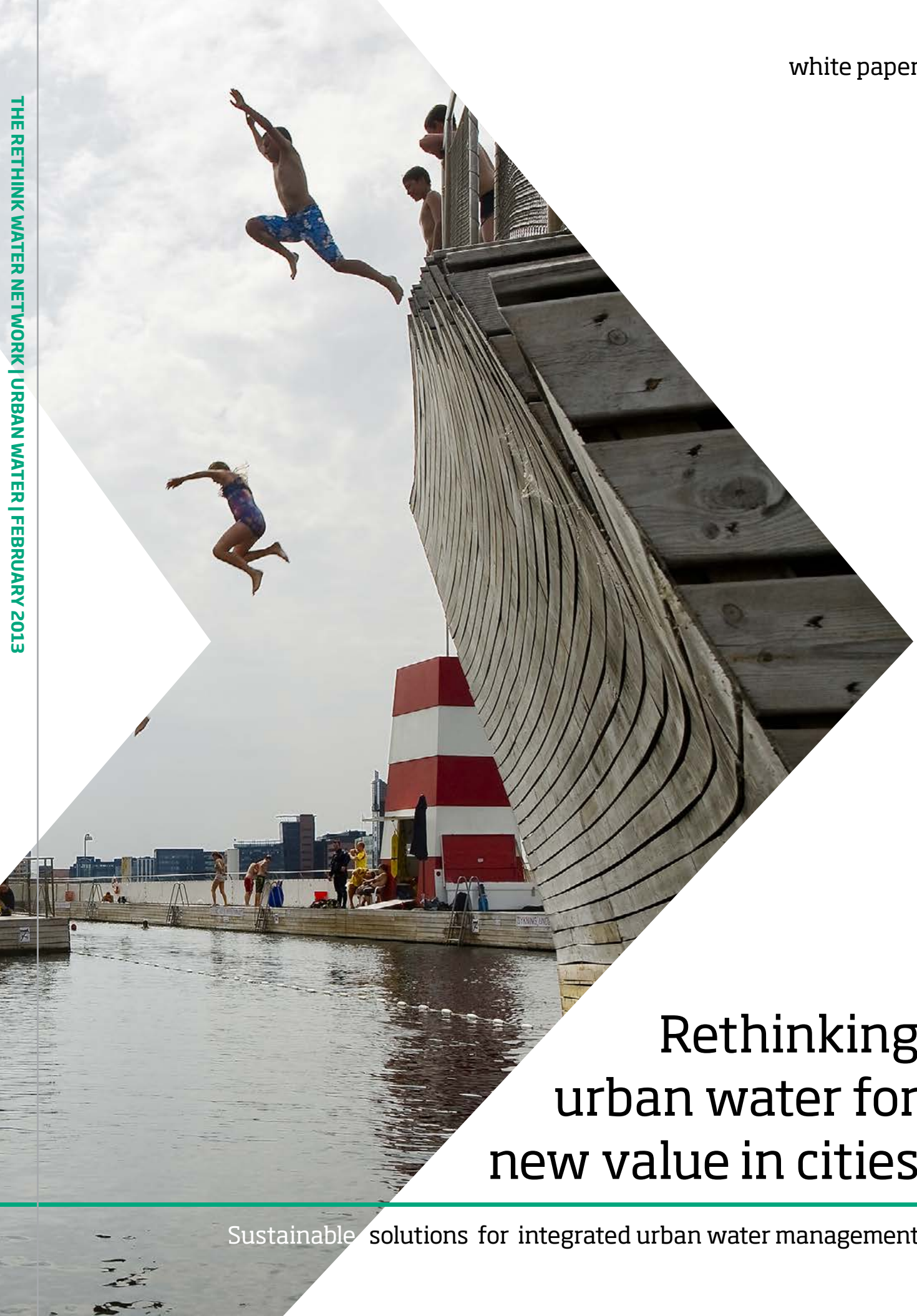
white paper

THE RETHINK WATER NETWORK | URBAN WATER | FEBRUARY 2013



Rethinking urban water for new value in cities

Sustainable solutions for integrated urban water management

Rethinking urban water for new value in cities
Sustainable solutions for integrated urban water management

Version 1.0

Frontpage picture
Copenhagen harbour bath at Islands Brygge
(Photo: Kontraframe/City of Copenhagen)

About this white paper
This white paper is developed by the Rethink Water network in Denmark. The work is coordinated by the Danish Water Forum. The Rethink Water network consists of more than 50 technology and consulting companies, water utilities, water organisations and public authorities. It was established to support our partners internationally in developing the highest quality water solutions.

Quoting this white paper
Please quote this white paper and its articles: "Klee, P. (Ed.), 2013. Adding new value to cities with urban water - Sustainable solutions of integrated urban water management. The Rethink Water network and Danish Water Forum white papers, Copenhagen. Available at www.rethinkwater.dk"

Editor
Danish Water Forum Pia Klee ***pikl@danishwaterforum.dk***

Contributors
Alectia Karsten Nielsen ***ksni@alectia.com***
City of Copenhagen Lykke Leonardsen ***lykleo@tmf.kk.dk***
Greater Copenhagen Utility Sonia Sørensen ***sons@hofor.dk***
COWI Arne Bernt Hasling ***abh@cowi.dk***
DHI Anders Chr. Erichsen ***aer@dhigroup.com***
DHI Morten Rungø ***mor@dhigroup.com***
DHI Claus Jørgensen ***clj@dhigroup.com***
NIRAS Jens Christian Riise ***jcr@niras.dk***
Orbicon Jakob Larsen ***jala@orbicon.dk***
Rambøll Christian Nyerup Nielsen ***cnn@ramboll.dk***
Rambøll Rikke Hedegaard Jeppesen ***rkhj@ramboll.dk***
Rambøll Søren Hvilshøj ***srhs@ramboll.dk***
Teknologisk Institut Ulrik Hindsberger ***uhi@teknologisk.dk***
Tredje Natur Flemming Rafn Thomsen ***frt@tredjenatur.dk***
Tredje Natur Ole Schrøder ***os@tredjenatur.dk***
Aarhus Water Lene Bassø ***lba@aarhusvand.dk***

Executive summary

Sustainable solutions are no longer a choice for most societies: they're a must. Especially in our cities. We must all strive to balance the quality of people's lives with sound economic and environmental development

FRANK JENSEN
Lord Mayor of
COPENHAGEN

Cities are growing. Today's urban population of 3.2 billion will rise to nearly 5 billion by 2030, by which time three out of five people will live in cities. Added to this, many cities face additional pressures of rising sea levels and extreme weather events, bringing with them the risk of flooding and/or periods with little or no water. In dry periods temperatures may rise even further, due to the urban heat island effect. This white paper sets out a wide range of examples showing how Danish water expertise is used in Denmark, and around the world,to help find the best sustainable solutions for cities.

An integrated approach is cost effective

If wastewater and stormwater management are integrated at an early stage with the urban planning process of existing cities, or in the development of new areas, benefits and synergies can be achieved, making additional costs relatively small. Waiting until town planning is completed or until extreme weather events occur, only leads to higher costs and more complicated solutions.

More return from investments

If cities replace the 'business as usual' approach to dealing with water with a holistic view of the situation, incorporating new blue and green structures as an integrated part of urban development, it will generate more value for money. Waterfronts, docklands, canals and lakes help to create exclusive areas which attract resourceful people and businesses. Studies from estate agents in Denmark show that property prices in these types of areas are up to 70 percent higher than in locations just a few hundred meters away from the water.

