



# Water in the sustainable city

Cities worldwide are facing growing challenges in storm water management. This working paper compiles experiences from Copenhagen, Dordrecht, Hamburg, London, New York and Seattle, based on interviews and a conference held in Gothenburg, Sweden in November 2014.



# Process of change: Successful implementation of good water management practices in six cities

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## Background

Urbanization is a continuous and growing process all over the world, as it is in Sweden. At the same time, we are threatened by climate change, which will affect us all wherever we live. The degradation of the environment is counteracted by many means, but new threats continue to emerge. Nine out of ten catastrophes globally are connected with water – too much water or too little. In the face of what might seem to be a dark future, many cities have taken steps to plan for a brighter future. Some cities focus on climate change, some on environmental threats, and others take a holistic approach and plan for a better, healthier, and economically vibrant city under all circumstances.

The same is also true for many Swedish cities. In doing so, they are constantly looking for good examples abroad. In order to facilitate this searching for advice and good examples, Swedish Water House started a project designed to describe the planning processes in cities that are known to have dealt with the problems in a way that might be also interesting in the Swedish context. At the same time, the City of Gothenburg is in a planning phase where they explicitly express interest in learning from other cities. It was decided to arrange the “Water in the Sustainable City” (“Vattnet i den hållbara staden”) conference, which drew together representatives from cities that could help Gothenburg on their journey.

The six cities selected to be included in this report are:

- Dordrecht, the Netherlands
- Hamburg, Germany
- London, UK
- Copenhagen, Denmark
- New York, USA
- Seattle, USA

# The conference

The conference “Water in the Sustainable City” was held in Gothenburg in November 2014. It was well attended by some 300 participants from Sweden and abroad. The conference was recorded and shown on Swedish Television’s Kunskapskanalen in January 2015. Video recordings of the presentations are available at [www.ur.se/Produkter/187040-UR-Samtiden-Vattnet-i-den-hallbarastaden-Det-nya-Goteborg#Alla-program-i-UR-Samtiden-Vattnet-i-den-hallbara-staden](http://www.ur.se/Produkter/187040-UR-Samtiden-Vattnet-i-den-hallbarastaden-Det-nya-Goteborg#Alla-program-i-UR-Samtiden-Vattnet-i-den-hallbara-staden).

**Method** | The contents of this report is based on two sources:

1. The conference “Water in the Sustainable City” in Gothenburg 12-13 November, 2014
2. Interviews with decision-makers and professionals in the six cities represented at the conference

Interviews were conducted before the conference with representatives from Dordrecht, Hamburg, London, Copenhagen, New York and Seattle. The interviews were conducted by Per-Arne Malmqvist, Helene Sörelius and Brita Forsberg for SP-Urban Water Management.

The aim of the report is to facilitate comparisons between the cities and their different processes of change. The report was written on behalf of SP-Urban Water Management by Brita Forsberg, Per-Arne Malmqvist and Helene Sörelius.

- What are the overarching sustainability goals: Growth? Environment? Climate change and adaptation? How are the goals described?
- Are there specific plans for water or is water included in general planning?
- How and where was water used and incorporated into recent development projects?
- Who was the main driving actor?
- Was the formal planning process politically driven or driven by other actors?
- What was the level of participation and involvement of citizens, enterprises, local associations?
- How important were economic factors in terms of increasing focus on water?

- Were there opposition and/or alternatives? How were conflicts avoided or managed? Were compromises made? Are people satisfied? Which groups are unsatisfied? What do they dislike?
- How much media coverage was there?
- What would you change if you were planning a similar project now?

## Main organizers

**Kretslopp och vatten** (The Department of Sustainable Water and Waste Management), City of Gothenburg, is a municipal department working to create a closed loop society including water supply, wastewater treatment and waste management.

**Dag@Nät** (Storm water & pipe networks), Luleå Technical University, engages in research and development in sustainable solutions in co-operation with public and private actors.

**VA-teknik Södra** (Water and wastewater technology), Faculty of Engineering, Lund University, is a programme that seeks to strengthening research, development and education within the water supply and wastewater treatment sectors. It is one of four clusters supported by Svenskt Vatten/ the Swedish Water and Wastewater Association.

**SP-Urban Water Management** is a development and consultancy company working with strategic planning of water supply and wastewater treatment.

**Swedish Water House** is a unit at SIWI that provides meeting places for innovative thinking on emerging issues, knowledge dissemination and multidisciplinary policy development concerning the global water situation.

Several other research and professional organizations also took part in the planning of the conference.

# City Blueprints: Water and climate adaptation challenges in cities

It was stated in the report from the World Economic Forum 2014 that water is number three of the top ten global risks – and rising in importance – after “structurally high unemployment/underemployment” and “fiscal crises in key economies”.

Water is an important and urgent issue. Cities are the main problem holders but also solution providers. However, time for action is limited. The current EU Smart City policy focuses on digital and telecommunication technologies, as well as energy and transport to improve the quality of life of citizens and make cities more sustainable. The primary focus is not on water, waste water, climate change mitigation and adaptation, housing and solid waste etc.

The UN estimates that the world population will grow from 7 to 9.3 billion between 2011 and 2050, and that the number of people living in cities will increase from 3.6 to 6.3 billion, while the number of those living in rural areas will decline. This means that world population growth will be absorbed by cities. Together with migration from rural areas to cities, during this period more than 200,000 people – every day – will need to find a new place to live in an urban environment. In other words: another 5,000 Gothenburgs will need to be built to 2050.

Unsustainable urbanization and climate change leads to heat-island effects, drought and flooding. In 2011, Copenhagen received 150 millimetres of rain in just two hours causing damage at a cost of nearly EUR 1 billion.

According to the International Institute for Applied Systems Analysis, (IIASA), these kinds of costs will increase in Europe from an average of EUR 5 billion to EUR 24 billion by 2050. Furthermore, the frequency of extreme weather events will increase from once every 16 years to once every 10 years.

According to UNEP, costs related to water infrastructure will amount to EUR 23 trillion to 2030. It is very likely that inaction will be more expensive than timely steps to refurbish or construct new cities and to implement better practices, including climate mitigation and adaptation measures.

On its own, technology is insufficient. Good governance is also important, including the active involvement of citizens in the development of new organization models for a new generation of services, and a greener, healthier lifestyle. We need to learn from mistakes and best practice to improve our cities.

