resources assessment (conventional & non conventional), overall trends • Water quality: assessment, trends, sensor network for pollution & contamination control	Prior to implementation
Salt water Intrusion mitigation	• Modelling • Remediation technologies (active barriers, pumping- treatment-reuse of treated waters)	Prior to and during implementation
Global water management scenario builder	• Demand and supply balancing modeller • Pollution and contaminants control modeller • Salt water intrusion mitigation modeller • Economics modeller	Prior to implementation
Sustainable supply of quality water	• Detection, mitigation of pollution at source • Water treatment • In line artificial storage for mitigation of seasonal fluctuations • Monitoring network including alarm systems • Integrated eco-technological solutions for remediation and mitigation of degraded water zones	Prior to and during implementation
WRM/DSS	• Best scenario selection criteria • Best scenario selector algorithms	Prior to implementation

Enabling technologies		
	Research items	**Time for completion**
Knowledge capture	• Data base system • Technologies to support data collection, sampling, surveys • Improvement of spatial and temporal measurement with new sensors/data loggers and multilevel permanent monitoring • Real time data loading from monitoring network and soft data sources, seamless data transfer from sensors to data base and modellers	Prior to implementation
Salt water intrusion mitigation	• Detection of fresh water – salt water interface during seasonal changes • Use of technical measures for sea water intrusion mitigation: horizontal wells and directional wells for active barriers and brackish water withdrawal in estuaries • Electric resistivity/ well-logging/array methods, multi electrode systems in boreholes, detection of vertical flow in boreholes • Surface electric surveys (FDEM,TDEM methods) • Application of remote sensing techniques associated with GIS • Hydrogeochemisty: rock – water – interactions to discover underground flow paths • Environmental isotope technology and artificial tracing: calculation of turnover time of groundwater, determination of the origin of fresh water components from brackish water including its seasonal fluctuations • Non steady state hydraulic modeling of salt water intrusion as well as hydro-geochemical modelling • Configurations for artificial groundwater recharge from coastal and submarine springs in winter time (when they are of fresh water only)	Prior to and during implementation
Environmental friendly way to add water from desalination	◦ RO pilot plant with energy recovery system ◦ Optimisations of operation of a RO plant in coordination with other sources, systems and storages ◦ New and efficient intake and discharge system	Prior to and during implementation

Global water management scenario builders	• Improvement and optimization of resource management, data management and real time predictive modelling • Modelling of pollution and contaminant flow • Modelling of economics for new technical solutions (alternate water resources, salt water intrusion mitigation, in line artificial recharge efficiency and cost) • Techniques to support system analysis, information handling • Techniques to support monitoring, observations and survey activities, interventions, plan execution, operation and maintenance	Prior to implementation
Sustainable supply of quality water	• Sensors and network of sensors (surface and downhole) for detection and monitoring of pollutants and contaminants • GIS and remote sensing (spatial analysis) • Water treatment systems customized to water source and treated water use (specific membranes, bio systems, sludge management with by- products reuse) • Integrated ecotechnological solutions for remediation and mitigation of degraded water zones	Prior to implementation
IWRM/DSS	• Technique to support decision making	Prior to implementation

A number of potential implementation cases have been identified.

- **Rivers Rhine, Meuse and Scheldt delta (transboundary)**

The delta of the river Rhine, Meuse and Scheldt is becoming increasingly brackish due to intrusion of sea water and upcoming of brackish groundwater. Utilities, industries and agriculture have to face these huge changes by developing and implementing advanced approaches for integrated water resource and demand management and innovative low cost, low energy and small footprint technologies for desalination. These technologies and management practices are highly relevant for many river delta zones around the globe facing similar challenges.

- **Coastal zones in Cyprus**

The water sector in Cyprus is over dependent on the low rainfall as little groundwater and surface water is available for all the competing uses. Besides large agricultural water demand and the water needs of the population there is a large and seasonal tourism demand. There is a booming development in Cyprus especially in and near the coastal zones. Expensive desalinated water is bought by the Government and sold at a lower price to the population. There is an urgent need for a water master-plan addressing all water issues in support of IWRM in Cyprus, including better geographical distribution, water reuse technologies, cheaper desalination technologies and public acceptance. A link should be made with ongoing projects as Aquastress, Smart & Optima.

- **Algarve region in Portugal**

Algarve is a typical Mediterranean climate region located in South of Portugal with low annual average rainfall and growing water demand for agriculture and tourism related activities. Sustainable development of the region requires economical efficient water resources management. Decision support systems for integrated surface and groundwater resources, as well as appropriate coastal defence strategies are needed. Issues to be addressed are: better management of water resources, overdependence on low rainfall, salt water intrusion, water regime variability, extreme events (floods and droughts), growing demand from agriculture and tourism, safe production systems with optimal reuse of wastewater and other non-conventional waters, system management to allow permanent availability of water for fire fighting, coastal erosion and exchange of information to stakeholders in a cross-border setting.

- **Transboundary water management along the Southern Adriatic/Dinaric coast (transboundary)**

This project, nowadays discussed in various national platforms of the region is essential for the further sustainable development of the Eastern Adriatic coast. Meanwhile contacts have been established in all countries associated with the project:

  - Croatia with the water supply of the coastal strip in the Southern part of the country (Bosnia-Herzegovina could be incorporated)
  - Montenegro with its tremendous development of tourism along the coast needs additional water, which could be provided by the project
  - Albania with its strong industrial objectives in the North combined with tourism in the South
  - Greece with its serious problems of waste water treatment and waste disposal in the sea

In all countries there exist a reasonable number of stakeholders with a strong and realistic interest in the project.

- **Bordeaux estuary**

Eocene aquifer is the main groundwater resource for Bordeaux and the area. Over exploitation, harbour activity and dredging lead to a huge piezometric depression and growing salinization from marine and fossil water intrusion.Several actions have been taken already to provide alternative water resources in particular for the industry. Research is needed to develop a specific estuarian hydro-geologic model, understand better the changes in quality in a complex multi-layer system and evaluate the feasibility of aquifer recharge.

- **Levante Spanish Coast**

The Levante coast is a high risk zone due to:

  - Shortage of resources (very poor rainfall)
  - Growing demand from tourism (drinking water and sports and entertainment activities)
  - Desalination projects causing environmental impact because of wastes discharges
  - High population density
  - Extreme events (floods and droughts)

- **Maresme Region Cataluña**

The Maresme region is a high risk zone due to:

  - Shortage of resources (poor rainfall, groundwater salt intrusion)
  - Climate events (little annual rainfall but in very few episodes causing flooding)
  - High population (high increase in summer due to tourism), protection of the quality of bathing waters
  - Agriculture activities impacting quality of groundwater

- **Almiros basin (Thessalonique-Greece)**

30% of the land in Greece is facing desertification and the water table dropped by 30-40m since 1980. The Almiros basin in the Thessaloniki region is affected by a mismanagement of water resources, a lack of systematic monitoring of key parameters and groundwater

quantity and quality issues. In the present situation, the 200 km2 area is affected by a strong growth in household consumption, salt water intrusion due to over-pumping of ground water and nitrate contamination from fertilizers. There is on top a strong competition between the water consumption by agriculture (83%) to grow cotton and corn and the vast seasonal water needs for tourism in front of the limited surface water supply. A sustainable development of alternative water resources has to be developed and salt water intrusion mitigated. Waste water reuse is a very high potential resource and waste management a critical issue to be solved . The full spectrum of water resource management solutions has to be used for this particular case and the developed integrated solutions will be transferable to other areas in Greece as well as other regions of the Mediterranean belt. The consortium of committed partners already is identified and this IC could start very quickly with the proper support form the greek authorities.