A clear vision is key

An integrated approach to water management is the most cost-efficient way and is essential to solving the challenges of increasing urbanisation and climate change faced by many cities. However, to achieve a sustainable society, the urban planning that is required goes beyond the reach of the city authorities and the water utilities alone. What is needed is collaboration among various stakeholders. Having a clear vision and common goals is the key to success.

Prioritising investments

Urban water management must include the intelligent handling of climate change and the identification of potentially attractive urban environments to be created. But also fundamental is the systematic identification, analysis and evaluation of water-related risks, like flooding, or the potential contamination of drinking water. Establishing a clear picture based on thorough assessment makes it possible to decide which solutions are worth investing in.

Integrating water with urban development, Copenhagen, Denmark *Despite the small size of the country, Denmark's coastline is more than 7,000 kilometres long (4,000 miles) and nowhere in Denmark is more than 50 kilometres (30 miles) from the sea. So using water in a constructive manner is an inherent part of Danish culture. Like many other waterside cities, Copenhagen, the capital of Denmark, has undergone a transformation from an industrial to a modern knowledge-based economy. Over the last decade Copenhagen has modernised and improved its old water infrastructure to provide for an expanding city and for climate change. This has been seen as an opportunity to create more value through better integration of the water system with urban development.*

Photo: Aerial photo, Jan Kofod Winther

Attracting resourceful people through coastal development, Copenhagen, Denmark The capital of Denmark spreads along the narrow sound that lies between Denmark and Sweden. Already 80 years ago a beach park was founded here, just five kilometres away from the centre of Copenhagen. However, the state of the beach was very poor and facilities were scarce. About 10 years ago the City of Copenhagen decided to invest 25 million euros to develop a piece of "engineered nature", the new Amager Beach Park. It has almost 2 kilometres (1.2 miles) of attractive beaches, promenades and amenities, a headland for scuba diving and a lagoon for water sports such as kite surfing. This project is an example of how water attracts resourceful residents and businesses. Property prices in Southern Copenhagen, which includes the area around Copenhagen harbour baths and Amager Beach Park, are today almost 70 percent higher than the Copenhagen average. For villas and townhouses near to Amager Beach Park prices are more than 20 percent higher than the average in southern Copenhagen. (Courtesy: Hasløv & Kjærsgaard, DHI and NIRAS)

Upgrading the city centre and early warning systems, Aarhus, Denmark Denmark's second largest city, Aarhus, is a waterside city, with a river that connects the city centre and port in a coherent blue structure. In 1989, the city council decided to begin opening up the river, step by step, reversing a decision taken 60 years before, when the river was covered over all the way through the city to the bay. Today the river is a very important element in the redevelopment of the city centre. An early warning system for the bathing water quality assures safe recreational use of the river, nearby Lake Brabrand and the area at Aarhus Harbour very close to the city centre. The investments have included a system for the integrated control, in real time, of the sewerage system and wastewater treatment plants. The system is based on hydraulic models that describe the transport, dilution and decay of E.Coli and it consists of four coupled parts (1) a rural catchment model calculating the rainfall run-off from the rural area, (2) sewer catchment models calculating flows, run-off, CSO's and E. coli-transport, (3) a lake and river model calculating flow pattern and E. coli transport and (4) a harbour model calculating flow pattern and E. coli transport. (Courtesy: Aarhus Water and DHI)

1. Rethinking urban water solutions

Business as usual is no longer the way to think about urban water. An integrated water management approach is, from an overall perspective, the most cost-effective route in dealing with urban water and climate challenges

SØREN HVILSHØJ
International Water Director
RAMBOLL

Cities are growing. Today's urban population of 3.2 billion will rise to nearly 5 billion by 2030, by which time three out of five people will live in cities. Added to this, many cities face additional pressures of rising sea levels and extreme weather events, bringing with them the risk of flooding and/or periods with little or no water. In dry periods temperatures may rise even further, due to the urban heat island effect. For cities to solve these new challenges, they need to invest in the water supply, in wastewater treatment, rainwater drainage and, in some cases, in coastal protection.

A classic or an integrated approach?

But these challenges also present the opportunity to rethink urban development and gain greater value from every cent invested. If cities replace the 'business as usual' approach to dealing with water with a holistic view of the situation, incorporating new blue and green structures as an integrated part of urban development, then water becomes a valuable asset. For instance, the problem of flooding in densely populated urban areas after heavy rains has typically been solved by increasing the size of the sewer and stormwater network. In contrast, Denmark has chosen an integrated approach. Although initially more complex, involving a broad range of environmental, economic and social strategies (including considering drainage solutions, upstream delayed rainwater storage and, sometimes inevitably the construction of enlarged stormwater pipelines), nonetheless seen from the overall society perspective, it is more cost efficient.

New approach giving greater overall value

This white paper sets out a wide range of examples showing how Danish water expertise is used around the world to deal with climate change and urban development in a sustainable way. However, it should be understood that taking the integrated approach is a journey. Just a decade ago, most cities in Denmark saw water as something to hide and remove in sewers, not as the valuable resource it actually is. Now most Danish cities have changed their approach. Water is seen once again as an asset with enormous potential to enhance daily life for people living in the city. This makes large investments easier to justify to the public and today water in Denmark plays an important role in urban development and economic growth.

Climate adaptation preventing stormwater damages, Copenhagen, Denmark
In summer 2011, in the Danish capital Copenhagen, 150 mm (six inches) of rain fell in under three hours, flooding streets and basements, and causing damage of almost a billion euros, more than a billion dollars. This highlighted the need for more integrated and sustainable urban water solutions. In 2012 the City of Copenhagen decided on a new comprehensive Copenhagen Climate Adaptation Plan, probably one of the first climate adaptation plans in the world to take an overview of the whole technical water circuit. (Courtesy: City of Copenhagen).

2. Developing visions, common goals and integrated solutions

With the right vision and by setting ambitious targets you will pave the way to achieving previously unreachable goals

PER JACOBSEN
Director, Water Supply & Sewerage
GREATER COPENHAGEN UTILITY

People's love for water leaves its imprint on cities in so many ways – from the historic fountains and modern pools that mirror the city in their surface to the enormous variety of waterfront developments that have sprung up along harbours, rivers, lakes and canals. For many former port cities, the docks now stand empty or newer facilities have been moved away from the historic centre, leaving centrally located commercial or naval docks that are no longer in use. These cities are in a state of transformation from their industrial past to becoming urban centres in a modern knowledge-based economy. This is happening just as many of them are also dealing with more extreme weather events and rising sea levels.

Boosting urban development

Swimming in Copenhagen's harbour was out of the question seven years before the first harbour bath opened in 2002 at 'Islands Brygge.' Frequent overflows from the sewerage system posed serious health risks. Today this spot is one of the trendiest in Copenhagen and property values, the local business community, tourism and the quality of life for Copenhagen's citizens have received a major boost. Waterfronts, docklands, canals and lakes help in creating exclusive areas, attracting resourceful people and businesses. This is an important consideration when new water investments are under discussion. In 2012 a study by researchers from the University of Copenhagen showed that property prices increase by an average of 10 percent if the property is within walking distance of a park or an area of urban nature. Proximity to the coast increases property prices by 15-30 percent, an increase that vanishes once the property is more than 300 meters (1,000 feet) away from the water.