Cities need to start investing in adaptation measures based on long-term visions and strategies, and in sharing best practice. Politicians should not focus on short-term success, but on long-term planning and implementation as cities have a long generation time. The longer political leaders wait, the more expensive adaptation becomes, and the greater the danger to citizens and the economy.

Good water governance will lead to attractive water-wise cities, where less water is used, more water is reused, and where surface water and groundwater will be less polluted.

## Messages

- Demonstrate that the longer political leaders wait, the more expensive adaptation becomes, and the danger to citizens and the economy increases.
- Present questions, and proposals, to politicians that they are likely to find easy to accept.
- Do not just try to persuade but even emotionally convince politicians.

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The conference presentation was made by C. J. (Kees) van Leeuwen, Principal Scientist KWR Water Cycle Research Institute and Professor of Water Management and Urban Development, the Netherlands.

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## Dordrecht, The Netherlands

Dordrecht is the oldest city in the Dutch area of Holland and until 1421, it was the most important as well. It prospered on taxes on imported goods. But in 1421, a big flood hit the city. Food and agriculture on the hinterland were destroyed, and its prime location gone. Now it lies below sea level on reclaimed land. Twenty-six per cent of the Netherlands is below sea level. Spatial planning is regulated by the government.

The island of Dordrecht is threatened by flooding due to high discharges from the Rhine and Meuse rivers from one side, and from storms at sea from the other. The historical centre, which is not protected by a structural defence, is flooded on average once every five years. People say that they would not accept flooding twice a year, but if it happened it would still not be a reason for them to relocate. There are over 1,000 historic monuments in this area, and the protection of houses against flooding must be done by inhabitants themselves as it is not a state responsibility. The City of Dordrecht is responsible for the provision of sandbags in case of extreme high water, early warning systems and crisis management.

Dordrecht is an “island city in the water” with 120,000 inhabitants. The city pays special attention to how to deal with rivers and the sea, but has also an integrated strategy to manage storm water, sewage and water supply.

Extra retention facilities have been built. Barriers have been built with road surfaces on top of them, and storage basins have also been installed.

Wielwijk is an area within the primary defence structure with poor building standards and social problems. Renovation plans, which actively involved inhabitants, included a water plan, a new sewage system, redirection of a busy road, the creation of recreational areas with retention facilities, and a policy to encourage walking or biking to the city centre.

The former harbour area, Stadswerven, will be rebuilt with modern buildings along the quays which are flooded daily from time to time. Water velocity is low in the sea and rivers, so new solutions need to be tailor-made by designers. New designs quickly needed new norms and co-operation models included in a flood risk management plan, a city development plan, a crisis management plan, as well as a policy and governance plan that covers norms, roles and responsibilities.

Dordrecht is initiator and lead partner of the Managing Adaptive Responses to changing flood risk initiative, (MARE), as well as other projects giving it a substantial amount of exposure. This, in turn, is of interest to politicians, and the city has won an award for having the best urban water plan in the Netherlands.

Programmes in which Dordrecht is an active or lead partner:

- Interreg IVb North Sea Programme Projects
- MARE (2009-2012)
- Climate Adaptation Mainstreaming through Innovation (CAMINO) (2013-2015)
- LAA/Network: Learning and Action Alliance of public and knowledge institutes, national- regional- local government, city to city (transnational) learning

#### **Dordrecht interviews**

- What are the overarching sustainability goals: Growth? Environment? Climate change and adaptation? How are the goals described?

Hurricane Katrina in August 2005 was the wake-up call for Dordrecht and the start of the flood risk management plan that involves all public organisations from the government to citizens. Dordrecht is a key partner in several studies on climate change adaptation and water management, so awareness in the city is high.

The city has an extensive network of district heating which is powered by a local waste-treatment plant. The use of wind energy is also set to increase in the years ahead. The island's CO<sub>2</sub> emissions are reduced by an active commitment to solar energy, (home-owners are encouraged to install solar panels on their homes).

Government goals are translated into plans at multiple scale levels by civil servants.

- Who was the main driving actor?
- Was the formal planning process politically driven or driven by other actors?

Spatial planning is regulated by the government.

- Are there specific plans for water, or is water included in general planning?

There is a special water plan, and overall water concepts are incorporated in the city-wide structure plan. A very important issue in all new developments is the prevention of negative effects on local water bodies by creating a robust sewerage system combined with (temporary) storage in public spaces.

- How and where was water used and incorporated into recent development projects?
- What was the level of participation and involvement of citizens, enterprises, local associations?

The planning process had a large political and administrative involvement together with companies, project developers and Rijkswaterstaat, the Ministry of Infrastructure and the Environment. The city administration works closely with the Water Board. Residents were only involved late in the process.

Dordrecht communicates with citizens to build awareness, and provides information on how to protect properties. Water campaign weeks are held regularly. The city has 1,200 local water ambassadors who act as facilitators. The "Urban Flood Management Walk", is a local attraction in the historical centre of the city.

- How important were economic factors in terms of increasing focus on water?

The Flood Risk Strategy is based on a multilayer-safety concept. This strategy uses all existing landscape features and comprises a solution for the 'what if' scenario. When a dike is breached, an emergency strategy and an evacuation plan are in place. The first layer is protection, (through structural defence). The second layer is prevention, (spatial planning solutions); and the third layer is emergency planning and crisis management.

Centuries of building under the influence of high water have resulted in historic buildings that are beautiful examples of adaptable construction. The quality plan recently

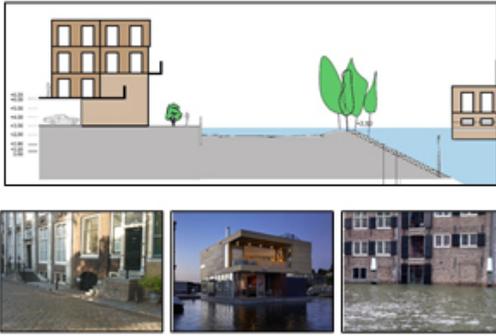
Dordrecht in The Netherlands is fighting against the power of tidal water. Stadswerven, a former industrial area, will have modern buildings that can withstand daily flooding. drawn up for new buildings in the city described this as an inspiration for new constructions. The urban plan launched diversity in the construction height: as high as necessary for safety but low and experimental where possible. This allows for a diversity of housing types. This approach is clearly different from the traditional one.

#### **Messages from Dordrecht**

- Mainstream investments and combined investments for renewal or maintenance with adaptation measures.
- Involve residents, invite them, listen to them, build and keep track of relationships.
- Shape a learning and action alliance that enhances political interest – this will also lead to greater resource allocation.
- Adapt with public and private partners.