- **Dammour region in Lebanon:**

Over 50% of the potable water resource for the city of Beirut is supplied from groundwater. The sustainability of this resource is threatened by over-exploitation and consequent intrusion of marine saltwater into productive karstic limestone aquifers. This situation has resulted in a steady decrease in the amount of available fresh water for the city of Beirut and its suburbs. Water resource officials from the Lebanese Ministry of Energy and Water are planning an artificial recharge (AR) program for Beirut (Dammour area) in an effort to control marine saltwater intrusion of the aquifer. It is also likely that domestic and agricultural waste might have contaminated the aquifers. Additionally, there is no system for managing groundwater data and no regular monitoring program. The goal of this IC is to enter in a close relationship with the Lebanese Ministry of Energy and Water to assess the magnitude of the water quality and quantity problems and go into a full cooperation to develop, install and qualify an integrated water management solution able to significantly increase the capacity of quality water supplied to Beirut and potentially apply it to other Lebanese regions in full compliance with the key objectives outlined in the 10 year Water strategic plan.
The emphasis here is the understanding and sustainable operation of the karstic aquifer system including its artificial recharge and the salt water intrusion mitigation. The full spectrum of IWRM/DSS solutions will be explored. The optential for a wide dissemination of the results in similar regions is contempalted , in Lebanon and beyond.

4.5 Pilot 2: Sustainable water management inside and around large urban areas

Urban areas, and especially large or densely inhabited ones, raise specific issues in terms of water management.

Often the concentration of water uses and users, does not correspond to available water resources. This generates pressures on these resources and on the environment: as a result of over abstraction and discharge of treated or non treated point and non point pollution. The key objectives are therefore the reduction of the ecological footprint of urban areas on water resources, as well as a fair and efficient interdependence and co-ordination with surrounding areas.

Management of urban water systems can be complex because of the interaction with the different components of urban systems and with urban land management. Diagnosis, decision support and management tools need to offer solutions from real time to long term, and to integrate multiple stakes and aspects.

As a consequence of the two issues above, concentration and complexity protection (of drinking water sources) and prevention (of flash flooding) actions need highly safe, robust and integrated solutions, not only within the water management sphere, but also with the more general aspects of urban management.

Urban areas are greatly diversified, in their relation to water resources and uses. This diversity depends for instance on:

- climate and topography
- quantity and quality variability of available water resources
- size and population of the area, activities located there; pace of urban growth
- characteristics of the different parts of the urban, peri-urban and rural surrounding areas, and of their interdependencies
- intra-annual variability of population, activities, and water uses
- economic and social conditions
- condition and appropriateness of infrastructure assets including treatment facilities

What is necessary for sustainable water management inside and around large urban areas?

- balancing water demand and supply
- ensuring water quality and security
- protecting the environment and reducing the ecological footprint of big cities
- Designing, managing, and maintaining sustainable infrastructure assets

PILOT TITLE: Sustainable water management inside and around large urban areas		
Generic RTD		
	Research items	**Completion date**
Balancing demand and supply	• Deeper understanding of domestic water use and customer expectations • Analysis of psychological, sanitary and technical barriers for water reuse or use of alternative resources • Understanding epidemiology and designing quality standards specific to water uses • Design health secured dual or multi-sources supply strategies/systems (both technically, legally, and sociologically) • Assess availability and treatability of new resources	Prior to implementation Prior Prior During Prior
Ensuring quality and security	• Integrated risk assessment on urban water systems • Integrated risk management on urban water systems, in conjunction with other technical systems • Optimization of systems monitoring (water quality, hydrology and hydraulics of rain events) • Exploration of multi-barrier treatment systems • System solutions for flood management and reduction (integrated forecasting modelling and control, online storage, individual retention) • Design forecasting and early warning systems suited to quick events in large urban areas	During During During Prior During During
Protecting the environment and reducing the ecological footprint of big cities	• Further exploration of pollutant removal at source options • Exploration of multi-barrier treatment systems • Integrated modelling platforms of sewer and drainage systems including storage and treatment • Design of processes using less non renewable energy and materials, and less polluting chemical inputs • Optimization strategies on both wastewater and sludge treatments, considering global impacts • Reuse (see above) • Design strategies to combine different water systems structures in different parts of an urban and peri-urban area • Understanding and monitoring of pollutant migration and accumulation in soils	During Prior During Prior and during Prior and During Prior and during During

Designing and managing sustainable infrastructure assets	• Multi-purpose information systems on assets • Forecasting and modelling tools on assets condition, failures and impacts • Decision support systems considering operation, maintenance and rehabilitation of assets • Optimization of urban multi-utility works	During During During During
Enabling technologies		
	Research items	**Completion date**
Monitoring, sensor and communication technology	• Economical, reliable and maintenance free energy sources and sensors • On-line monitoring of water quality and of treatment processes, for collective systems • On-line monitoring of water quality and of treatment processes, at individual level (domestic, "small" professionals) • New analytical techniques and sensors, in particular for bacteriology, taste, smell • Sensors and communication systems for monitoring of assets condition and operation (nano-sensors inside the materials and in the close soil) • Systems for rapid assessment of toxicity	Mid and long term Mid-term on collective systems, Long term at individual level Mid and long term Mid term Long term
Advanced treatment technologies	• Drinking water treatment adapting real time to raw water quality • Treatment through wetlands "natural" systems and bio-systems (MBR,SBR) • Small and mid sized treatment plants suited to built environments • Smell treatment • Optimization of sludge treatment , waste management (dewatering, separation & valuation of by products) with minimum and well controlled disposal • Real time monitoring and control of treatment plants • Multi-barrier treatment systems • Selective removal processes • Conceptual improvements of existing treatment technologies, new technologies • Inline wastewater treating pipes	Long term Mid term Mid term Mid term Mid term Mid term Mid term Mid and Long term Long term Long term

Technologies for producing energy and products from wastewater; technologies for reuse of waters; both at collective and individual scales	• Advanced oxidation processes to handle small quantities of pollutants in a robust way • Optimization of sludge production, pre-treatment and use • New approaches based on biomimetics • Treatment of roof and road runoff	Mid term Short and mid term Long term Mid term
Tools to cost-effective and sustainable management of assets	• Monitoring of assets operation and condition (see above), including location of existing assets • Durable and low impact rehabilitation technologies for pipes and networks; forecasting of further evolution of pipes condition • Self-healing materials for pipes	Mid and long term Mid term Long term
Water saving and water sharing processes, appliances, practices	• Enhanced leakage control tools • Waterless (or limited water consuming) washing technologies • Smart and equitable distribution systems to cope with shortage situations • Education on water saving behaviours • Individual economical and reliable metering systems, linked to tariff structures and billing procedures allowing both demand management and social access to water	Mid term Long term Long term Short term Mid term
Risk assessment and risk management tools	• Multi-hazard and multi-risk modelling tools (natural events, technological hazards, assets failures) • Mid and long term scenarii on climate, water resources, water uses • Real-time forecasting and management of drainage systems and retention facilities	Short term Ongoing short term Short term
Integrated design of water systems combining networks and decentralized processes	• Assessment of performance of decentralized and of mixed systems • Mid term management systems of evolving systems, from “all pipes” to semi-decentralized systems	Mid term Mid term

A number of potential implementation cases have been identified.

- **Sustainable water management for London and SE of London, United Kingdom**

The need for options to redress the supply/demand imbalance in a large urban area - a large scale trial of different options for the delivery and management of water supply services to new housing areas (such as Thames Gateway). This includes better leakage detection and repair technologies and more efficient ways to rehabilitate ageing buried infrastructure.

- **Utrecht, Netherlands**

The city of Utrecht is a fast growing centre in the Netherlands. Integration with large suburbs places the current waste water treatment plant in the very centre of the city. This large WWTP (15.00 m3/h) needs a complete upgrade to meet future FD demand. The city of Utrecht looks to the current site (35 ha) as a promising location to fulfil its other obligations for housing and commercial activities. Engineering and planning studies are fulfilled to see if this is a viable option. New technologies to treat the water to future demands will be tested in the coming year. The large water flow could be used for several applications: industry, public area, the city surface water or even used in the houses. Decoupling of rainwater will be of importance to lower the flow and increase the organic contents. Integration of the new plant in a house or commercial buildings has to meet strict regulations for health, environmental and welfare. The lowering of the current site to a small integrated site gives large economic drivers to make this plan feasible. The planning is at least 10 years. In this time many new technologies / concepts can be tested.

- **Lyon, France**

To develop and test full-scale innovating methods, techniques and solutions for the management of urban drainage systems in order to improve the sustainability of these systems : BMPs, Real Time Control, etc. The implementation case is supported by the Urban Community of Lyon, Suez Environnement, Veolia eau, and relies on an existing federation of 15 research laboratories (OTHU project).