The vision makes the difference

An integrated approach implies that different stakeholders have to coordinate their efforts

Showcase for climate adaptation technology, Copenhagen, Denmark *Copenhagen will, like many other cities, face heavier rainfall in future due to climate change. One idea to avoid flooding is to let water remain longer in the urban space. With this idea in mind – and the promise of increased recreational value and biological diversity – the City of Copenhagen is now transforming a densely populated neighbourhood of 50,000 square metres (500,000 square feet) into a showcase for climate adaptation technology. It will demonstrate how rainwater can be managed by more natural and effective means. The architects will reclaim 20 percent of the street area by optimising the infrastructure and parking spaces according to current standards. Bicycle paths will act as stormwater channels, water towers, green roofs, urban gardens and green houses will delay the water and canals will carry excess water out to the harbour. (Courtesy: City of Copenhagen and Tredje Natur).*

Boosting urban development with integrated wastewater strategies, Copenhagen, Denmark *Copenhagen Harbour has been transformed in just a decade from an industrial port to a vibrant cultural and social centre of the city. People can now take a swim and enjoy water playgrounds right in the centre of the city. By modernising the sewage system, adopting a cleaning programme and diverting local rainwater, the water quality improved so much that the City of Copenhagen was able to open a public harbour bath in 2002. Protection against wastewater discharge during excessive rain is solved by integrated waste water strategies and innovative technology. An integrated bathing water forecast system measures sewage discharge and dynamic hydraulic and bacterial models ensure that the water quality stays in compliance with the EU bathing water directive. This real-time system is also used in other beach areas in Denmark as well as in the some of the most popular beaches in neighbouring Sweden. (Courtesy: Copenhagen City and DHI).*

to reach a common target. To achieve a sustainable society, the urban planning that is required goes beyond the reach of the city authorities and the water utilities alone. It requires collaboration between their consultants, contractors, equipment suppliers and the local residents. A clear vision and common goals are the keys to success. Most integrated water solutions will require a 'flexible attitude' from stakeholders. Thus, appealing to people's imaginations makes a huge difference in working with integrated green and blue structures:

Think of a city harbour so clean that people go swimming every day; imagine an urban park where nursery school children can safely go fishing; think of teenagers cycling round an urban lake having a great time; picture a retired couple enjoying the shade of the trees by a pond on a beautifully planted roundabout; and then, imagine that you wouldn´t have to imagine it anymore...

Benefits of an integrated approach

The integration of water solutions with urban development is a way to reintroduce water as an asset in urban living. There are a variety of tools and methods available for the development of innovative integrated water solutions. These include software to enable the visualisation of possible future scenarios that can help in convincing decision makers and stakeholders about the benefits of integrating blue and green structures. The more obvious benefits are that integration decreases the hydraulic load on wastewater treatment and reduces the number of combined sewer overflows. Integrated solutions also decrease the risk of flooding and related costs. A final argument is that infiltration of rainwater will increase groundwater regeneration, valuable to cities where groundwater is an important water resource.

Water is a prerequisite to all life, even in the city! Water creates magical and exciting locations that strengthen the cohesion and sustainability of cities. Integrating water in urban planning is a unique formula: 1 +1 = 11

FLEMMING RAFN THOMSEN
Architect and Partner
TREDJE NATUR

New blue vision for the harbour, Copenhagen, Denmark *One of the visionary ideas for Copenhagen is to expand the number of blue and green recreational areas. Today, the harbour covers a third of the city's total area, but still only a few areas can be used by the city's inhabitants and even fewer are recreational areas. With the launch of 'Blue Visions', which presents five ideas to strengthen Copenhagen harbour's recreational value, the City of Copenhagen wants to show politicians and inhabitants how the harbour can be developed into a more valuable and healthier urban environment. The water in the harbour is so clean that you can swim and fish here, a privilege that only few major port cities in the world share. One of the proposals is to create new blue spaces, a second-generation harbour bath, that with a network of floating islands is a contemporary take on Copenhagen's tradition of artificial islands and islets. This would give people direct access to the water, where they could bathe in small heated lakes and relax between hot stones in sauna caves. (Courtesy: Tredje Natur)*

3. Assessing risks and opportunities

Developing the best water solutions requires thorough data collection, data processing and evaluation of opportunities and risks. Integrated modelling and planning tools are invaluable for making the right investments

KARSTEN NIELSEN
Business Unit Director
ALECTIA

Water is attractive in urban environments and when managed wisely it offers ample opportunity for urban development. But water can also become a hazard in the event of heavy rainfall or other extreme weather. Water can risk damaging urban structures, human health or the environment when it accumulates in large volumes and/or contains hazardous substances or harmful organisms. Thus a fundamental part of urban water management – along with identifying opportunities for developing attractive urban environments and the intelligent handling of climate change – is the thorough identification, analysis and evaluation of water-related risks like flooding and contamination of drinking water.

How to prioritise investments

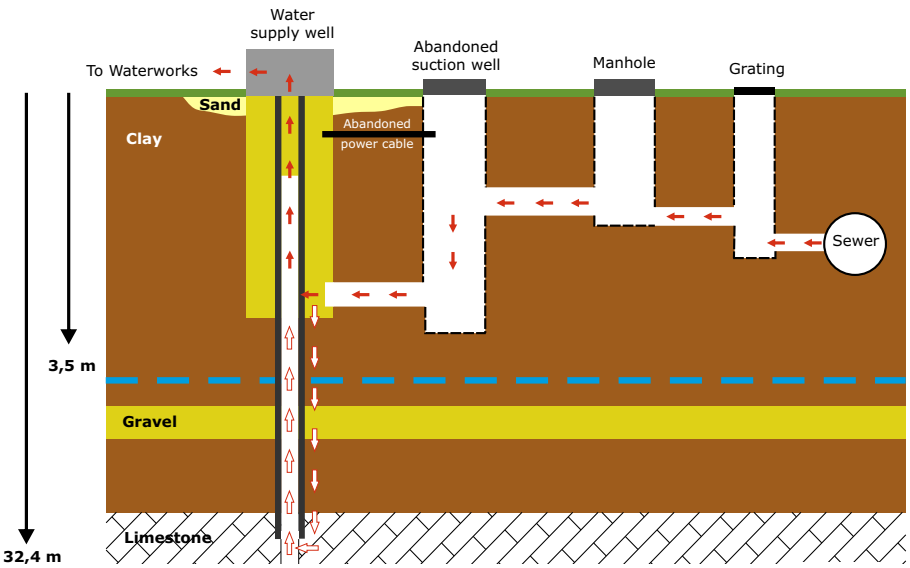
Flooding is a threat in many cities around the world and it is a complex situation to solve, since it can be caused by a rise in sea levels, by more water in rivers and streams or by over-filled sewers after heavy rain – or a combination of all three. Because of the multifarious nature of the urban water cycle, risk assessments are complicated and call for a number of tools to systematically assess and address risks. Thorough assessment will clarify which of the solutions are most suitable for investment in the different areas. These assessments are based on a set of criteria regarding required investments and potential economic gains and losses – in infrastructure, buildings and property value, in agricultural or industrial production, in cultural heritage and in public health.

The experience in Denmark, and from Danish consulting and technology companies working internationally, is that timely integrated urban planning is very important as a means of addressing the increasing risk of damage from extreme weather and rising sea levels. It is, at the same time, considered as an opportunity to create new urban water environments with high recreational value. By applying advanced tools combining statistical analyses, databases, spatial data (Geographical Information Systems - GIS) and deterministic modelling with economic prioritisation, it is possible to obtain a more accurate picture, so as to be able to take decisions and make the best investments.