### Urban plan Stadswerven – spatial planning

Photo and illustration: City of Dordrecht



Dordrecht in The Netherlands is fighting against the power of tidal water. Stadswerven, a former industrial area, will have modern buildings that can withstand daily flooding.

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## Hamburg, Germany

Hamburg is situated in the north of Germany and is surrounded by a network of rivers, (the Elbe, Alster and Bille). Due to proximity to the North Sea, Hamburg is also exposed to tidal water. The city is Germany's second largest city with some 1,770,000 inhabitants. Hamburg is growing rapidly, and there are plans to provide 6,000 new affordable residential units per year. Like so many other cities, Hamburg was hit by intense rainfall in 2011. The event took place on 6 June and resulted in widespread flooding due to 500 mm rainfall in just a few hours. Hamburg's average annual rainfall is 733 mm.

In 2009 the RISA project, Rain Infrastructure Adaptation, was established. The project ended in 2014. It was organised in four inter-disciplinary working groups: urban drainage; urban + landscape planning; traffic planning; river basin management.

One of the main tasks of the "urban + landscape planning" working group was to analyse the planning process in Hamburg with respect to water/storm water. Several projects have been studied from the design competition to the zoning process and implementation.

The results are as follows:

- Complex arrangements of responsibilities between ministry, local authorities and agencies
- Too little awareness among urban, landscape and traffic planners of issues concerning water and the necessity to consider climate change
- The belated involvement of water-related expertise and too close boundaries of project areas
- Too little reference to topographic issues on site
- Insufficient political backing
- Insufficient monitoring of the implementation, too few human resources

Based on these results the following recommendations have been prepared to reinforce the value and significance of the topic "(storm)water" in the planning process:

- Develop an integrated city-wide plan for Hamburg with focus on the aspects "City-Water-Landscape" as a basic concept for new development but also for the retrofitting of existing urban areas
- Develop additional water-related planning instruments at the zoning plans level – "Wasserwirtschaftlicher Begleitplan"

- Encourage multifunctional use of areas (open spaces and traffic areas)
- Offer training and professional exchange between members of the local administration
- Create clear lines of responsibility between ministry, local authorities and agencies.

The working group “urban drainage” was focussing on providing new GIS planning tools, e.g. a map illustrating the potential for infiltration in Hamburg as well as a map showing the potential to disconnect private properties from the sewer system. In 2012 Hamburg introduced a storm water tax giving property owners a reduction on the storm water bill if they implement sustainable urban drainage systems on their private property.

As part of the RISA project Hamburg has published a handbook on the design and construction of water-sensitive school yards. There are several pilot schools where the new strategy has been implemented.

### Hamburg interviews

*What are the overarching sustainability goals: Growth? Environment? Climate change and adaptation? How are the goals described?*

Growth and climate change are the most important goals with the overall vision “a green, inclusive and growing city by the water”. The urban population is changing, and changing the city in the process. The overriding development objective will be “More City in the City”.

The International Building Exhibition 2013 shows real-life building projects integrated in the general planning for Hamburg.

*Are there specific plans for water or is water included in general planning?*

In the overall vision water is only included in the general description but there are several plans which are focusing on water (open water bodies and the sewage system), such as flood risk management plans, plans for the implementation of the EU water framework directive and other plans for the sewage system.



Photo: Johannes Gerstenberg

“A green inclusive, growing city by the water” is the Hamburg vision. Older residential areas are upgraded and new affordable housing is added. When investing in refurbishing and new buildings there are also investments in green and beautiful infrastructure to reduce flood risks.

*How and where was water used and incorporated into recent development projects?*

Hamburg has been working on new concepts for storm water management and climate protection since 2007.

Hard-made surfaces, built-up areas, and changing precipitation patterns resulted in an increase in storm water runoff which has to be managed in terms of quality and quantity. New legal and quality demands concerning storm water management and flood management are in place.

*Who was the main driving actor?*

The State Ministry for Urban Development and Environment of Hamburg, Behörde für Stadtentwicklung und Umwelt Hamburg, and the Municipal Water Company, Hamburg Wasser, started the RISA project in 2009 (RISA = Rain InfraStructure Adaptation). The aim is to develop a structural plan for rainwater 2030 to achieve flood protection, water protection and near-natural water balance.

*Was the formal planning process politically driven or driven by other actors?*

Rainwater management is a municipal, joint task. RISA is a huge project technically, politically, administratively and legally. It seeks to integrate water management into urban and regional planning by including, for example, spatial and traffic planners, urban drainage and water body planners, and civil engineers.

The results of RISA need to be scaled down to major points into a so-called “Senatsdrucksache”, i.e. a legal document, which is published by the Hamburg government for the Hamburg Senate, which is discussed by various officials and political districts. This process is necessary to ensure that the structural plan gets a binding character. In order to prevent obstacles for a successful implementation the “Senatsdrucksache” is being discussed with several stake-holders before it is presented to the Hamburger Senat.



Photo: Dörthe Heien

Hamburg is a fast growing large city influenced by rivers, the sea and tidal water. The big flooding in June 2011 made it clear that urban planners and water specialists must cooperate to create a sustainable and safe city.

*What was the level of participation and involvement of citizens, enterprises, local associations?*

The communication concept of RISA ensures information provision and education of all relevant stakeholders, (citizens, municipal and political administrations, operating companies for drainage systems and water bodies, consultancy and engineering companies, universities, etc.).

*How important were economic factors in terms of increasing the focus on water?*

They were important. Overall cost projections for rainwater management in Hamburg to 2050 were made. The Water Framework Directive and the Floods Directive are being implemented. In 2011 Hamburg accomplished the preliminary flood risk assessment, and published flood hazard maps and flood risk maps in 2013. Affected residents fear a capital loss for their properties due to the new legal requirements. Making clear how important such measures are to protect Hamburg from flooding – now and in the future – is challenging.

*Were there opposition and alternatives? How were conflicts avoided or managed? Were compromises made? Are people satisfied? Which groups are unsatisfied? What do they dislike?*

People feel that climate change is really taking place – which helps us make clear that urban infrastructure has to be adapted.

Collaboration between different stakeholders in stormwater management has improved through RISA. The “stormwater management” issue is high on the political agenda. The general conclusion is that compromises could be made without conflicts.

*What would you have changed if you were planning a similar project now?*

Several smaller projects are easier to manage than one large project; finding a good balance between interdisciplinary work and result orientation.