- **Lisbon, Portugal**

Greater Lisbon region is located in South of Europe and is a sprawling area of about 3 million people. One of the most relevant challenges is a more effective coordination among institutions in the scope of urban water management, based on a better understanding of the current institutional and organisational context. Another one is capacity to adapt to new challenges (such as water scarcity, extreme meteorological events, …) without degradation of service. Issues to be addressed are, growing demand from urbanization and tourism, water leakage, asset management, water quality issues and water quality control in coastal areas, extreme events, risk management (seismic and terrorism), flood management in urban areas, innovative approaches based on ICT.

- **Demo City Århus, Denmark**

Integrated operation and management of water related infrastructures. The Municipality of Aarhus and Aarhus Water are working towards integrated operation and management of the water related infrastructures in the urban and peri-urban areas. The ongoing and planned work within this topic includes:

  - Dynamic operation of well fields and water works according to demand
  - Real time monitoring, modelling and control of distribution networks
  - Real time rainfall measurements and forecasts by radar
  - Real time forecasts of sewer overflows and flooding
  - Real time monitoring and process control of wastewater treatment plants

- Integrated real time control of sewer systems and waste water treatment plants
- Early warning system and forecast for bathing water quality
- Restoration of wetlands and construction of green areas including lakes/canals/harbour as an integrated part of the water infrastructure
- Public information system on water – status and forecasts

  and is done/planned to be done through projects carried out in cooperation with universities, research institutes, consultants and suppliers – depending on the type of project

- **Berlin, Germany**

Due to the limited water load from upstream, Berlin relies mostly on its own recycled water (up to 70% on summer) offering the concept of a local IRWM where all issues of large urban areas must be addressed. The Berlin Centre of Competence for Water (KompetenzZentrum Wasser Berlin, KWB) has already gathered local partners, from universities to public and private actors to finance and carry out research mainly dedicated for application to the Berlin case but also to cooperate with other partners internationally. This consortium provides the opportunity for immediate cooperation between Berlin and others ICs.

- **Oslo, Norway**

For many years, the water utility of Oslo has had an extensive focus on new technologies for materials and measurements systems and on modern management systems for the entire urban water cycle. They have actively supported and hosted development and improvements of technologies for the water and wastewater systems. The case comprises three main issues, namely network management, organic waste recirculation and water treatment:

- Urban water network management comprises issues on computer systems for data collection and management, new technologies for in-pipe condition assessment and determination of residual lifetime as well as testing and verification of renovation methods. Amongst others an ambitious plan exists to rebuild part of the main sewer system in virgin soil beneath other urban structures by micro-tunnelling.
- Oslo considers recirculation of organic waste back to land to be a sustainable way for handling this material, providing necessary measures are taken to protect human and animal health and the environment. This implies treatment of all organic wastes prior to land application, including the production of biogas and biofuels. Norway has a long tradition for recirculation of organic wastes like sludge (biosolids) and source separated organic household waste. This is also supported by a legal framework.
- The receiving water (Oslo fjord) is important for recreation and vulnerable for wastewater pollution. Removal of toxic compounds and pathogens are prioritized issues, including the upgrading of existing treatment plants to meet increased demands on capacity and efficiency.
- Impact on climate change; Two different impacts are determined, namely the increase of NOM (natural organic matter) in drinking water, and the increase of flood frequency. They are further described under the topic of extreme hydroclimatic events, to be included in the Oslo case.

- **Prague, Czech Republic**

Biofuel : Increasing energy prices (ever growing demand), decline of conventional energy production (peak oil), GHG emissions reduction (Kyoto Protocol and European post 2012 goals) are creating conditions for a shift in paradigm in biomass management. The recently approved Biomass Action Plan points clearly on that direction. One of the issues addressed in the Plan is the need for increased energy recovery of waste biomass. In that context, it is necessary to develop systems that will fit into existing infrastructure to help overcome the new

challenge. This topic is a priority for Prague, dealing with fate of sludge from 1,400,000 I.E. urban waste water treatment.

- **Ile de France (Val de Marne)**

The rei-urban region East south East of paris is concerned with the global water management of its water resource which is affected by urbanization, decrease of impermeation by ground coverage, lack of rain and storm water catchment , saturation of large watertreatment plants by rain water through sewage for mere disposal at cost in river Seine,…This is a really interesting case as it combines the needs of industrial , agricultural and domestic communities. There is a strong will from the region to have an integrated water management approach for the water resource and already a lot of activities at the public level and local authorities are taking place for further action and budgeting for inplentation of modern and efficient technologies. The key ingredients are related to distributed water catchment and treatment with significant use of natural systems such as wetlands and biosytems, natural filtration like in Berlin, in line local storage of treated water, the notion of dual network also is envisioned. This could be a very interesting show cae for other large cities in Europe and the rest of the world. And for Ile de France, the communities already are on top of the issues.

4.6 Pilot 3: Sustainable water management for agriculture

The agricultural sector is by far the largest consumer of fresh water. Worldwide, agriculture accounts for two thirds of all water used, mainly for irrigation. In Europe about 30% of the abstracted fresh water is used for agricultural purposes and up to 73% in Southern Europe. The objective of this pilot is to develop and implement technologies and methods that will make it possible to meet future challenges for environmental protection, impacts of global change, increasing economic competition and change of land use in agricultural areas. The vision for the agricultural sector is that:

- Agriculture will produce sufficient, affordable and safe food and other agro-products, while achieving sustainability
- Agriculture will use water more efficiently, and will make better use of non-conventional resources
- Agriculture will increasingly require new technologies, equipments and facilities from the water sector resulting in strong economic stimuli for this sector
- Agriculture will integrate environmental protection in production

What is necessary for sustainable water management in agriculture?

- Safe use and reuse of water in agriculture and its long-term impact on the environment. This calls for the design of new technologies and management methods for e.g. 'Cascading' systems and safe reuse of treated wastewater.
- Improvement of water use efficiency at different scales (local, regional, economic branch). This needs a) the development of new water management tools, such as integrated models and decision support systems at basin level, b) the improvement of sustainable production methods (including options for organic farming) at farm level and c) improvement of water use efficiency and water productivity.
- Reduction of diffuse pollution caused by agrochemicals, nutrients and manure. This will require the development of cost-effective, easy-to-access and adaptive technologies for precise dosing and application: agro-chemicals, fertilization and semi-liquid manure spreading.

The implementation cases in this pilot are focused on issues, such as insufficient treatment of wastewater from farms, water scarcity, groundwater overexploitation, diffuse pollution and flooding.

PILOT TITLE: Sustainable water management for agriculture		
Generic RTD		
	Research items	**Completion date**
Safe use and re-use of water from non-conventional sources in agriculture and its long-term impact on the environment	Design new technologies and management methods for 'cascading' systems and safe reuse of treated wastewater	Prior to implementation and during implementation
Improvement of water use efficiency in agriculture at different scales (local, regional, economic branch)	Improving integrated water management methods (e.g. DSS) and technologies from field plot to river basin scale	Prior to implementation and during implementation
Reduction of diffuse pollution caused by agrochemicals, nutrients and manure	Develop strategies and technologies for minimizing the use and losses to the environment of pesticides and nutrients, and especially for replacing mineral fertilizers by an environmentally efficient use of manure, wastewater treatment sludge and other bio-wastes (including the implementation of organic farming)	Prior to and during implementation

Enabling RTD			
Alternative water resources	• Safe production systems with optimal reuse of wastewater and other non-conventional waters	• Integrate all agriculture sectors with other water and waste users, for increased water efficiency and sustainability while lowering effluents and impacts	Medium/long term
		• Improve technology and methods for use and re-use of brackish, drainage, saline water and wastewater	Short term
		• Develop diagnosis methods that allow to adapt wastes to local conditions to avoid soil degradation	Medium term
		• Develop real time sensors and methods to control water quality (minerals, pH, contaminant)	Short term
		• Develop affordable tools to secure water quality from non-conventional sources and allow sustainable reuse	Medium term