Reducing the risk of flooding, Maputo, Mozambique *Like other African countries, Mozambique faces a growing number of extreme weather events. Historically the capital Maputo lacked adequate urban planning. A lack of decision-making tools compounded the problem of recurring floods. A new approach, which combines hydraulic principles with GIS analyses to predict flood risks and to adapt urban areas to climate change, is helping the Ministry for the Coordination of Environmental Action and the National Institute of Disaster Management to carry out appropriate urban development plans and disaster risk reduction. Investments have been made in airborne topographical scanning, institutional analysis and flood inundation mapping to increase the capacity and preparedness for urban adaptation to climate change. (courtesy: COWI).*

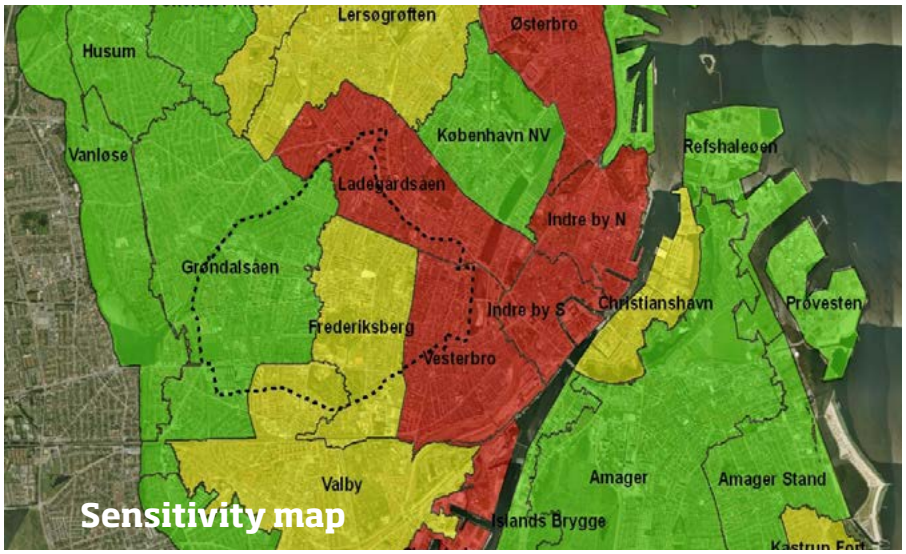
Hydraulic models for flood protection strategy, Prague, Czech Republic *After a severe flood in 1997 the Czech government adopted a flood protection strategy. The Prague Flood Model, developed by Danish water experts, was part of the strategy. Emergency plans for Prague city centre and the suburbs were updated based on model results, the weakest points in the flood defences were identified and suggestions for improvements were assessed. Based on those analyses, the first phase of flood protections for the Old Town was designed and implemented in 2001. Just one year later, in 2002, Prague experienced its worst floods in history, and the model showed its value in guiding the response of the city authorities. They were able to close mobile barriers at the right time and place to save lives as well as protecting the historical Old Town. The model has since been reassessed and updated regularly and has been used for the design of the complete flood protection system as well as in urban planning , including the drawing up of risk maps as required by the EU Flood Directive. Three years ago, an interactive tool, Operational Flood Maps, was introduced and has successfully been in operation since then. It is connected to eleven city water level gauges and enables the City Hall Crisis Management Department to estimate and forecast the extent of flooding.(Courtesy: DHI).*

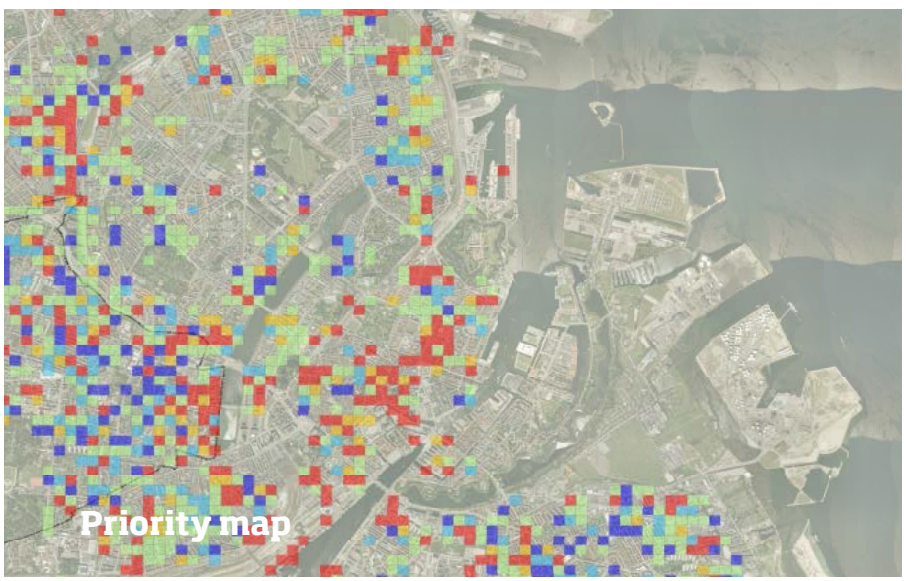
Tracing drinking water contamination during flooding, Tune, Denmark *Often flooding causes the contamination of water supply systems. The Tune Waterworks in Denmark faced this situation on several occasions in periods of heavy rainfall. In 2009 high levels of coliform bacteria caused a serious outbreak of severe diarrhoea. A series of water samples and a systematic technical risk audit of the entire waterwork system, including extraction wells and the distribution network, identified one particular extraction well to be the source of the problem. Detailed analysis showed that the well had been constructed with a minor stormwater pipeline designed to pump away rainwater from around the well head, but the construction had been altered ten years prior to the outbreak, and now sewage water was entering after heavy rain. Tune Waterworks closed down the well, intensified their water analysis scheme with rapid bacterial measurements, constructed an emergency waterworks and installed ultraviolet disinfection at the clean water exit point. (Courtesy: Rambøll).*



Urban development, Aalborg, Denmark *Flood maps are an invaluable tool for climate change adaptation planning. Combined with advanced mathematical models – and if based on ultra-precise terrain data collected with airborne laser scanning techniques – they provide precise answers to where flooding will occur and how rainwater will flow on the terrain surface after heavy rain. This combination of flood maps and advanced mathematical models was used in developing a former freight area close to the centre of Aalborg, Denmark's fourth largest city. The vision for this area is to create an innovative green neighbourhood. Local drainage of rainwater is planned, using rain gardens, green roofs and open channels. The load on the public sewer, which is a piped part of a stream, and the amount of rainwater reaching the downstream recipient is thereby considerably reduced. The sizing of the drainage systems has been calculated by prioritising areas with a tendency to flood. (Courtesy: NIRAS).*

Local rainwater drainage, Copenhagen, Denmark *Part of Copenhagen's water strategy is to reduce the risk of leakage from sewers, so a target has been set of handling 30 percent of rainwater locally. A model and decision-making tool for the use of sustainable urban drainage solutions (SUDS) has been developed. Investigations at plot level have shown the potential for infiltration of water using fascines, rain gardens or infiltration beds, green roofs and the recycling of water. For a district in northern Copenhagen the level of sustainable infiltration of water was then determined. Based on assembled data, the impact on groundwater levels has been assessed, taking into account potential sea level rises under an expected future climate scenario (Courtesy: Alectia).*





Risk and priority maps, Copenhagen, Denmark *In 2012 the City of Copenhagen was ready with a cloudburst plan and strategy for the greater Copenhagen area. The plan includes different overview maps showing flood risk, economical risk, sensitive areas and priority systems to avoid damage in the event of heavy rainfall. (Courtesy: COWI and Ramboll).*

4. Integrating stormwater opportunies with urban planning

Stormwater initiatives can be integrated with city planning creating more liveable cities

LYKKE LEONARDSEN
Head of strategy and authority
CITY OF COPENHAGEN

If wastewater and stormwater management are integrated at an early stage with the urban planning process, benefits and synergies can be obtained, making additional costs relatively small. Waiting until town planning is completed or until crisis events occur, only leads to more complicated problems and higher costs to resolve them. Considering stormwater as a valuable resource, not as a waste problem or a threat, during the planning process can reduce the cost of climate adaptation and give greater benefits, improving the city and people's lives.