## Messages from Hamburg

Planning instruments are necessary as is a city-wide integrated water plan with a focus on water including urban and landscape aspects. There should be a water management support plan at the same level as zoning plans with the aim of reinforcing the value and significance of water during the planning process.

Important working steps to implement integrated storm water management (based on the results of the PhD thesis by Elke Kruse):

- Form an interdisciplinary team (water managers, urban/landscape planners, traffic planners etc.)

- Identify priority areas on a city-wide scale which are focusing both on water but also on public space
- Consider the different urban structure types for the implementation of sustainable urban drainage systems in the city
- Analyze infiltration capacity, availability of space etc. on a city-wide scale
- Write a vision and guidelines and secure support through a political resolution
- Generate a city-wide plan or an integrated master plan
- Implement pilot projects and involve the public

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# London, UK – The Thames Tideway Tunnel

In 1860, London had two million inhabitants. In 1910, there were four million, and in 2013 more than eight million. The Greater London Area is home to more than 12 million people. London is situated by the Thames, a tidal river, and is regularly flooded. The scale of the overflow problem is huge. On average, 39 million cubic metres of untreated sewage and rainwater are discharged to the Thames in a typical year, with an average of 50 discharges. In 2013, approximately 55 million cubic metres were discharged into the Thames. The densely populated city and combined sewers from the Victorian era are the main reasons for this.

Thames Water was asked by the UK government to provide a solution to the discharge problems, and EU demands to meet the Urban Wastewater Treatment Directive. They suggested a tunnel, (the Thames Tideway Tunnel), as the most cost-effective solution. Thames Water is a private water utility and the UK's largest water and wastewater services company. It supplies around 2,600 million litres of tap water to some nine million customers across London and the Thames Valley daily. It also removes and treats more than 4,000 million litres of sewage for 15 million customers.

Sustainable Urban Storm water Drainage Solutions, (SuDS), are not considered sufficient as a single solution, but will be implemented locally or targeted to complement the tunnel and prevent growing problems in a growing city.

The Thames Tideway Tunnel is a classic water infrastructure technology project. The tunnel will be 25 kilometres long, and have a width of 7.2 metres. It will intercept 34 Combined Sewer Overflows, increase storage capacity and capture 95 per cent of the waste water that would otherwise be discharged into the Thames when it enters service in 2023. Construction is due to start in 2016.

Around £1.4 billion of the Thames Tideway Tunnel's construction cost will be financed by Thames Water, and £2.8 billion by Thames Tideway Tunnel Ltd. Thames Water's contribution will fund development costs, enabling works and interface works. During 2013, Thames Water was looking closely at the costs and benefits of the proposed programme of work until 2020 with the economic regulator, Ofwat. The total cost will be determined by Ofwat in a forthcoming price review.

Planning took six years. It was based on the Planning Act 2008 and included upgrading of wastewater treatment works as well as regular public consultations with a variety of stakeholders. These measures will sell in the need for the tunnel investment and give people what they pay for – a cleaner, healthier river.

Thames Water has actively engaged with stakeholders about the Thames Tideway Tunnel. Stakeholders are any individual or group that has an interest in Thames Water. They include customers, employees, regulators, shareholders, suppliers and the wider community, national, regional and local governments, MPs, the Consumer Council for Water, and non-governmental organizations and pressure groups. The Stakeholder Engagement team oversees communications for major engineering projects, liaises with local, regional and national government, and undertakes public consultation exercises, community engagement and customer research.

## **Interview with Phil Stride, Thames Tideway Tunnel**

Thames Water is a private company tasked with managing water and wastewater services in the London area. London differs in this respect from the other cities being interviewed. Therefore, another set of questions was developed.

*What role does Thames Water play when it comes to urban planning in London? Are you active in committees etc., when the city develops long-term and short-term plans for sustainable water management? (Urban drainage included).*

The Greater London Authority is responsible for city planning. It develops the strategic "London Plan". Local planning is conducted by the 32 London boroughs. Thames Water is consulted on water and wastewater service issues. Thames Water does not have an equal voice in planning matters, rather, it has a consultative role. The relations and roles in planning have changed little since responsibility was in the public sector.

*It is easy to understand the benefits of the Tideway Tunnel and which problems it solves. Yet there might have been alternatives upstream – SuDS of different kinds. To what extent was this considered in the planning phase?*

A comprehensive study on water quality in the Thames resulted in four options, among them upstream solutions with SuDS, and the tunnel, which turned out to be the most sustainable and economical alternative. It was the only one that fully met environmental standards and EU directives. The SuDS alternative would have cost considerably more and taken up to 40 years to complete. The London Plan supports all kinds of SuDS, as does Thames Water.

*Would upstream solutions be within the jurisdiction of Thames Water?*

It is the responsibility of the London boroughs. But in one district, Counters Creek, flooding was a serious problem. Thames Water started a multi-faceted project to meet this challenge. Improved sewers and SuDS of different kinds were among the measures taken.

*Was there any debate during the planning phase? What was the debate about? Who were the main opponents?*

The sewer system in London is very old, and the city is very dense. Some people, mostly academics, argued for green solutions, but these should be seen as complementary elements, not the main solution. Three kinds of opponents were taking part in the debate, academics, and action groups, and property owners who would be directly affected.

*Was there political consensus for the decision to build the tunnel?*

The decision for the tunnel project was made in political consensus, across the parties.

*Was the tunnel considered to be the most sustainable solution? Or the most economical?*

The tunnel is definitely the most economical choice. If it is the most sustainable choice depends on how you define sustainability and where you draw the system boundaries – if you include transportation, carbon footprint etc.

The alternatives may be more sustainable in some respects but probably not from an overall standpoint.

*How is the tunnel project received by the public? By the media?*

Regular market research is carried out in support of decision-makers. Most of the eight million people in London support the tunnel, only a small minority are against it. The media reflects this. Of course there are positive and negative stories. The recently received planning permit was welcomed by the media, although not universally.



Thames Tideway Tunnel in London is a gigantic project aiming at making the river Thames cleaner.

### Recommendations

- Use Sustainable Urban Storm water Drainage Solutions as much as possible;
- Consult with people, with stakeholders;
- Sell in the need you have; comfort their worries and give them what they pay for.

## London, UK – Sustainable Urban Storm Water Drainage Solutions, SuDS

The US expression for SuDS is BMP, Best Management Practices, and in Sweden LOD, Lokalt Omhändertagande av Dagvatten (Local Storm Water Management).