Water use efficiency	• Improvement of integrated water management methods, such as modelling, at basin level • Improvement of on-farm environmental-economic water management methods, such as modelling (also accounting for options for organic farming) • Improvement of water use efficiency and water productivity, and increase system performance	• Approach to minimize the secondary impacts of efficiency (e.g. salinisation, sealing). • Development or upgrading of rain harvesting for increasing soil water holding capacity (e.g. dry farming, minimum tillage, direct seeding). • Develop or adapt specific tools (leak detectors, sensors, real time water monitoring). • Develop low cost, turnkey site specific management methods for all types of farms, including new technologies and systems in irrigated areas. • Improve governance at water-shed level accounting for end users constraints. • Improve knowledge and tools available to help defining new strategies and regulations in land application of compounds. Analyses are to be integrated at river basin level. • Improve modelling the of extreme hydro-meteorological events (drought and flood) on agricultural water management, and consequently water for food. • Improve knowledge and tools available to integrate aquaculture into coastal and river basin management. • Improve tools for improved river basin management (water saving, less uncontrolled emissions and better yields) 'water productivity'.	Medium term On going Short/medium term Long term Ongoing Ongoing Medium term Medium term Medium term

Water use efficiency (continued)		• Investigate the socio-economic and legal political barriers against implementation of a more efficient water management • Develop strategies for removing these barriers (such as cost recovery, financial supports, controlling, revision of water rights, training, demonstration sites) • Develop technology networks for establishing and improving sustainable farming practices, including hardware and software applications (such as new IT technologies which facilitate effective communication between various stakeholders) • Develop tactical DSS for irrigation and fertilization including weekly forecasting tools on water needs and availability	Short term Medium term Medium term Medium term

Reduction of diffuse pollution	• Development of cost-effective, easy-to-access and adaptive technologies for precise dosing and application: • Agro-chemicals • Fertilization • Semi-liquid manure spreading	• Development of on-line monitoring of nutrients and pests technique • Comprehensive analysis, monitoring and global assessment of manure and bio-solids management scenarios (economical, ecological and social issues) • Environmentally safe slurry storage, separation and recycling technologies; also for enabling manure quality improvements and maximization of value of manure • Improved knowledge of soil sealing process and soil biogeochemistry, especially the fate (transfer, lifecycles) of nutrients (nitrates, phosphates), agro-chemicals and organics • Development of biological, low chemical or chemical free pest control methods • Development of low input cropping systems aiming for products for alternative use	Short/medium term Medium term Short/medium term Medium/long term Short term Medium/long term

A number of potential implementation cases have been identified.

- **Agricultural water demand in Cyprus**

Wastewater reuse is already practiced in Cyprus. However, there are problems, mostly related to social acceptability and technical issues relating to treated effluent storage during winter. Water conservation and appropriate allocation policies.

- **Terras (Technologies for Effectuating the Renovation of Abandoned Soils) Netherlands**

The lack of management of terraced agricultural land causes different types of problems, like erosion and degradation of water resources causing local droughts, floods, fires and risks to communities and substantial damage to constructions. It also leads to an enormous loss of cultural heritage and landscape beauty. Three European research networks are active in describing these processes and in studying possible solutions. TERRISC has been especially active in describing the natural risks of under-managed terraced landscapes. ALPTER quantifies the different effects and proposes a decision model to focus solutions on the biggest risks. REPS is a very active network in understanding, describing, safeguarding and propagating the techniques of dry-stone building. TERRAS is initiated by members of these networks in order to supplement, adapt and unify existing research that can serve the re-valuation and re-utilisation of (semi-)abandoned agricultural land in such a way that it counteracts the above described negative effects and reverses it in a sustainable development process.

- **Jucar Basin, Spain**

Reuse of urban wastewater for irrigation. Reuse several times the water for irrigation through an extraordinary system of drainage ditches. Modernization of the irrigation system in the traditional irrigation districts (from gravity to pressure, to move from surface irrigation to drip irrigation reducing losses). Hydro-economic models and participatory DSS are being applied. Nitrates as a problem in the aquifers in the coastal plains, due to the extensive irrigated land and the high use of fertilizers.

- **Bretagne, France**

A vulnerable area for the EU Nitrates Directive, with insufficient treatment of wastewater from farms (numerous big and small breeding units), though in progress, and with loss of nutrients or pesticides from fields (not to mention other pollution sources).

- **Piave Basin, Italy**

A reorganisation of the water management system is foreseen which could adopt a new integrated water project largely based on a dual water system which should convey irrigation water and non-drinkable water. Low efficiency irrigation systems are in operation with important environmental side effects, such as the maintenance of surface water flows all over the year in an area with limited natural rivers. In discussion is the substitution of inefficient irrigation systems, largely based on an open channel network, with pressure pipes. This could result in a shift from surface to more efficient sprinkler irrigation (reducing losses and demand by 40%). Hydro-economic models and participatory DSS are being applied. Water quality (diffuse pollution by agro-chemicals and nitrates) and quantity aspects are both relevant and, participatory actions have been conducted with local stakeholder. In discussion is the development of cost-effective, easy-to-access and adaptive technologies for precise dosing and application.

- **Lower Rhine, Germany**

Due to intensive agriculture and life stock farming together with low depth of groundwater table there are high values of nitrate pollution. Many measuring points show values exceeding 50 mg/l. Changing of farming practices and the employment of advanced water treatment technologies are needed.

- **Skjern River and Ringkjoping Fjord, Denmark**

A basin, which is located on an outwash plain of mainly coarse sandy soil. The agricultural area covers a large proportion of the area (>60%). There is a large nitrate leaching from many of these farming systems. There is also on some livestock farming systems (dairy and pig) an accumulation of phosphorus in the soil which may lead to large risks of P losses to the surface waters. The water quality of both Skjern River and Ringkjobing Fjord into which the river drains, are thus heavily influenced by the N and P losses. There is need for management strategies and technologies for improving nutrient use efficiencies in both field and livestock production systems. There is a need to develop DSS at both farm and regional levels to reduce nutrient inputs to river basins. This may preferably be based on farm scale models.

- **Crete**

Despite the relatively high precipitation, water consumption constitutes a relatively small portion of water availability due to unequal temporal and regional distribution and high evapo-transpiration rates. Thus, there is a very high potential for use of non conventional water resources.

- **Anthemountas basin, Greece**

Reuse for irrigation, although still not applied, is one of the management options promoted and which will probably be applied in the mid to long-term future (maybe even earlier). Urbanization pressures from the nearby metropolitan centre, and with excessive groundwater overexploitation, mostly due to current agricultural activities and practices.

4.7 Pilot 4: Sustainable water management for industry

Water is of prime importance for the industrial sector as it is used in a variety of ways for transport, cooling and heating, cleaning, washing and also as raw material. Major water using and/or discharging industries include pulp and paper industry, textile, leather, oil/gas, chemicals/pharmaceuticals, food, energy and metal (including steel). The industrial sector is of great economic importance, where water related cost can reach up to 25% of the total production cost. The objective of this pilot is to develop and implement technologies and methods, in support of the vision that in the near future water for the industry is not a consumable or utility anymore, but a highly valuable asset: a vital element used in close conjunction with production processes. As second largest water user, industries will develop these technologies to be independent for the supply and further treatment of this critical factor, and will define and apply water qualities up to their specifications.

What is necessary for sustainable water management in industry?

- Water fit for use,
- Closing water cycles,
- Reducing environmental impact and water costs,
- Water quality monitoring and control
- Control of biofouling, scaling and corrosion

The pilot will focus on clusters of industries which have similar problems rather than at an area or site. The subjects can be related to: the type of industrial activity (sector related), the use of water for specific purposes (e.g. cooling water) or the existing of non-technological barriers (e.g. legislation, culture). For the latter group, the problems to be solved can be directly related to the area or site, but the solutions are primarily focused at measures within the factory. Some topics, (i.e. corrosion) are typically generic while other topics have both generic and enabling aspects. Water fit for use has generic parts (definition of water quality for utility water) and enabling parts (defining water quality for specific processes). Implementation cases will focus on sectors of industry using large amounts of water.