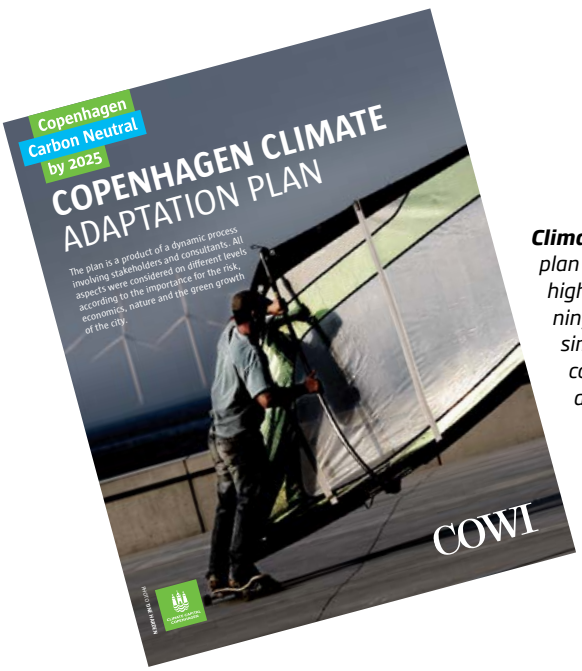
Expanding stormwater capacity

Stormwater drainage systems have to be very large to handle extreme weather events like cloud bursts and thunderstorms, often much larger than the sewerage systems currently in place. When planning for an expansion of the capacity, the most cost effective solution is often to integrate large structures like canals, lakes and storage basins into the stormwater system. When not used for stormwater, these systems can contribute in other ways, for instance, in creating green corridors that give shade and help cool the city. If the terrain is suitable, stormwater can be used for generating power, when it flows from a higher to a lower level.

Local rainwater drainage, Copenhagen, Denmark *In an urban area of Copenhagen, canals and lakes form the central feature with the layout of the channels and their edges defining different spaces within the environment. The huge development in the area is thus solved with the canals receiving run-off rainwater to offset the load on the existing drainage systems. The more polluted rainwater from roads and carparks is handled separately in the system to protect the quality of water.*

Handling normal rainfall

The handling of regular rainfall can be achieved through the city water system, locally in different neighbourhoods or by individual households. It can be infiltrated for use in the water supply, if this is dependent on groundwater. It can be retained for use as secondary water when lesser water quality is sufficient, thus re-



Climate adaptation strategy, Copenhagen, Denmark *A very detailed climate adaptation plan for Copenhagen is now complete. It contains detailed dynamic analysis of flood risk from high sea levels and heavy rainfall. The proposals it contains – for integration with urban planning in existing and new urban areas – are for dams, dikes, sluices, canals, circulation and similar systems for protection against flooding. The plan includes economic analysis of the consequences of flooding and of possible interventions based on sophisticated statistical and economic methods. The purpose is to identify the most appropriate interventions and timing for measures to avoid or reduce damage to infrastructure, water supply, sanitation and buildings. It also contains a summarised risk over a hundred year period for the optimised framework of action based on cost-benefit. The software MIKE Flood was used for dynamic modelling of the whole city and advanced GIS applications used for illustration, impact assessments and risk assessments. (Courtesy: City of Copenhagen and COWI)*

We need to rethink our urban design and spatial structures. In Northern Europe thirty percent of all built-up and paved areas are at risk from flooding

RIKKE JEPPESEN
Architect
RAMBØLL

ducing the load on drinking water resources. Or it can be harvested for recreational purposes, that also provide environmental and economic benefits.

Analysis to locate weak points

Many powerful analytical tools have been developed by Danish companies, including those which support an integrated approach. An initial screening can be performed with relatively little data while a very detailed analysis of the hydraulic performance of the whole integrated water system requires models of the soil conditions, sewerage network, canals, retention basins, surface conditions, elevation etc. The detailed analysis is then combined with modelling of the full dynamic hydraulic performance of different measures. This makes it possible to find the weak points.

Finding the right solutions

Identifying the best integrated solutions requires experience with stormwater handling and utilisation. Verifications can be done to the desired level of documentation for technical feasibility and economic feasibility with the use of the right data and decision support tools. In Copenhagen, the most feasible solution was found to be a combined approach with principal drains relieved by local drainage in combination with parks, green corridors, canals, roads and tunnels which store or transport water. Most structures provide additional functions for purposes like recreation or public transport.

Cost benefit analysis helps prioritise

A cost benefit analysis will help identify the most feasible risk level for stormwater protection. This is a calculation of the macroeconomic and financial effects of taking no action compared with making the city climate resilient to different levels of security. The economic risk is estimated based on the likelihood of an incident versus the cost involved in reducing the risk to a certain level. A cost benefit analysis also includes an overview of the economic effects on different stakeholders, break even points for different safety levels and the most feasible point at which to make the investment.

Master planning for urban development, Skolkovo, Russia *The Skolkovo Innovation Center is a new high technology industrial area near Moscow. It has ambitions to become a Russian version of Silicon Valley, hosting innovative front-runners, both Russian and international, and scientific institutions. A foundation established by the Russian president aims to develop the area of four square kilometres (1.5 square miles) into a smart, vibrant and sustainable city, setting new global standards for urban development and building design. The draft for the master plan was reviewed by Danish experts, as part of a feasibility study, and alternative, more sustainable design features were proposed. Focus areas are transport and mobility, energy supply and demand, water, wastewater, waste management and smart city concepts. In addition, a new active park with a sustainable office building of 6,000 square metres (65,000 square feet) and a 1,300 square metres (14,000 square feet) business centre has been designed. (Courtesy: Rambøll)*

Interdisciplinary planning, Hvidovre, Denmark *Climate change involves more than heavy rainfalls and rising sea levels. From an urban perspective a variety of areas will be affected. In Hvidovre, a suburb of Copenhagen, the need for a coordinated climate adaptation effort is being taken seriously. In recent years several episodes of flooding have occurred after heavy rains and the city's water supply has been seen to be vulnerable to flooding. The solution has been simultaneously to develop individual plans for the water sector, climate adaptation, water supply and wastewater. The approach has demanded a professional and interdisciplinary approach, and close cooperation between the municipality and the water utility. (Courtesy: Rambøll).*

Stormwater solutions, Fornebu, Norway *The former Fornebu International Airport in Norway closed in 1998 and has been transformed into a green and active residential area and public park with water as an important visual element throughout. The Nansen Park, a new section of the Fornebu park, was completed in 2008 and includes solutions for the managing of stormwater, green structures with gutters, cleaning ponds, retention basins and an outlet to the sea. (Courtesy: COWI).*

5. Controlling the risks in time

Health issues must be at the top of the agenda in managing urban water challenges. Plans for preventative measures must be in place.

CLAUS JØRGENSEN
Senior Biologist and Head of the WHO Collaborating Centre for Water and Health
DHI

In 1854, in London, England, John Snow identified contaminated water from a pump in Broad Street as the means of transmission of cholera. He persuaded the local authorities to remove the pump handle to prevent further transmission of the disease. That same year, Robert Koch proved that sand filtration of drinking water reduced the risk of cholera infection.

Snow and Koch are in many ways the forefathers of urban water management since they identified water related risks, and designed and implemented interventions as well as the means of monitoring their effect. Today we know much more about the hazards and risks related to water, not only the risks of becoming ill but also the risks of flooding and environmental damage.

Water related legislation on drinking, waste and bathing water aim to reduce these risks by setting standards and demanding monitoring. Water utilties, on the other side of the table, work hard to establish barriers and control measures to reduce the risks to an acceptable level, while still serving the needs of the urban population.