Richard Ashley, Sheffield University, has a background as a sewer inspector in the Greater London Area. Ashley opposes the Tideway Tunnel because he believes that SuDS, sustainable drainage systems, are far more sustainable, as well as being a better economic alternative:

Water is but one of the components of a smart and liveable city – albeit a critical component. Water in all its forms is an opportunity. Surface water as a resource helps deal with floods and pollution. It can deliver many and multiple benefits by managing the source. It can be reduced by using storm water harvesting. It can be restored by infiltration and (over-)irrigation.

London has less rainfall than Melbourne, but London is flooded every year. Melbourne handles urban runoff at source, and considers ecosystems benefits. The benefits of SuDS would be experienced from day one; unlike the tunnel where benefits will come (if ever) only when the last ‘brick’ has been laid in 20 years’ time. SuDS are required for new developments. Water utilities can now offer SuDS maintenance services.

Cities will be better places to live with trees and water – and departments that work effectively together for multifunctional infrastructure that integrate water systems. Delivering single-problem solutions will never solve chronic problems.

Surface water used as a resource helps dealing with floods and pollution. This requires changes in governance, insti-

tutions, regulations, behaviours and attitudes, especially on the part of professionals. Philadelphia's Green City is the result of rewriting the ordinances for storm water. This took five years.

The expected gains are primarily enhanced recreational opportunities, improved aesthetic qualities and property values, less heat stress mortality, plus better water quality and other benefits. Ecosystem services provide GBP 7 in benefit for every GBP 1 invested to address local flood

risk and water pollution. Philadelphia will spend USD 1.6 billion to achieve this over 25 years. Permeable pavements are initially more expensive than conventional ones, but require less maintenance and repair costs which result in overall cost savings.

Society needs more value from its infrastructure and services. It also needs interactive infrastructure in 'smart' functioning systems.

### Recommendations

- Use Sustainable Urban Storm Water Drainage Solutions as much as possible;
- Consult with people, with stakeholders;
- Multi-functional, multi-benefit and valuable – dumping the pipe-bound mentality and managing storm water using green infrastructure.

### References

The presentations at the conference were made by Phil Stride, Head of the Thames Tideway Tunnel and Richard Ashley, professor at Sheffield University. Phil Stride was also interviewed.

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## Copenhagen, Denmark

Copenhagen is the capital of Denmark, and has almost 570,000 inhabitants. It is situated on two islands, Sjælland and Amager, by Öresund, the wide strait between Denmark and Sweden connecting the North Sea with the Baltic. Copenhagen has an average annual rainfall of 600 mm.

Copenhagen was voted the European Green Capital of 2014, and won the Most Liveable City Award for the second time in the same year.

In just two hours in the early evening of 2 July 2011, Copenhagen received 150 mm of rain that flooded the central parts of town and caused damage to buildings and critical infrastructure amounting to EUR 1 billion. This sparked a planning process. There had been another major

downpour in August 2010. Similar events occurred in August 2011 and August 2014. It is evident that weather in the Danish capital will be warmer, wetter and wilder.

Copenhagen has two main strategies: "The Copenhagen Climate Plan 2025", and "The Cloudburst Plan of 2012". There is also "The Most Liveable City Strategy" of 2009.

There are 300 projects with their own descriptions and political processes. Work will continue for 20 years defined in annual project packages. The focus is on synergies with other urban projects and prioritizing projects. HOFOR – Greater Copenhagen Utility – will be a close partner in all aspects. Partnerships are also established on private land.

The expected cost for improvements and new infrastructure is EUR 1.3 billion based on shared financing, water taxes for water management, and taxation for urban spaces. The aim is to create greener, better urban spaces when it is not raining, and increase quality of life. The water tariff is part of the working policy: “If you take care of your own storm water, you get a reduction.” The average annual water tariff will increase by EUR 125 for houses and apartments. Costs are expected to increase during the first 15-20 years, and then decrease steadily.

Compared to conventional solutions, these approaches will be cheaper; they will contribute to less flooding – less damage, lower insurance costs and higher house

prices. Typical solutions are cloudburst boulevards that transport water, (V-shaped roads that collect water and allow it to flow away quickly); delaying boulevards that hold water in ditches with vegetation; and central delays that store water in parks or ponds.

Copenhagen is planning to transform several areas in the built-up and densely populated inner city in order to make them water-safe.

Sankt Jørgens sø (lake): lower water level in the lake and build a new park on the wider banks that can store up to 40,000 m<sup>3</sup> of water in case of cloudburst. A pipe empties the lake – and collects water from the Vesterbro neighbourhood, that has no natural runoff.

HC Andersen Boulevard with dense traffic is a “cloudburst boulevard” that leads the water to the harbour.

Tåsinge Plads (place) was inaugurated 6 December 2014. It is the first climate adapted open space – a “wild oasis” with open water courses.

Sankt Anne Plads in the old town will be shaped as a bowl to retain rainwater for irrigation or transfer to the harbour.

Enghaveparken (park) has a new attraction – storm water pipes above the ground for people to see and touch.

### **Copenhagen interviews**

*What are the overarching sustainability goals: Growth? Environment? Climate change and adaptation? How are the goals described?*

Overarching sustainability goals, growth, an attractive city, well-being of the citizens, environment, climate change and adaptation are all important. The Mayor would perhaps choose growth – without growth the city will not have money to do anything. The inhabitants would choose liveability – a safe town where it is nice to live.

*Are there specific plans for water or is water included in general planning?*

Copenhagen has two main strategies “The Copenhagen Climate Plan 2025” and “The Cloudburst Plan of 2012”.

There is also “The most liveable city strategy” of 2009. Water plays a more and more important role in the plans. The municipality implemented a large number of projects that have improved the water quality in the former commercial port, so it is now possible to swim in the harbour and use it for recreational purposes related to water.

*How and where was water used and taken care of in recent development projects?*

Risk mapping was done to document the expected effects of a 100-year rain with climate factor 1.4 on the central parts of the city measured in millimetres of rain on the ground – if nothing was done to prevent flooding. There are seven catchments in Copenhagen. A special, concrete plan was made for each individual catchment following the natural flow of water, and also suggesting integrating storm water management with urban space improvements.

*Who was the main driving actor? Was the formal planning process politically driven or driven by other actors?*

The climate adaptation plan was started on the initiative of the technical and environmental departments and there was political support for drafting the plan as well as adopting the plan. The city has a programme to follow up that goals have been met.