PILOT TITLE: Sustainable Water Management in Industry			
Generic RTD	**Research items**	**Tasks**	**Completion date**
Water fit for use	• Defining specific Water Quality demands (general applications) • Identification of disturbing effects of constituents • Application of alternative sources • Water Quality Control • Water Quality Management	• Develop knowledge to improve insight in water quality demands for general applications (general processes, cooling water, steam production). • Deriving measures for minimizing input or formation of detrimental substances • Develop on line sensors and monitoring systems • Implementing results in European and national policy	Prior to and During implementation Prior and during Implementation Prior
Closing the water cycle	• See above at topic 1 • Integrated energy and water management • Feed back of boil. Treated effluents	• Development of new (small scale) (pre)treatment and disinfection technologies	
Sludge, concentrates and deposits	• Sludge reduction and management • Concentrated salt streams	• Develop new low sludge treatment technologies • Develop technologies for treatment of concentrated salt stream	Prior and during implementation
(Bio) Fouling, scaling and corrosion	• Mechanism of scaling and fouling in processes and cooling water systems • Fouling prevention in membranes and pipes and removal technologies • Increasing recycling rates	• Develop knowledge of fouling processes in different applications • Develop new methods and chemicals for fouling prevention	Prior to implementation Prior and During implementation

Enabling RTD			
	Research items	**Tasks**	**Completion date**
Water fit-for-use in specific sectors	• Improve insight in water quality demands for specific processes and process steps • Dedicated treatment technology • Water Quality Control	• Fundamental research on water quality demands in different industrial sectors • Develop selective treatment processes • Disinfection technologies (Food, Pharma) • Development of new sensors for on-line measurement of specific parameters (of microbiological parameters)	Prior During Prior Prior and during
Closing the water cycle	• Facing complex water systems within the framework of closing the water cycle • Scaling and fouling effects of closing the water cycle • Water Quality Control Management and Monitoring • Modelling of water and energy systems • Water treatment for side streams	• Elaborating better knowledge for process and unit step operation • Development of models for water and energy systems for industrial sectors • Development of small scale techniques, hybrid membrane processes	Prior and during
Sludge and concentrates	• Regain of materials from sludge • Treatment of brines from specific processes	• Technologies for selective removal of raw materials from sludge • Selective technologies for removal of contaminants from brines	Prior and during Prior
Emission reduction of priority substances	• Reduction of endocrine effects of effluent (e.g. from paper industry) • (Selective) removal of priority substances from waste water stream to comply with WFD	• Development of tests for determining and characterizing the endocrine effects • Measures for minimizing endocrine effects (prevention, removal) • Development of selective adsorbents • Development of selective membrane technologies	Prior Prior and during

A number of potential implementation cases have been identified.

Different from the other thematic areas the ICs of Water in Industry are not focused at a specific location but at different industrial sectors. One of the starting points is that the different sectors can learn from each other focussing on specific subjects.

- **Integration in sustainable Water use in Industry**

In a first implementation case Chemical Industry, Paper Industry, Food Industry and Textiles Industry will focus at this cooperation, by knowledge exchange and common technology development and implementation. The use of specific expertise from one sector into another will bring sustainable water management in industry a big step forward. Within this cooperation the knowledge of the next implementation will also be used.

- **Chemical Industry (Sweden, the Netherlands)**

Besides Water Quality Definition and control, the focus in this case is at prevention of fouling and scaling and the selective removal of priority substances from complex waste waters. The latter is of big importance in relation to the Water Framework Directive (WFD).

- **Paper Industry (Germany Spain)**

An important issue is the combined energy and water re-use. Besides the removal of priority substances and dyes play an important role. Because paper industry did close their water cycle to a great extent, other sectors can learn a lot from their specific problems and limitations. Close cooperation with the Paper Platform is a must.

- **Textiles Industry (Slovenia Turkey)**

For textiles also the combination of water and energy management is of importance, as is the removal of dyes and priority substances in combination with salt removal and closing he water cycle. The smaller scale and other specific SME problems will have attention. There is also a strong link with the Textile TP.

- **Food (Spain, Netherlands)**

Food Quality and Safety in relation with water quality is the main issue. Attention will be paid to Quality control systems (focus at microbiological parameters). The new European legislation gives room to the use of other Water Sources besides drinking water, but safe Food is the basis.

- **Tanning industry (Turkey)**

Issues to be addressed are process water and waste water management in the tanning industry, water quality criteria for process and treated water. Good housekeeping for water management issues, water saving measures and operational water problems. Definition and segregation of reusable and non-reusable water flows, development of individual or combined advanced and innovative treatment technologies for reuse. Priority pollutants and control technologies. On line monitoring and control for minimisation of failures thought operation. Feasibility of developed options and measures to be taken to provide the implementation.

4.8 Pilot 5: Reclamation of degraded water zones (surface and groundwater)

European rivers and lakes are of great importance for our economies and our well-being, but more generally they support crucial ecologies that make up our natural environment. Since the industrial revolution human pressures have increased with rapid economic growth, urbanization and uncontrolled exploitation of our water systems. Rivers have been dammed, lakes have been used as dump sites, and coastal waters have been used as seemingly unlimited sinks for the effluents of our cities. As a consequence many of our waters have been degraded.

Since the introduction of the Urban Wastewater Treatment Directive much has been done to reverse this situation. . At the launch of the Water Framework Directive (WFD) 20 % of European surface waters

were seriously threatened, 60 % of its ground waters were over-exploited and 50 % of its wetlands had 'endangered' status. Now many countries are struggling to find the methods and the means to implement the WFD.

In particular the situation is serious in the Member States in Eastern Europe, mainly due to lack of treatment, over-exploitation, lack of environmental legislation and/or lack of enforcement of the legislation in the past. These states expect rapid economic growth and it is imperative that this growth is matched by appropriate environmental planning. Some areas in Western Europe have similar needs as they transform from traditional manufacturing industries to more service based societies with greater emphasis on human well-being as a key factor for future economic development.

What is necessary for the reclamation of degraded water zones?

- Development of techniques:
  - to map the state of degraded water sources systems
  - to derive the cause-effect relationships that have led to the degraded state
  - to generate information that can support transparent decision making between all stakeholders
  - to plan scenarios for system restoration, covering physical, ecological, social and economic benefits and costs
  - to mitigate specific adverse impacts
- Development of optimal strategies and Decision Support Systems
- To guide optimal investment strategies and/or optimal allocation of water resources
- To provide integrated forecasting and Early Warning Systems, using real-time data, integrating hydrological parameters, pollution loads, temperature, bacteria and water quality:
  - develop contingency plans for various stakeholders;
  - monitor progress in implementation on a wide variety of parameters
  - monitor compliance with regulations, including EU directives
- To demonstrate the effectiveness of such methods in a limited number of actual implementation cases
- To derive from these cases 'lessons-learned' and 'best-practice' guidelines for possible application in similar cases in Europe and outside Europe
- To disseminate this information to stakeholders involved in such similar cases
- To develop appropriate treatment technologies to ensure that discharges to the environment can reliably meet the required standards

The implementation cases will address following overarching issues:

- The requirement for cross border co-operation between countries and all involved parties
- Ensuring the active participation of all stakeholders, including NGOs and local communities, in water management activities
- Balancing the interests of the environment with the interests of those who depend on it

PILOT TITLE: Reclamation of degraded water zones (surface and groundwater)		
Generic RTD		
	Research items	**Completion Date**
IWRM: Information for Integration	• Integrated data acquisition and monitoring covering hydrological, hydrographical and water quality data • Integration of real time rain-fall runoff and efficiency of treatment plants • Integration of flood forecasting with forecasting of erosion of landfills • Coupling of socio-economic aspects • Model-data integration, Coupling of models, Uncertainty analysis • Pragmatic indicators to show achievement of IWRM objectives	Prior Early/during During
Model Application & Demand and Supply	• Decision Support System to optimize water infrastructure investments • Decision Support Systems to allocate and use water resources	Prior During
Dissemination and uptake & Enabling Framework	• Integration of socio-economic aspects • Valuation of water resources and environmental assets • Information system for a transboundary public • Knowledge on barriers for integrated water solutions implementation	During During
Adaptive Systems	• Impact of climate change on a river basin and implications for management of the basin and the systems being developed	Early/during
Appropriate quality and security	• The management systems of risks at all levels of the water cycle • Surface and groundwater protection at the basin scale • Availability of comprehensive water quality and nutrient monitoring tools • Availability of emergency water supply systems	During During During
Environmental Impacts	• Better methods and tools to set environmentally sustainable river flows and limit abstraction	During
Enabling RTD		
Sensors	• Sensors for on-line water quality and water quantity monitoring • Sensors for on-line bio-monitoring	Prior During
Demand and Supply	• Aquifer recharge and recovery technologies	During
Reduce negative environmental impacts	• Reduce water based emissions • Technologies for monitoring, controlling and removing diffuse and point source pollution • Usable products from sludge • Soil erosion reduction methods	During During During During

A number of potential implementation cases are described

- **Integrated management of the Danube basin (transboundary)**

The Danube is one of the world's largest and most international river basins. Just like many other basins, its environmental quality is under pressure of human activities that affect the quantity and quality of water in the river basin. The main environmental issues linked to the management of the soil, sediment and water system of the Danube river basin are: soil contamination, soil sealing, organic pollution, hazardous substances, hydro-morphological alterations (such as damming) and the management of infrastructure for energy, navigation and flood defence. There is a need for balancing economic development of the different economic sectors accounting for their relative contribution to pollution of the Danube River, in particular, diffuse pollution from agriculture will remain a major challenge.