Tools for preventative action

In Denmark, the water sector has a long tradition of managing risk in the urban water cycle using advanced, knowledge-based tools such as models, sensors, data management systems and decision support systems. When integrated with information and communication systems, these tools offer the means for preventive and corrective actions and ensure due diligence in urban water management.

Sensors as input providers

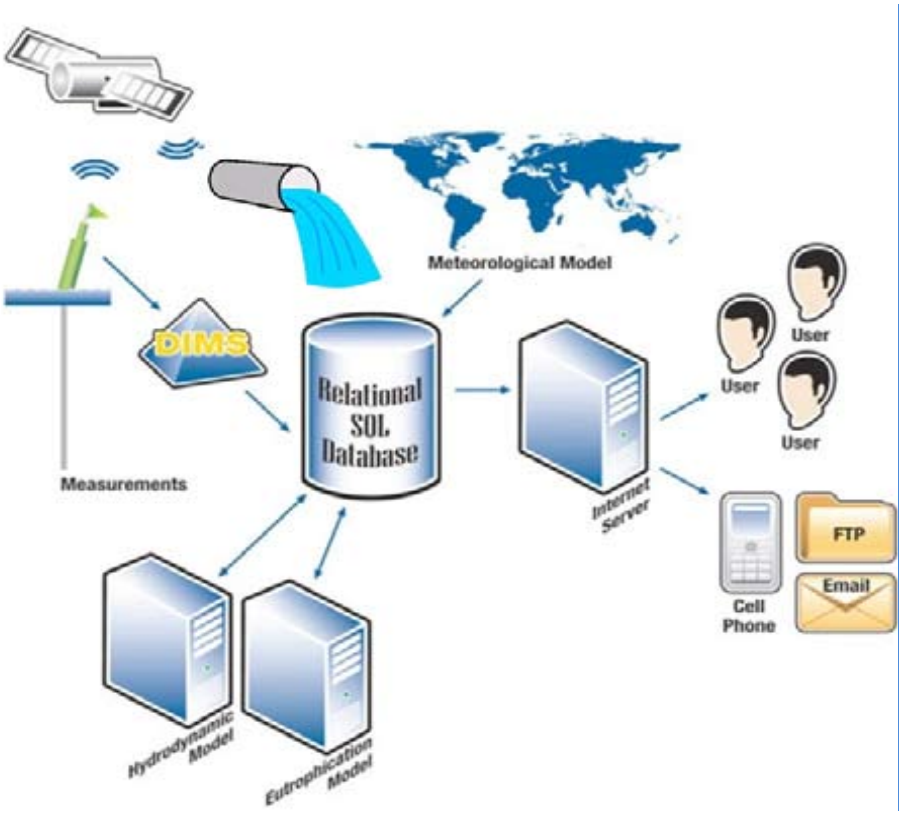
Models are used to gauge the effects of interventions, while sensors monitor operational parameters or directly detect hazards. Combined with process knowledge, the sensors provide the necessary data for optimisation and monitoring of the water and wastewater treatment process. Furthermore, sensors provide input to online models of sewerage systems, water distribution networks, river basins and so on, for intelligent management, early warning systems and decision support systems.

Prepared for extreme weather with intelligent handling, Copenhagen, Denmark *One of the main causes of wastewater pollution is the overflow that can happen during exceptional rainfall. Intelligent wastewater handling enables the treatment of a greater volume of wastewater using existing infrastructure, leading to fewer overflows and reduced pollution. A cost-effective system, the first of its kind, is now providing seamless co-ordination between sewerage systems and wastewater treatment plants at the Lynetten wastewater treatment plant that services 760,000 residents of Copenhagen and annually processes 80-110 billion cubic metres of wastewater (20,000 to 30,000 billion US gallons). (Courtesy: Lynettefællesskabet and Rambøll)*

Handbook *A handbook on the design of flood control solutions has been developed by Grundfos to assist application engineers, designers, planners and users of sewage and stormwater systems to incorporate axial- and mixed-flow pumps.*

Flood protection with advanced pumping solutions, Saint Petersburg, Russia *Saint Petersburg Flood Prevention Facility Complex is the principal line of defence in protecting the beautiful Russian city against flooding. The complex involves dams and related hydraulic structures extending over 25.4 kilometres (15.8 miles) and comprises two navigation passes with approach canals, six water gates, eleven protective dams and a six-lane highway with a tunnel, bridges and road interchanges passing over the protective dams. When a flood threatens, the dock chambers fill with water, the floating gates rise to the surface and are moved to the middle of the navigable canal reducing the impact of the storm surge on the Neva Bay water area. When the flood danger recedes, the floating gates are led back into the docks and the water is pumped out. The draining of the dock chambers is executed by advanced pumping equipment installed at each of the pump stations at the Northern and Southern sides of the navigable canal. All the pumps feature a special design and the pump stations are located in cast-in-situ reinforced concrete framing below the water line. The drainage water that may accumulate at the lower level of the hydraulic structure is installed at the level of 22 metres (72 feet) below the water line. (Courtesy: Grundfos).*

Calculations and visualisations with advanced software technology, Bangkok, Thailand *Calculations and mapping with advanced software technology, Bangkok, Thailand In 2011, huge floods submerged large parts of Thailand and the capital Bangkok with serious economic consequences. The government of Thailand has now teamed up with Danish water experts with the goal of saving lives, protecting infrastructure and flood-prone cities. The expected flow of water in the case of extreme flooding has been calculated and mapped, and software technology is now in place to advise on how torrential rain can be directed between reservoirs, extensive river systems and special areas selected for controlled flooding. Planning and early warning systems are due to be established to limit and control future floods, because it is already too late to try to prevent flooding once rain is falling heavily. A number of measures and a strategy for dealing with critical flooding situations must be in place weeks in advance. (Courtesy: DHI)*



Monitoring water quality at swim resorts
Taking a swim can present a serious threat to health when short-term pollution is caused by sewage overflow. To protect bathers EU legislation requires that water quality be monitored for the indicators of faecal pollution, E. coli and Enterococci. To overcome the shortcomings of traditional control systems, an online Bathing Water Forecast System has been developed in Denmark and has been in operation since 2002. The system provides water managers, as well as beach visitors, with a continuous evaluation of current bathing water quality as well as a forecast for the coming days. It is an online predictive tool making it possible for water managers to follow developments in water quality and reliably assess the need for short term action, such as temporary closure of the beach, or long term action, such as reduction of sewer overflows. The system uses sensors for the detection of sewer overflows and hydraulic modelling and estimation of the concentration of E. coli and Enterococci. The model can also be used to determine the risk of infection and to predict different scenarios. This is useful for water managers in considering the effects of planned actions. (Courtesy: DHI)

Stormwater solutions with multiple purposes, Roskilde, Denmark *Good collaboration between many parties is needed if the partners are to think in unconventional ways. Such was the case with a new stormwater storage solution in the city of Roskilde in Denmark. The storage tank serves a double purpose as a recreational facility for skaters. Close cooperation was successfully achieved between all the stakeholders, consultants and sub-contractors to get the unit to function optimally for different purposes and at the same time comply with the technical specifications. (Courtesy: COWI).*

Flood protection at high sea levels, Aarhus, Denmark *As described earlier in this white paper, the Aarhus River has been reopened step by step over two decades, reversing a decision taken 60 years ago to concrete it over throughout the city to the bay. A new urban waterfront will become reality when the last part of the river is reopened in 2014. This final phase is an comprehensive climate adaptation project giving the city an extensive lock system, and one of Denmark's largest pumping stations. It will protect Aarhus city centre against flooding from rising sea levels and in situations of excessive rainfall. The design of the lock and pump system is based on comprehensive water modelling expertise. (Courtesy: ALECTIA, Schmidt Hammer Lassen Architects, Architect Kristine Jensen).*

6. Developing the best solutions through stakeholder engagement

Cities get the most cost-effective solutions and better overall value when the authorities, citizens, urban planners, architects and water experts all work together with common goals

JACOB LARSEN
Director
ORBICON

In many countries it is common practice that proposals for public investment are offered up for consultation by experts, lawyers, organisations and the public before they go through, in order to avoid unforeseen situations. For more than a century public hearings have also been an important tradition in Denmark, both for small and large scale public projects. What may be more unique is the Danish tradition of inviting the most important stakeholders directly into the development process. By taking different perspectives and agendas into account, it is possible to achieve more satisfying and cost-effective solutions.