*What was the level of participation and involvement of citizens, enterprises, local associations?*

Organisations and other municipalities are key as water does not respect administrative boundaries. Citizens will be involved in all the projects. Local anchoring – and local co-operation with local knowledge are important and will be granted through local committees and neighbourhood regeneration.

*How important were economic factors in terms of increasing focus on water?*

The economic factor behind giving water more attention was very important. Documenting the cost/benefit analysis was also important as well as the possibility to create a better and healthier city with more recreational opportunities.

*Were there opposition and/or alternatives? How were conflicts avoided or managed? Were compromises made? Are people satisfied? Which groups are unsatisfied? What do they dislike?*

Climate Adaptation Solutions include changing the use of the city surfaces and water bodies. This gives conflicts of interest. We engage in dialogue with citizens and stakeholders on how to achieve compromises where all interests can be met.

*How much media coverage was there?*

In general climate adaptation has gained much interest in the media in recent years. The City of Copenhagen's work has also received considerable publicity, as we are well advanced in planning and implementation.

*What would you have changed if you were planning a similar project now?*

Better co-ordination between consultants and earlier involvement of other disciplines in planning to qualify solutions and economic estimates.

### Recommendations from Copenhagen

- Adaptation is a precondition in future urban planning.
- It will influence how we plan and utilize urban spaces
- It will influence the development and planning of recreational spaces
- We want to make sure that we control the water in the future urban planning – and that we can use water as a resource.

Photo: City of Copenhagen



In July 2011 part of central Copenhagen were totally flooded. Two hours rainfall resulted in insurance costs estimated at up to 6 billion Danish crowns or 7 million Euros. The event was the start of an intensive planning work with strong political support. Copenhagen should become a greener, healthier, better and safer town.

Photo: City of Copenhagen



Gutters cannot manage intense rainfalls in the dense, paved city center. Therefore Copenhagen is planning green areas and streets that are built to collect, retain and lead rainwater. This decreases the flood risk and in addition the streets will be nicer and more beautiful.

Photo: City of Copenhagen



HC Andersens Boulevard is one of the main streets in central Copenhagen with intense traffic by cars, bicyclists and pedestrians. The boulevard will have another function too – lead rainwater to the harbour without disturbing the traffic.

### References

The presentation at the conference was made by Lykke Leonardsen, Head of Climate Unit, City of Copenhagen.

The interviewees were Tina Saaby Madsen, City Architect, Jan Rasmussen, Project Director, Clima, and Lykke Leonardsen.

<http://international.kk.dk/artikel/climate-adaptation>

Copenhagen has two main strategies “The Copenhagen Climate Plan 2025” and “The Cloudburst Plan of 2012”. There is also “The most liveable city strategy” of 2009.

HOFOR – Greater Copenhagen Utility  
www.hofor.dk

# New York City, USA

New York City is the largest and most densely populated US city with 8.4 million inhabitants. It is a coastal city situated where the Hudson River meets the Atlantic Ocean.

Close to New York City is Avene, a small beachfront community located on a peninsula in Jamaica Bay, Rockaway, Queens, south of Manhattan. Avene was partly devastated by a storm in 1914 and severely hurt by Hurricane Sandy on 26 October 2012. It was a forgotten area, the perfect location when filming the “Boardwalk Empire”.

Hurricane Sandy was a wake-up call for New York, Avene and the world. One effect was the “Far Roc (For a Resilient Rockaway) design competition” created by interested partners to make Rockaway and Avene a resilient and adaptive area for work, living and leisure. Avene will be revitalized into a dense, modern and attractive place designed to interact with the sea.

**Resiliency:** the ability to quickly return to a previous good condition

**Adaptivity:** the ability to readily adjust to suit different conditions

White Architects took part in the competition with the winning project “Small means and great ends” that makes Avene part of an ecological landscape with bird habitats, a landscape that uses nature reserves for green pockets. Wave energy and sand motors form breakwater basins that protect the coastline from erosion, like the dunes in Holland. Avene would be constructed with 50 per cent affordable housing, have green roofs, be car-free and have semi-private outdoor spaces in the centre of the housing blocks where storm water could be stored. Storm water would be directed from houses and other essential functions to the sea and wooden board walks would run along the houses on the shore. Parking lots would be underneath the buildings allowing flooding water to flow freely. Floodable facades and flexible panels, public spaces as social nodes, nature education, a teaching orchard, a conference centre and a co-operative system were also suggested in the project.

But also the large and dense New York City is leading the way in demonstrating how even older cities can improve their environment.

## New York interviews

*What are the overarching sustainability goals for New York City: Growth? Environment? Climate change and adaptation? How are the goals described?*

“Overarching Environmental Plan” that was decided by Mayor Bloomberg. It focused on water quality, extending

to add parklands, the clean-up of contaminated sites etc. It was a broad plan.

The plan of 11 June 2013 “A Stronger, More Resilient New York – Road Map for Resiliency” signals growth that balances diversity avoiding making New York City an elite city.

200,000 new housing, old city building renewal and renovation to get higher standard are important parts of the plan launched by the present Mayor de Blasio. There are goals for air, energy and the reduction of carbon emissions but also on preparing for floods and extreme weather. The Mayor plan sets 80 per cent carbon reduction as the target to be met by 2050.

## *Are there specific plans for water or is water included in general planning?*

A new “Water Demand Management Plan” will conserve water citywide, and there will be water shortage rules to impose use-restrictions during droughts and infrastructure repairs.

Overflows put a focus on minimizing combined sewers and build new infrastructure. There are close plans to protect wastewater treatment plants. 10 out of total 14 plants that were damaged during Sandy had to be closed due to flooding. The receiving waters have been a driver for the planning process. In New York City, there is a lot of attention on recreational waters.

## *How and where was water used and taken care of in recent development projects?*

The strategy is to improve and expand drainage infrastructure, reduce combined sewer overflows with Green Infrastructure and high-level storm sewers, periodically review rainfall trends and implications for storm-water infrastructure. The new performance standard greatly reduces allowable peak discharges of storm water by requiring on-site storage and slower release to the sewer system. The city is giving grants for the construction of permeable asphalt. It has resulted in a few really successful projects involving big institutes.

Water is used in the same way as for the last 100 years. What is new is “on-site-reuse”. Twenty new buildings have onsite reuse systems for grey, black, storm-water, for irrigation and cooling towers. There will be new technologies and new companies delivering them. The challenge is that we don’t have a water quality standard for reused water.

## *Who was the main driving actor?*

New York City may be unique. It has a very active Department of City Planning, DCP that was driving area-wide rezoning (reclassifying) plans. Zoning determi-

nes the size and use of buildings, where they are located and, in large measure, the densities of the city's diverse neighbourhoods.