- **Operational integrated water management in the Hornad basin, Slovakia and Hungary**

The Hornad River in the eastern part of Slovakia continues in Hungary (the Hernad River) and discharges into the Tisla. At present one of the main issues in the basin is the water quality of the river in relation to pollution control. A waste water treatment plant is under construction in Kosice (Slovakia) in order to prevent (amongst others) natural conservation areas and drinking water abstraction sites near the Slovak-Hungarian border. Another issue is flood management, as peak discharges of the river in Slovakia lead to flooding in downstream areas of Hungary. In addition to the problems of flooding itself, the water quality of the river is deteriorated due to erosion during flooding of landfills with industrial waste and seriously endangers the downstream natural conservation areas as well as drinking water abstraction.

- **Integrated water management and river rehabilitation in the Tame catchment, Birmingham, United Kingdom**

The Tame catchment is heavily urbanized system draining the city of Birmingham. The river systems are heavily modified and suffer from poor water quality and ecology and sewer flooding. Some significant progress has been made on the HR Wallingford SMURF project including extensive stakeholder and citizen engagement, which is seen as one of the key drivers for effective IWRM and river rehabilitation to deliver environmental and social benefits. However, new technology (software, decision-support) developed for integrating water quality, ecology and planning needs greater integration with flood risk management and sustainable drainage systems in order to improve water management.

- **Rhone Aval, France**

Interest: develop a global approach to preserve and manage all the uses of water, in a sustainable development approach, for a catchment that is heavily urbanized upstream, with the city of Lyon, widely used for energy generation and subject to heavy floods. Its aquifers is also the major source of water extraction with increasing problems of iron and manganese. The industries and especially chemical industries are numerous. This project gathers all the main stakeholders including major companies, technical centres and economical advisers.

- **Integrated management of the Minho basin, Portugal and Spain**

River Minho is coincident with borderline between Portugal (North) and Spain (Galicia) for about 60 km. Point and diffuse pollution arising from urbanization, agriculture and industry greatly affect water resources. Management of cross-border issues implies the development of cost-effective management tools towards adequate environmental protection strategies, ensuring compliance with environmental legislation (e.g. WFD). Stakeholders commitment makes this case an opportunity to develop and test specific tools

before implementation elsewhere. Issues to be addressed, pollution load and water quality, poor water quality and ecology, safeguarding drinking water extraction, water for energy generation, balancing economic development and increased pollution, river restoration, eutrophication and vulnerability of estuarine systems, hydro-morphological changes and the effect on water quality, management of cross-border issues.

- **Ria de Aveiro and Ria Formosa, Portugal**

Ria de Aveiro and Ria Formosa are two coastal shallow lagoons systems. As a result of socio-economic transformations those highly productive ecosystems are now under jeopardy. As a result of massive investments, degradation has been controlled. Nevertheless, there is a need to define: i) cost effective complementary actions for protection; ii) ecological recovery actions; iii) new threats. Issues to be addressed, pollution loads and water quality, mechanisms of transfer of mercury accumulated in sediments from contaminated spots to other areas of the lagoon and to coastal water, processes of bioaccumulation, impacts of wastewater discharges in the coastal ecosystems, soil and groundwater contamination resulting both from agricultural practices (particularly pesticides), urban development (mainly traffic in urban areas) and industrial activities (Complexo Químico de Estarreja), toxic algal blooms, eutrophication, effects of xenobiotics compounds associated with the discharge of waste water, degradation of coastal habitats, coastal erosion and dune overwashing and breaching and sand mining and dredging needs at the inlets and navigation channels.

4.9 Pilot 6: Proactive and corrective management of extreme hydro-climatic events

The central-European floods in August 2002 and the extremely dry conditions during the summer of 2003 highlight the fact that Europe is both exposed and vulnerable to these types of hazards. Recent work on climate change indicate that such hazards are likely to become more frequent with warmer wetter winters and drier, hotter summers in different parts of Europe.

Droughts have proved to be the most costly of all major hazards while being perhaps the least understood. Like floods, they cannot be totally prevented but the socio-economic impacts can be reduced by mitigation and preparedness and through better forecasting and prediction their impact can be reduced. On a global scale, floods account for over 65% of people affected by natural disasters and they are the most damaging of all natural disasters. In Europe, the reported number of disasters caused by floods has increased dramatically within the last two decades. Whether this is caused by increasing urbanization, climate change or other mechanisms is currently under debate. Forecasting is a sustainable way of adapting to and managing such disasters. This is widely recognized and is clearly stated in the recommendations of the 118 governments represented at the International Conference on Freshwater held in Bonn in 2001, which was designed to place water higher in the sustainability targets begun in Agenda 21:

'Water management arrangements should take account of climate variability and expand the capacity to identify trends, manage risks and adapt to hazards such as floods and droughts. Anticipation and prevention are more effective and less expensive than having to react to emergencies. Early warning systems should become an integral part of water resources development and planning.'
Bonn Recommendations for Action (2001)

Risk-based approaches will allow the integration of water disaster management into more general water resource management strategies, for example, combining the Water Framework Directive with the forthcoming Flood Directive.

What is necessary for proactive and corrective management of extreme hydro-climatic events?

- Forecasting the hydro-meteorological aspects
- Warning systems, monitoring network and crisis management
- Long term flood mitigation
- Short and long-term drought management
- Regional scale flooding
- Local scale multiple hazard management
- Drought and river flow management

PILOT TITLE: Adaptation and mitigation of extreme hydro climate		
Generic RTD		
	Research items	**Completion date**
Forecasting The hydro-meteorological aspects	• Integrated data acquisition and monitoring • Assessment of combined uncertainties and management for decision making • Robustness and redundancy of monitoring and forecasting systems • Adaptable models and systems • Data assimilation including satellite remote sensing • Coupled hydrological and meteorology modelling • Novel monitoring systems	

Warning systems, monitoring network and crisis management	• Rapid hazard and risk assessments and risk assessments • Novel monitoring systems • Novel and effective warning delivery (media, communication, wording) • Organization of security and intervention structures • Public organization • Diagnosis and assessment methods • Related hazards such as health, water quality, crop loss and multi-hazard handling • Integrating monitoring, forecasting and crisis management • Combined forecasting of water resources and water needs	
Long term flood mitigation	• Impact of climate and land-use change on floods • Pale climate-hydrology datasets, analysis and integration into models of past climate • Systemic approach to prevention protection monitoring forecasting • Improved disaster management systems • Integrated emergency response systems, managing pollution events, health risks • Improving flood recovery technologies, systems and socio-economic tools • Socio-economic assessments • Optimise physical, economic, environmental cost/benefits of controlled flood plain storage • Warning crisis management recovery • Systemic analysis and diagnosis of situation with correlated hazards • Land use policies • Public organization • Quick diagnosis and repair techniques on assets • Resilient materials and buildings • Diagnosis and assessment methods • Integrated modelling • Risk and uncertainty assessment for flood management	
Short and long-term drought management	• Improved climate models to predict both long duration extensive, and local, short term high intensity meteorological droughts • Combined forecasting of water resources and water uses / needs • "Optimisation" of water uses and savings (see other pilots) • Seasonal forecasting • Drought warning and monitoring systems • Low flow forecasting	