Engagement for successful solutions

Much can be achieved by introducing interdisciplinary cooperation across utilities, authorities and companies, and by involving stakeholders, including the citizen, early in the process. There will always be pros and cons for involving citizens in the development process, but extreme weather events – and the solutions to them – will affect citizens on a local scale directly, so the local area is one of the most important aspects to consider in the planning and design process. Citizens should be informed and consulted when planning water spaces in the city to avoid problems and get their support, which is important for the success of any solution.

Stakeholder involvement is manageable

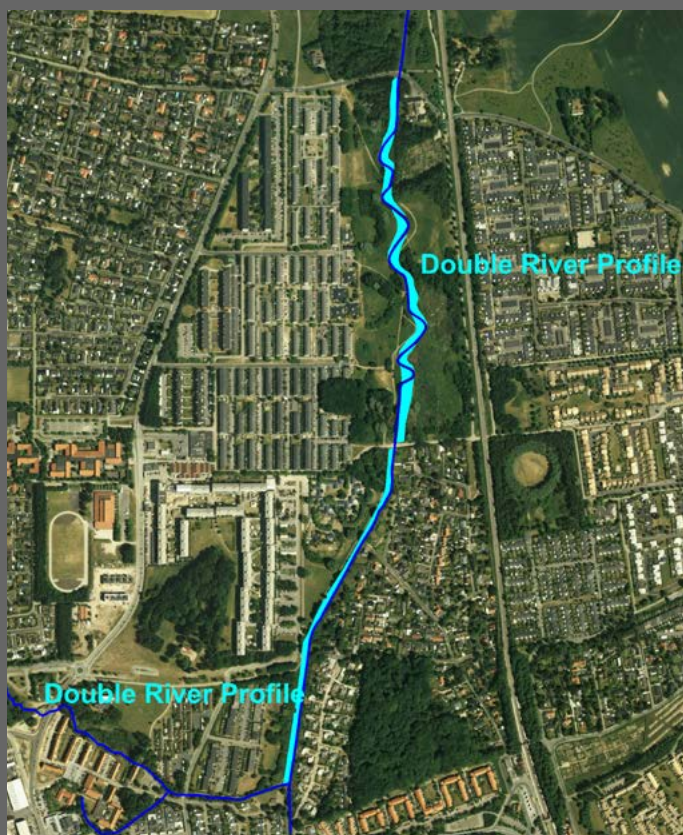
To achieve the smoothest flow in the initial design phase and subsequent construction, the process must be managed in a structured way and designers and engineers must be open to the opinions of others. For the best outcomes in integrating stakeholder opinions into urban planning projects urban planners must take responsibility for identifying suggestions and factors that are worth considering for both public and private stakeholders. They should present them in an understandable manner and create the right space for close dialogue. The negotiations that follow the presentation should be managed into specific topic tracks, to ensure not to lose sight of the goal, while including those who have interests and ideas for the projects. Experience with public process management is vital.

Engaging the citizen in the process of climate adaptation, Middelfart, Denmark *Two major floods convinced Middelfart, a historic market town in central Denmark, to develop a climate adaptation plan which, among other elements, includes the local retention of huge amounts of water. As public roads, private properties and gardens would be affected, the challenge was to get the public authorities and homeowners volunteering to work for a common cause, together rethinking the distribution of water. Sharing the common goal to improve recreational facilities while reducing the risk of flood damage spurred a visionary project in which the authorities, the water utility, consultants and citizens worked together. They created the input for technical, aesthetic and locally-based solutions for improved drainage of rainwater in a 450,000 square metres area (five millions square feet). An innovative process ensured that stakeholders, authorities and citizens were already involved in the preliminary project, which created the platform for an architectural competition. (Courtesy: Orbicon)*

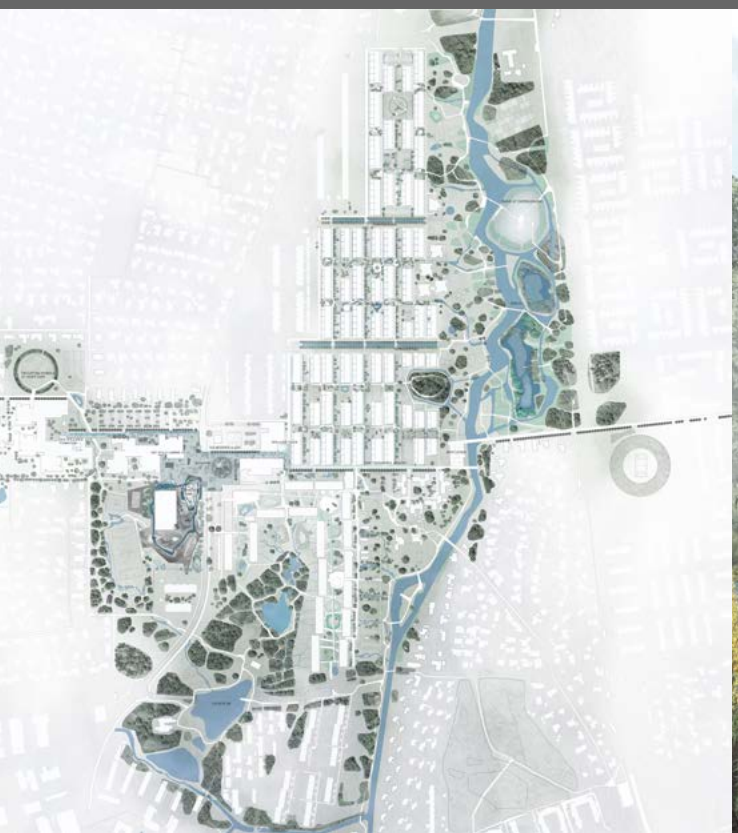
What's important in climate adaptation is to use a holistic and interdisciplinary methodology. It sounds easy, but it is not! Skills relating to the entire water cycle must be covered by the working team

Jens Brandt Bering
Business Unit Director
NIRAS

Step 1: Climate adaptation strategy, Usserød River, Kokkedal, Denmark *Heavy rainfall in 2010 led to severe flooding in a residential neighbourhood of Kokkedal, a town thirty kilometres north of Copenhagen. The river that runs through the town's various districts burst its banks for the first time ever. To avoid this terrible situation from recurring, the three municipalities that the river winds its way through decided to develop a joint climate adaptation strategy. A year later, after close collaboration between the administrations of the three municipalities and the water utilities, an effective climate adaptation strategy had been developed. The strategy was based on exact simulations of water flow in streams and sewers and of potential water levels. It contained three elements: strategy description, a catalogue of solutions and a joint contingency plan. As a first step, the river was rerouted to delay the water, and other preventive measures such as the construction of dikes undertaken to ensure the protection of low-lying residential areas. (Courtesy: NIRAS)*