*Was the formal planning process politically driven or driven by other actors?*

The Mayor's Office of Long-Term Planning and Sustainability oversees the development of the "PlaNYC" which is the sustainability and resiliency blueprint for New York City. It is a successful collaboration between the agencies, organizations, and New Yorkers. Collaboration is very important since there are multiple agencies involved, both public and private.

*What was the level of participation and involvement of citizens, enterprises, local associations?*

The "City Environmental Quality Review" has a public component and a process for all rezoning including stakeholder involvement. It involves the public and voices their concern. All do not always want growth and changes of their neighbourhood.

*How important were economic factors in terms of increasing focus on water?*

Widespread on-land storm water management can make it possible for New York City waters to meet the Clean Water Act standards for safe swimming and fishing, while meeting local sustainability goals of creating more green open space, cooling and cleaning the air we breathe, reducing our energy costs, generating accessible green jobs.

In the NYC Wastewater Resiliency Plan measures were based upon costs and level of risk reduction. There are

similar analyses for water demand management, green infrastructure, and traditional infrastructure.

New York City uses three alternatives regarding waste-water treatment plants:

- Cost to Protect At-Risk Assets (Adaptation Cost)
- Value of Assets At-Risk (No-Action Cost)
- Cumulative Risk avoided over 50 Years (This estimate incorporates the probability of storms.)

"Recovery, Adaptation, Mitigation and Planning, RAMP", is working closely with community partners to address issues of recovery, sustainability and resilience in the face of a changing climate. RAMP targeted the most venerable populations after the storm Sandy. It is now harder for those communities to bounce back after the storm. Focus is on sustainable community development.

*Were there opposition and alternatives? How were conflicts avoided or managed? Were compromises made? Are people happy? Which groups are not so happy? What do they dislike? How much media coverage was there?*

Plans are popular and have high priority among New York residents. The interest of the public in sustainability was expressed in the "Climate March" in New York on 21 September 2014. It coincided with the climate talks at the United Nations summit. Before Sandy, plans were more general and theoretical "old traditional utility". It was difficult to explain climate change. After Sandy there has been a different conversation.

## References

The presentation of the Averde project at the conference was made by Sander Schuur, White Architects.

Interviewees were Vlada Kenniff, Managing Director, NYC Environmental Protection and Jaime Stein, Head of Sustainable Environmental Systems Program, Pratt Institute, School of Architecture.

### Overarching Environmental Plan

[http://s-media.nyc.gov/agencies/planyc2030/pdf/iclei\\_planyc\\_case\\_study\\_201004.pdf](http://s-media.nyc.gov/agencies/planyc2030/pdf/iclei_planyc_case_study_201004.pdf)  
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### Water Demand Management Plan

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Recovery, Adaptation, Mitigation and Planning, RAMP. <http://ramp.prattpspd.org/>

# Seattle, USA

Seattle is situated in a beautiful landscape between Lake Washington and the Pacific Ocean. It has a deep water port, and a volcano is located some 100 kilometres away. The number of inhabitants in the urban centre is around 640,500, and 3.5 million in the metropolitan area. Seattle is a city that is growing and redeveloping fast. Microsoft, Amazon and Boeing have their offices and production facilities in Seattle. But along with its technological progress, there is an awareness of potential threat from the natural environment. It has a Nordic climate, with large amounts of rainfall which varies in intensity across the area. After 14,000 years of continuous inhabitation there is still a strong on-going cultural impact from Native American's sense of the sacred in species, lands and waters.

Seattle is a "model city":

- Only 5-STAR Community Rating for national leadership in sustainability – 2014
- Greenest City in US – Corporate Knights – 2014
- Fastest Growing City in US – US Census – 2014
- #1 Smartest City in North America – Fast Company – 2013 etc. etc.

The industrial boom after the Second World War led to pollution of Lake Washington and over-fishing, over-building of the water systems. In 1958 people began to demand a cleaning-up of Lake Washington. The first Earth Day in 1970 was another alarm. Environmentalism was launched and has broad acceptance in Seattle.

In 1997 Diana Gale, the new Director of Seattle Public Utilities and the first non-engineer, integrated the water utility with other municipal services. In 2000 the campaign to save the Chinook salmon started. It was a campaign with a high symbolic value.

Leading edge regulation and investment made sustainable changes possible. Now the Green Building Policy has resulted in over 200 LEED buildings (LEED: Leadership in Energy and Environmental Design). Sustainable infrastructure demands make it necessary to think broadly about alternatives to achieve good results.

For example, in certain areas of the city, new development must use natural methods for storm water control or demonstrate why they cannot. This default towards natural strategies simultaneously improves water quality and enhances the beauty of the city.

SEAstreets or Street Edge Alternatives eliminate runoff and recharge groundwater at lower costs, improve real estate values due to more greenery and make the city more walkable.

Another example is Seattle's Green Factor. It is a landscape requirement in neighbourhood business and multi-family

parts of the city that new development must include 30-60 per cent of the site area in green walls, green roofs, or porous pavement. This begins to implement a vision that all urban land is managed as an integrated urban ecosystem.

In 2011 ecological resilience with a pre-disaster plan enters the dialogue.

## Seattle interviews

*What are the overarching sustainability goals: Growth? Environment? Climate change and adaptation? How are the goals described?*

All four goals are important to us. It is up to the Mayor to rank them. For solid waste applies the three Rs (reduce, reuse, recycle) rule instead of a new landfill or incineration. It is forbidden to not recycle organic materials. Energy conservation is promoted instead of a new nuclear plant.

*Are there specific plans for water or is water included in general planning?*

The city-wide plan is called the Comprehensive Plan. It includes all land uses. All infrastructures including water, transportation, solid waste, power generation and more must be consistent with the Comprehensive Plan. There are separate drinking water plans, storm water plans, waste water management plans and others. Seattle has an active policy for water supply including an active research agenda, real time rain monitoring and a portfolio of strategies including efficiency improvements and partnerships.

*How and where was water used and incorporated into recent development projects?*

In the water sector focus is now on reducing the combined sewer overflows (regulated by EPA, the US Environmental Protection Agency). This is mainly done by upstream efforts such as rain gardens, rainwater harvesting, infiltration, swales, permeable asphalt and more. In all sectors the city aims to conserve resources rather than extend them.