Enabling RTD		
Regional scale flooding	• Climate modelling of large scale floods • Integrate paleoclimate-hydrology datasets, and analysis into models of past climate • Discrimination of large scale frontal weather systems in fine resolution regional climate models, and improved prediction in global climate models • Improve weather radar and real time flow forecasting systems • Assessment of local consequences of climate change on extreme events • Improved management of river channels and floodplains to accommodate flood waters • Integrating, reducing flood risk, de-canalisation, ecosystem restoration • Spatial planning aspects • Novel monitoring systems (including radar and spatial approaches) interfaced with forecasting models • Understanding mud flows situations • On line real-time storage in networks • Storage in natural and low impacts areas • De-canalization and rehabilitation of rivers • Understanding impacts at regional scale, with indirect damages • Resilient materials and buildings • Quick diagnosis and repair techniques on assets	
Local scale multiple hazard management	• Understanding relationship between landslides and rain • Understanding mudslides • Understanding and monitoring dam or dike breach embankment failure mechanisms; diagnosis systems / methods • Modelling, risk and mitigation of associate sediment / mud flows	

	• Improved understanding and design to mitigate risk of catastrophic dam wall failure • Tools to assist spatial land use planning in flask flood prone areas - human dimensions, education and training • Understanding human and physical vulnerabilities, especially in case of flash and/ or torrential floods • Climate modelling of increased flash floods • Flash flood forecasting • Novel monitoring systems (including radar and spatial approaches) interfaced with forecasting models • Weather radar technologies and effective warning systems for mountainous terrain • Spatial planning • Modelling risk and its potential mitigation of associated • Systemic analysis and diagnosis of situations with correlated hazards • Drought and water pollution peaks • Climate modelling of flooding as a result of frozen ground/ice jams • Improve spatial /temporal RCM modelling of regions with an increased vulnerability to temperature related flooding • Ice jams, frozen ground, rapid snow melt, glacier lake outburst	
Drought, and river flow management	• Drought monitoring and forecasting • Reservoir operation and optimisation • Combined forecasting of water supply and water uses/needs • Drought and water pollution peak • Paleoclimate-hydrology datasets, analysis and integration into models of past climate • Improved modelling of physical drivers of drought onset and perpetuation • Improved modelling of small spatial extent, short duration, extreme meteorological droughts • Drought warning systems for Europe and the world, with sector enhanced mitigation information to the public and industries • Physical and social science to support drought plans • Reducing drought vulnerability through reduced water use in all sectors - public education • Reform of agricultural water use • Strategic environmental assessment and ecosystem recovery	

A number of potential implementation cases are described.

- **The Odra river, Czech republic, Germany and Poland**

The Odra River basin is subject to frequent and often catastrophic flooding. It is a transboundary river with headwaters in the Czech Republic, flowing through Poland and along the border between Poland and Germany. The Odra river basin is an interesting implementation site because it includes many of the phenomena to be addressed. It is subject to flash flooding in the southern mountainous tributaries in the Czech Republic and Poland. There is a large-scale basin that is transboundary draining to the Baltic Sea. The river is subject to ice formation, blocking etc and interestingly also subject to hydrological drought problems in the same manner as Germany. The data available is of high quality and the infrastructure development for flood protection is rapidly developing.

- **Danube and tributaries, transboundary**

The flooding of April 2006 highlights the importance of flood forecasting and flood management on the Donau. The Danube is a key transboundary river flowing through Germany, Austria, Czech Republic, Hungary, Yugoslavia, Rumania, Bulgaria, and the Soviet Union. The key issues for this river are related to the need to combine local strategies for flood management whether this is the construction of reservoirs or the implementation of a flood forecasting system, with the need to manage a large transboundary system. For example for flood forecasting a large-scale system exists for large-scale flood alerts however more detailed flood forecasting is required within each country or region or catchment, information needs to be exchanged between these local systems, and the consequences of flood management operations need to be transparent to all.

- **City of Nice, France urban flush floods**

The city of Nice represents a typical Mediterranean coastal city which is subject to convective storms arising in the Mediterranean. The proximity to the coast together with the rapid response to rainfall in urban areas mean that flood management and forecasting is a challenging problem especially if suitable forecast lead times are to be achieved for flood warning and flood operations. At the same time the influx of tourists in the summer and the substantial urban development and therefore the substantial infrastructure at risk means that the costs of such flooding is high.

- **Hamburg, Germany**

The combination of high population density, substantial infrastructure at risk and the rapid response to rainfall in large-scale urban areas such as Hamburg means that the potential costs of flooding may be substantial. Or stated another way, the potential benefits of effective flood management are substantial. The challenges include measuring and forecasting local rainfall and then combining this with high resolution modelling to determine where and when the highly localised flooding occurs.

- **The Glomma Basin, Norway**

The Upper Glomma catchment is located in a mountainous area between Oslo and Trondheim in Southern Norway and including several lakes and reservoirs. Further downstream the Glomma river flows out into the Oslo fjord about 2000 km further south.. The elevation range is from 586 to1595 masl. and the basin is representative of climatic and hydrological regimes in Scandinavia. The hydrological regime is dominated by snowmelt in the spring and summer rains. The water management issues include flood protection, and the operation of reservoirs for water supply and maintenance of ecologically acceptable flows.

- **Arade basin, Portugal**

As pointed out earlier droughts have been shown to be the most costly of all major hazards while being perhaps the least understood. Droughts occur over a larger time scale than flood events and the effects of climate and the possible effects of climate change are crucial particularly in southern Europe. The Arade basin in southern Portugal is representative of such basins. Accurate and reliable long-term meteorological forecasts are required at the same time as short-term drought mitigation strategies must be implemented.

- **Crimea, Ukraine**

The Crimean peninsula, representing the most southern part of Ukraine, is an area with limited water resources according to agro hydrological zoning. Within the last two centuries Crimea suffered three times severe drought, after which significant parts of steppe zone was practically deserted. Availability of water resources in the southern submountain part of the peninsula is better, but also showed strong changes on years. There are coastal, mountain, and steppe zones in Crimea. Development strategy for mitigation droughts and floods influence for rural areas and for reservoirs which are working for drinking water supply purpose too. Issues to be addressed are, development decision support system and demand management system for better allocate and use water resources, especially tacking into account quality of water resources, analysis of quantity, quality and availability of water resources based on the principles of integrated management (including creation of the appropriate knowledge base, and also modelling of processes), on line monitoring of water resources parameters, control of the selected parameters and development a system of remote access to information, protection and improvement quality of water resources, development and implementation of safe energy and water resources plans, increase efficiency of water and energy resources use and optimization using of water resources between drinking water supply purpose, irrigation and industry.

- **Oslo, Norway**

The impact of climate change in Oslo are two-fold, namely the change of water quality of drinking water courses and to the increase of storm frequencies leading to overload on wastewater systems followed by floods and pollution of local rivers. The case will comprise both these aspects, and it is also referred to the issues of Oslo case under pilot "large urban areas".

- *Degraded quality of drinking water*
  Water quality and treatment issues related to natural organic matter (NOM) has gained a lot of focus in many countries over the last years. Recent data show that there has been a significant increase of colour and TOC in surface waters in many regions in Northern Europe and North America over the last 1-2 decades (Sweden, Norway, Great Britain, Germany, etc). It has been speculated that climatic change is the main reason for this phenomenon (e.g. increased primary production, increased rate of biodegradation, increased flux from the watershed during more extreme precipitation events). Oslo has collected data over a long time period and has started a research program to analyze the impact of climate change on water courses.
- *Flooding of surface areas and pollution of urban rivers due to increased storm frequency*
  Increased storm frequency makes a significant impact on the city environment shown as surface flood and also pollution of local rivers, due to overloading the wastewater system. Oslo is situated in a cold climate region. The impact of climate change is not similar to warmer regions, but research on these complementary conditions will add valuable understanding to the ongoing climate change and the impact of it. In particular, the warming effect in generating local storms in urban areas should be investigated. Oslo possesses climate data for more than 100 years, and is supported by a highly competent research environment on this issue.