Step 2: Local rainwater drainage integrated with urban development, Usserød River, Kokkedal, Denmark *Rainwater handling can be used positively to create more interaction between the inhabitants of a city, more beautiful areas and a safer environment. After implementing the first phase of its climate adaptation strategy development, the city of Kokkedal moved into a second phase, where local management of rainwater becomes an integral part of urban development. In 2013, the city will implement a climate change adaptation project, that with its 15 million euro budget will be the largest in Denmark. The ideas and plans have been developed and will be carried out by a landscape architecture firm in collaboration with an architecture firm and a consulting engineering company. The city council sees the project as an opportunity to regenerate the entire city and create a new beginning, making the place more liveable and safer than it is today. The vision is an attractive town centre with new paths and active places where citizens can meet for water games, skating, football, golf and much more. The project area includes a park, nursing homes, a sports centre, a shopping centre and five residential areas. Approximately 3,000 people live in the project area. Up to the first stage of development in August 2013, citizens will be involved in the completion of the project. (Courtesy: Schønherr, BIG and Ramboll).*



Citizen-driven problem solving, Odense, Denmark *A new recreational area is the result of innovative cooperation between landowners in the city of Odense and Odense Water, solving the problems of flooded basements after heavy rain. Since 2005, the area had been seriously affected three times by stormwater that neither sewers, storm sewers nor flood retention basins could prevent. The local residents came up with the idea that Odense Water might buy some of the flooded properties to extend an existing flood retention basin. This was by far the cheapest solution and meant that residents could lay their fears to rest. (Courtesy: Odense Water - VCS Denmark).*

Energy efficiency and integrating water for a liveable city, Nanjing, China *Sustainable urban development plans for the Nanjing High Tech Zone on the west bank of the Yangtze River in China were designed to make the semi-developed area greener and more attractive for both businesses and citizens. The concept was to rethink and upgrade urban planning in the area to shift the development in a more sustainable and innovative direction, while at the same time safeguarding the growth of the city and ensuring its climate resilience. Solutions that would improve existing town plans, reduce energy consumption and create a greener and more healthy environment were developed in cooperation with Danish urban water experts. As a result, the water infrastructure of the city was transformed from occupying ugly technical-looking structures to being an integrated part of city life. The newly developed structures are used as green areas, recreational spaces, transport corridors for soft traffic, rest places, wetlands for water treatment and so on. At the same time the capacity of the water transportation and storage areas has increased making the city more climate resilient. (Courtesy: COWI)*

If your goal is water efficiency, Denmark is ready as a partner

Danish water companies have shown their courage and drive by working with their competitors in order to create the Rethink Water platform. They are showing the world that Denmark is ready to take responsibility and contribute to finding solutions to the major water challenges the world faces.

IDA AUKEN
Minister for the Environment
DENMARK

Geographically, Denmark may be only a tiny speck in the Northern Hemisphere, but our country has one of the world's longest coastlines and it is the world's largest shipping nation. The water in the harbour of our capital, Copenhagen, is so clean that people swim in it, and our tap water is as pure as the finest spring water.

Our knowledge about water is no coincidence. It began long ago, when we as Vikings spread fear and terror across the seas. Today, we want to spread something entirely different: knowledge and collaboration on how to improve water safety and water efficiency.

Denmark knows water

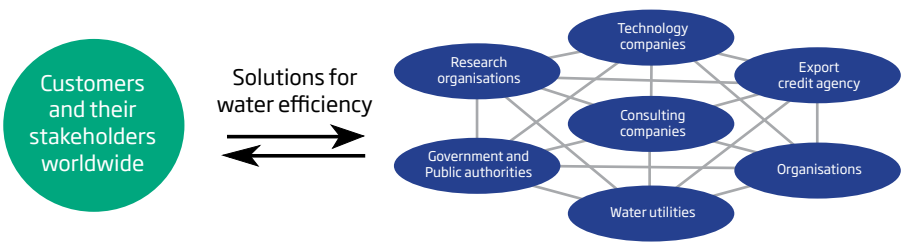
Denmark is not physically powerful, but we believe that knowledge is power. We know about water efficiency, because successive governments have addressed our country's limited natural resources, concentrating on using them efficiently. As a nation we are known for our ability to collaborate and for the fact that we strive to provide a safe, pleasant and healthy environment for people to live in.

Knowledge transfer for mutual benefit

Our expertise is in helping customers and stakeholders reach safe and effective water solutions, while developing their ability to profit from that knowledge in turn. We do our work while maintaining a healthy respect for different perspectives and agendas, as well as for the environment. As a country, we see great opportunity for mutual benefit in the transfer of knowledge and the growth in both partners' business.

Rethinking water together

Rethink Water is a network of over fifty Danish companies, organisations and institutions, specialising in water efficiency. The network brings together an unusually diverse and valuable mix of clients, researchers and governmental bodies, who have joined forces to share knowledge and expand business. Water is an increasingly scarce resource in most parts of the world. We need to rethink how we use it. That is why our name is Rethink Water.



Find more white papers, learn more about the Rethink Water network and get in touch with us at:

www.rethinkwater.dk

Consulting companies

Alectia	alectia.com
Bonnerup Consult	bonnerup.net
COWI	cowi.com
EnviDan	envidan.com
Gromtmij	grontmij.dk
Moe & Brødsgaard	moe.dk
Orbicon	orbicon.com
NIRAS	niras.com
Rambøll	ramboll.com
TREDJE NATUR	tredjenatur.dk
Øllgaard	ollgaard.dk

Technology companies

Adept Water Technology	adeptwatertech.com
Aquaporin	aquaporin.dk
AVK	avkvalves.com
Billund Aquaculture	billund-aqua.dk
Biokube	biokube.com
Danish Rootzone Technology	rootzone.dk
EcoBeta	ecobeta.com
Freewater	freewater.dk
Grundfos	grundfos.com
HOH BWT	hoh.com
I -GIS	i-gis.dk
LiqTech International	liqtech.com
MJK Automation	mjk.com
Mycometer	mycometer.com
NOV Flexibles	nov.com/fps
Novozymes	novozymes.com
OxyGuard International	oxyguard.com
PROAGRIA Environment	proagria.dk
Robotek	robotek.dk
Scandinavian No-Dig Centre	no-dig.dk
Siemens	siemens.com/energy/aeration
Silhorko-Eurowater	eurowater.com
SkyTEM Surveys	skytem.com
Stjernholm	stjernholm.dk
UltraAqua	ultraaqua.com
Wavin	wavin.com
Aarhus Geophysics	aarhusgeo.com
Per Aarsleff	aarsleff.com

Research institutes & demonstration projects

Danish Technological Institute	teknologisk.dk
DHI	dhigroup.com
Geological Surveys of Denmark and Greenland	geus.dk
Kalundborg Industrial Water Demonstration Site	symbiosis.dk

Water utilities

Greater Copenhagen Utility	hofor.dk
VCS Denmark	vcsdenmark.com
North Water	nordvand.dk
Aarhus Water	aarhusvand.dk

Organisations related to water

Copenhagen Cleantech Cluster	cphcleantech.com
Confederation of Danish Industry	di.dk
Danish Water Technology Group	dk-water.com
Danish Water and Wastewater Association	danva.dk
Danish Water Forum	danishwaterforum.dk
Danish Water Services	danishwater.dk
State of Green Consortium	stateofgreen.com
Water In Urban Areas Network	waterinurbanareas.dk

Governmental bodies & other sponsors

City of Copenhagen	kk.dk
Capital Region of Denmark	regionh.dk
Danish Trade Council	um.dk
Danish Ministry of the Environment	mim.dk
Danish Nature Agency	naturstyrelsen.dk
The Branding Denmark Fund	mfonden.dk

State of Green
Join the Future. Think Denmark

DWF
Danish Water Forum