In 1993 water conservation was high on the municipal agenda. Over a 20-year period overall water use has stayed the same by using conservation and pricing policies. At the same time the inhabitants they serve have increased by 400,000. The tariffs for water and wastewater service are high comparing with other cities in the US (maybe among the top five). Now performance is much more important than costs.

Rates are reduced if the drainage is decoupled. Storm water is decoupled each time there is an opportunity. For new developments a new code has been implemented: No storm water connection if there are other possibilities. The impermeable areas increase all the time, but moderately. In old areas storm water pipes and inlets are often undersized for intense storms, which often dump 50-70 mm rain an hour.

*Who was the main driving actor? The main driver is the citizens themselves. The plans are all developed by the Seattle Public Utility which co-ordinates. The formal planning process, was it politically driven or driven by other actors?*

There is a long-standing political consensus for the development of Seattle towards a more sustainable city focusing on concentrating development in existing business districts and the creation of “urban” villages. The vision is “Growing with grace”, a liveable, affordable and walkable city. Focus today is more on transportation than water. More than 50 per cent of the inhabitants commute in other ways than by car. Seattle takes climate change seriously and works with both mitigation and adaptation. Seattle aims to be carbon-free 2050. There is a city co-ordinating office for climate adaptation.

*What was the level of participation and involvement of citizens, enterprises, local associations?*

People are proud of their city and willing to accept policies and plans for increased sustainability. Consultation with citizens takes place regularly and is very important.

Illustration: Studio 216, Seattle



Seattle is a “model city”. It is a national leader in sustainability and the Greenest City in the US. South Lake Union, a former rundown industrial area, will be a green, climate adapted, livable and affordable part of the city with different types of housing, shops, schools, work places, green infrastructure. Amazon and Microsoft have their offices here. By using the heat from computer halls to upgrade district heating the new area will also be energy efficient.

## References

The presentation at the conference was made by Steve Moddemeyer, Principal Collins Woerman.

Interviewees: Ray Hoffman, Director, Seattle Public Utilities; Diane Sugimura, Planning Director; and Steve Moddemeyer.

Green Building Policy  
[www.seattle.gov/environment/buildings-and-energy](http://www.seattle.gov/environment/buildings-and-energy)

*How important were economic factors in terms of increasing focus on water?*

Seattle Public Utilities has developed a Strategic Business Plan that will guide our investments, service levels and rates for the next six years, from 2015 through 2020. Developing predictable rates was a key Plan goal. A rigorous process started in late 2012 that included input from customers, employees, elected officials etc.

*Were there opposition and/or alternatives? How were conflicts avoided or managed? Were compromises made? Are people satisfied? Which groups are unsatisfied? What do they dislike?*

There is no real opposition against actions for water and wastewater services, or for storm water management according to best practice. Development is always a balance of compromises and all goals are not met due to changes of different kinds. One concern is that people oppose to their parking lots being used for storm water facilities.

*How much media coverage was there?*

Media is most of the time positive to the developments but is of course reporting good stories and bad stories.

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[www.seattle.gov/dpd/cityplanning/completenesslist/greenfactor/whatwhy/](http://www.seattle.gov/dpd/cityplanning/completenesslist/greenfactor/whatwhy/)  
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http://2035.seattle.gov/  
http://seattle.gov/dpd/cityplanning/  
completenesslist/comprehensiveplan/  
documents/default.htm](http://www.seattle.gov/emergency-management/http://2035.seattle.gov/http://seattle.gov/dpd/cityplanning/completenesslist/comprehensiveplan/documents/default.htm)

[www.sustainablecitiesinstitute.org/topics/land-use-and-planning/land-use-and-planning-sustainability-principles](http://www.sustainablecitiesinstitute.org/topics/land-use-and-planning/land-use-and-planning-sustainability-principles)

[www.seattle.gov/util/AboutUs/Management/Director/StrategicBusinessPlan/index.htm](http://www.seattle.gov/util/AboutUs/Management/Director/StrategicBusinessPlan/index.htm)

# Conclusions and lessons learned

- **Sustainability is definitely on the agenda.** But there are different definitions of sustainability. It is necessary to develop and share consistent definitions to avoid misunderstandings.
- **Severe events started the processes of change in Copenhagen, Dordrecht, Hamburg, London, New York and Seattle.** It is necessary to spread understanding that severe rainfall can occur anywhere causing serious damage that will be difficult to repair, and that action must be taken in advance.
- **Good examples lead to actions.** Best management practices must be shared widely in order to be adapted locally, and also implemented in areas that have not yet had severe climate events. Actions to prepare for the unexpected is imperative.
- **CO<sub>2</sub> reduction has more focus than water.** CO<sub>2</sub> reduction is an issue for all six cities. Water has a top position in the World Economic Forum, Global Risk Report, but this status is not yet well-known. CO<sub>2</sub>, transportation and telecom often have more focus in city development plans.
- **Water is important but not interesting.** People working in water should realise that it is their responsibility to help planners, politicians and other specialists to understand water and the many fascinating aspects of water. Understanding water is necessary for taking the necessary precautions related to climate change, water shortage, flooding, pollution, urban planning etc.
- **Water comes in late in urban planning.** Urban planners and water professionals should co-operate early, closely, and consistently during the planning process to facilitate urban planning, find good solutions, well functioning systems and sustainability.
- **Form a Learning and Action Alliance.** The message from Dordrecht is that cities should form an alliance with the public, specialists, universities, companies, national-regional-local governments and other cities to learn from each-other and find suitable solutions for their own town or region.
- **Involve local residents Communication is an effective tool for management and planning.** Invite the inhabitants to take part in the planning process. Good and well prepared two-way communication leads to understanding which is the basis for acceptance and support.
- **Managing storm water via sewers, canals, retention spaces.** Conventional technical measures are used in combination with upstream actions even in city centres. Infiltration, vegetation, swales, etc. need to contribute to retaining storm water and reduce pollution of water.
- **Green cities.** The introduction of vegetation in densely populated cities is growing in importance in modern urban planning. Green roofs, green walls, planting of trees, upgrading of parks will increase liveability and reduce the negative impacts of storm water.
- **Where is modern rainwater harvesting in urban planning?** Collecting rainwater before it reaches the ground and becomes polluted storm water is a measure that not only provides clean water in small villages in poor countries but is suitable also in big cities in highly developed countries. More land can be used for building high-rise apartment blocks – on the condition that flooding is reduced to a minimum by rainwater collection and management. One such example is the Star City complex in Seoul, South Korea. There are more. [www.rainmaster.org](http://www.rainmaster.org) (website under development)

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