- **Ebro River**

The Ebro river watershed watershed is extremely interesting in that it contains basins with distinct hydrological regimes, from those of a high mountain climate - with frequent snowfalls – to others of a semi-desert climate. The basin flood and drought periods and therefore water management is crucial in this basin. To effectively manage the temporal variability of the water resource, the basin contains 41 reservoirs however the optimal operation of these reservoirs over a basin-wide scale represents a considerable challenge. Both short-term and long-term strategies for flood protection, drought protection and efficient reservoir operation for water supply are key requirements.

Summary tables Pilots and Implementation Cases
Strategic Research Agenda Water Supply and Sanitation Technology Platform

Pilot Theme 1	Implementation Cases	Country	Generic R&D issues addressed	Enabling Technologies addressed
Mitigation of water stress in coastal zones	Salt intrusion Rivers Rhine, Meuse and Scheldt Delta, twinning with Curaçoa	Transboundary project, France, Belgium, Germany, Netherlands	G1,G2,G4,G5	E1,E2,E4,E5
	Coastal zones in Cyprus	Cyprus	G1,G3, G4, G5	E1,E3,E5
	Algarve region in Portugal	Portugal	G1,G2,G3,G4,G5	E1,E2,E3,E4,E5
	Transboundary water management along the Southren Adriatic/Dinaric coast	Austria	G1,G2,G3,G4,G5	E1,E2,E3,E4,E5
	Bordeaux estuary	France	G1,G2,G3G5	E1,E2,E3,E5
	Levante Spanish coast	Spain	G1,G2,G3,G5	E1,E2,E3,E5
	Maresme region Cataluňa	Spain	G1,G2,G3,G5	E1,E2,E3,E5
	Almiros basin Greece	Greece	G1,G2,G3,G4,G5	E1,E2,E3,E4,E5
	Dammour region Lebanon	Lebanon	G1,G2,G3,G4,G5+karstic aquifers	

Research and Development topics	
Generic	Enabling
G1 Knowledge capture	E1 Knowledge capture
G2 Salt water intrusion mitigation	E2 Salt water intrusion mitigation
G3 Global water management scenario builder	E3 Global water management scenario builders
G4 Sustainable supply of quality water	E4 Sustainable supply of quality water
G5 IWRM/DSS	E5 IWRM/DSS

Pilot Theme 2	Implementation Cases	Country	Generic R&D issues addressed	Enabling Technologies addressed
Sustainable water management inside and around large urban areas	Berlin	Germany	G1,G2,G4	E1,E3,E5
	London and South-East of London	United Kingdom	G1,G3,G6	E1,E2,E4,E5,E8
	Utrecht	Netherlands	G1,G2,G3,G4,G5,G6	E1,E2,E3,E4,E5,E6,E7
	Lyon	France	G5	
	Lisbon	Portugal	G1,G2,G3,G4,G5,G6	E2,E3,E4,E5,E6,E7,E8
	Democity Århus	Denmark	G1,G2,G3,G4	E1,E2,E3,E4,E5,E6
	Oslo	Norway	G5,G6	E3
	Prague	Czech Republic	G6	E3
	Ile de France Paris	France	G1,G2,G3,G4	E1,E3,E5,E6

Research and Development topics	
Generic	Enabling
G1 Balancing demand and supply	E1 Monitoring , sensor and communication technology
G2 Ensuring quality and security	E2 Advanced treatment technologies
G3 Protecting the environment and reducing ecological footprint of big cities	E3 Technologies for producing energy and products from wastewater (including biofuel) and technologie for reuse of waters both at collective and individual scale
G4 Designing and managing sustainable infrastructure assets	E4Tools to cost-effective and sustainable management of assets
G5 Sustainable urban awter networks	E5 Water saving and water sharing processes, appliances, practices
G6 Sustainable and advanced waste water treatment, energy neutral sewage works, methane production, material recovery and reuse including recirculation of organic waste (biofuel)	E6 Risk assesment and risk management tools
	E7 Integrated design of water systems combining networks and decentralized processes
	E8 Domestic water demand including smart metering and tariff management

Pilot Theme 3	Implementation Cases	Country	Generic R&D issues addressed	Enabling Technologies addressed
Sustainable water management for agriculture	Agricultural water demand in Cyprus	Cyprus	G1,G2	E1,E2
	Technologies for effectuating the renovation of abandonned soils	Various countries, transboundary		
	Jucar basin	Spain	G1, G2, G3	
	Bretagne France	France	G3	
	Piave Basin Italy	Italy	G1, G2, G3	
	Lower Rhine	Germany	G3	
	Skjern river and Ringkjoping Fjord	Denmark	G3	E3
	Crete	Greece	G1	
	Anthemountas basin	Greece	G1,G2	
Research and Development topics				
Generic		Enabling		
G1 Safe use and re-use of water from non-conventional sources in agriculture and its long-term impact on the environment		E1 Alternate water resources		
G2 Improvement of water use efficiency in agriculture at different scales (local, regional, economic branch)		E2 Water use efficiency		
G3 Reduction of diffuse pollution caused by agrochemicals, nutrients and manure		E3 Reduction of diffuse pollution		

Pilot Theme 4	Implementation Cases	Country	Generic R&D issues addressed	Enabling Technologies addressed
Sustainable water management for industry	Integration in sustainable water use in industry	Various		
	Chemical industry	Sweden and Netherlands		
	Paper industry	Germany and Spain		
	Textiles industry	Turkey and Slovenia		
	Food industry	Spain and Netherlands		
	Tanning industry	Turkey		
Research and Development topics				
Generic		Enabling		
G1 Water fit for use		E1 Water fit for use in specific sectors		
G2 Closing the water cycle		E2 Closing the water cycle		
G3 Sludge, concentrates and deposits		E3 Sludge and concentrates		
G4 (Bio) Fouling, scaling and corrosion		E4 Emission reduction of priority substances		

Pilot Theme 5	Implementation Cases	Country	Generic R&D issues addressed	Enabling Technologies addressed
Reclamation of degraded water zones (surface water and groundwater)	Integrated management of the Danube basin	Transboundary	G1,G2,G3, G4,G5,G6	E1,E2,E3
	Operational integrated water management in the Honrad basin	Slovakia and Hungary	G1,G2,G3, G4,G5,G6	E1,E2,E3
	Integrated water management and river rehabilitation in the Tame catchment, Birmingham	United Kingdom	G1,G2,G3, G5,G6	E1,E2,E3
	Rhone Aval	France		
	Integrated Management of the Minho basin	Spain and Portugal	G1,G2,G3,G5,G6	E1,E2,E3
	Ria de Aveiro and Ria Formosa	Portugal	G1,G2,G3,G5,G6	E1,E2,E3
Research and Development topics				
Generic		Enabling		
G1 IWRM: information for integration		E1 Sensors		
G2 Model application & demand		E2 Demand and supply		
G3 Dissemination and uptake and enabling framework		E3 Reduce negative environmental impacts		
G4 Adaptive systems				
G5 Appropriate quality and security				
G6 Environmental Impacts				

Pilot Theme 6	Implementation Cases	Country	Generic R&D issues addressed	Enabling Technologies addressed
Proactive and corrective management of extreme hydro-climatic events	The Odra river	Czech Republic, Germany, Poland	G1,G2,G3,G4	E1,E2,E3
	Danube and tributaries	Transboundary	G1,G2,G3,G4.G5	E1,E2,E3
	City of Nice, urban floods	France	G1,G2,G3	E1
	Hamburg	Germany	G1,G2,G3	E2
	Glomma River	Norway	G1, G2, G3, G4	E1,E2, E3
	Arade basin	Portugal	G1, G4	E3
	Crimea Ukraine	Ukraine Crimea	G1,G2,G3,G4	E1,E2, E3
	Oslo increased levels of NOM	Norway		
	Ebro River,	Spain	G1, G2, G3, G4	E1, E2, E3

Research and Development topics	
Generic	Enabling
G1 Forecasting the hydro-meteorological aspects	E1 Regional scale flooding
G2 Warning systems, monitoring network and crisis management	E2 Local scale multiple hazard management
G3 Long term flood mitigation	E3 Drought, and river flow management
G4 Short and long-term drought management	

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