

9. Waste water treatment



Access to service;

In the City of Copenhagen wastewater from households and enterprises is managed in closed pipes underground. Most of the City has a joint system where stormwater from roofs and roads and household waste water is discharged for treatment in central treatment plants. Separate sewer systems only exist in the part of the city which is close to the ports. The choice of sewer system type has a historical basis. This also applies to the service offered by the City to its citizens and enterprises. The main principle is for wastewater from groundfloors to be drained off to sewers through gravitation. The whole City except for the nature area of Vestamager has sewers. The sewers are designed so that statistically overflow ground level only takes place once every ten years in joint sewer system areas, whereas separate stormwater pipes are designed so that overflow at ground level only takes place once every five years. The sewer systems are furnished with pumping stations and reservoirs for storage of wastewater during rainfalls. All wastewater is discharged for treatment at the two treatment plants of the Lynettefællesskabet community; *Lynetten* and *Damhusåen*.

Increasing urban development with accompanying expansion of the sewer system, as well as increased rainfalls intensity have meant increased pressure on central treatment plants. To minimise this pressure draining off of stormwater in new urban development areas and in major renovation work is to be carried out according to the SUDS principles (Sustainable Urban Drainage Systems). The new Ørestad district which was founded in 1996 and today is an area of 150 hectares, was established with a three-stringed system. In the three-stringed system, household wastewater is discharged to a central treatment plant, roof water is discharged to

recreational canals whereas road water is treated locally before being discharged to the recreational canals.

Flood occurrences and management

Three times in the past two years, Copenhagen has seen rain event which exceeded the capacity of the sewers. In all three events, the sewers were overloaded by surface run-off-water in large parts of the city. The events all caused major traffic disturbance as viaducts and similar were flooded with water. There was extensive basement flooding. The first steps towards combating such problems and similar problems with comprehensive measures were taken in the Copenhagen Climate Adaptation Plan. In the coming years, initiatives will be adopted to direct stormwater either to the ports/coasts or to areas where it will not do any harm, such as squares, sports facilities, parks.

Wastewater drainage from CSO (Combined Sewer Overflow) to recipients will be reduced by establishing reservoirs. Since 1995 the number of CSO has been successively reduced from 95 to 34 and annual overflow frequencies have been reduced from 20-70 overflows per year to 2-6 per year. The discharge volume to the ports has been reduced from 1.6 mill. m³ per year to less than 300,000 m³ of wastewater per year.. The water quality in bathing spots at the ports is now meeting the requirements of the Bathing Water Directive. The establishment of a warning system to warn against residual overflow has made it possible to bathe in the ports without any risk of swimming in polluted water. The establishment of reservoir capacity is the principal method applied for Copenhagen to meet the requirements of the Water Framework Directive on good ecological conditions in watercourses and lakes. There are plans to establish reservoirs (from 25 CSOs) in the Harrestrup Å catchment area in the period up to 2015.

Economic sustainability

The City of Copenhagen is working on long-term solutions through new construction and renovation of sewers. The expected operational life of pumping stations, pipes, reservoirs, etc. is between 50 and 100 years. A thorough preliminary investigation and planning will help prevent bad investments. Extensive work is being done with advanced, computer-based models of the sewer system at a high technical level. There is an organised collaboration with neighbouring municipalities and *Lynettefællesskabet I/S*.

Treatment of wastewater in large, central treatment plants generates low costs per treated cubic metre wastewater compared with decentralised treatment in smaller units.

Infrastructures sustainability (treatment capacity, treatment level; drainage systems rehabilitation)

The treatment plants *Lynetten* and *Damhusåen* both treat wastewater for organic substances, phosphorus and nitrogen by means of mechanical, biological and chemical processes. The treated wastewater is discharged to Øresund through 1.5 and 1.2 km long outfall sewers furnished with diffusers that ensure that the treated wastewater is well mixed with sea water.

	Lynetten	Damhusåen
Capacity, PE	750,000	350,000
Max. water supply during rain fall, m ³ per hour	41,500	28,000
Max. hydraulic capacity in biological installation, m ³ per hour	23,000	10,000

In the past decade, the City has put in great efforts to renovate the sewer systems in Copenhagen. As a result the sewer system is in good condition although parts of the Copenhagen sewers are very old. Today the sewers only require maintenance at the same rate as degradation. This means that there is no lacking behind of maintenance. No-dig methods are used to the extent possible taking into account the economy and traffic nuisance.

Environmental sustainability (energy efficiency, renewable energy, pollution prevention efficiency; sludge treatment and final disposal, public health

By a large margin, the two treatment plants are meeting the requirements set for wastewater treatment both in relation to national requirements and in relation to the Urban Waste Water Directive. The requirement values of the contents of the discharged water and the actual contents of the discharged wastewater are shown in table bellow. In connection with stormwater events, 5% of the annual water volume discharged may be diverted around the treatment plant through bypass. However, this water has been mechanically treated and is discharged through the ordinary outfall sewer.

Substance mg/litre	<i>Lynetten</i>	<i>Damhusåen</i>	Requirements
Nitrogen N	5.4	5.4	8.0
Phosphorus P	0.6	0.7	1.5
Organic substances BOD	1.0	3.0	15.0
Organic substances COD	37.0	36.0	75.0

In 2007, advanced water treatment management by means of online meters was introduced. This has led to better control of processes in the treatment plant which has improved the treatment. At the same time, the capacity at the treatment plants is being exploited optimally.

Excess sludge production from the biological and chemical treatment process undergoes anaerobic digestion before it is drained off and incinerated in the sludge incineration plant. The waste volume is thus reduced to the ash fraction and flue gas scrubbing products. The gas from digestion and surplus heat from burning of sludge covers 77% of the energy consumption of the treatment plants. Surplus heat is used for heating of houses via the district heating grid.

Calculation of quantities of substances in the inflow and outflow in 2010 as well as the effectiveness of treatment on the basis of this.

Parametre	Inflow tonnes per year	Outflow tonnes per year	Effectiveness
COD	52,539	2,619	95%
Tot-P	647	64	90%
Tot-N	4,145	529	87%

All sewers, pumping stations and reservoirs in the sewer system of the City are sealed to minimise the risk of people coming into contact with the wastewater or aerosoles from these. The treatment plants are also located far away from the nearest housing areas so that these do not cause health risks.

Integration into water management in general closing the cycle (efficient water use, treated waste water reuse)

Copenhagen is working systematically on bypassing stormwater from the sewer system in order to avoid rain overflows from sewers and overloading of treatment plants with stormwater. Local drain off of stormwater was selected as the way to keep the functional level of the sewers with increasing rainfalls and intensity in future. Stormwater is therefore managed locally and recycled as far as possible for e.g. watering or in water elements in the city with both recreational and architectural value.

Details of those targets achieved or not, to date (within the last 5 – 10 years). Provide a review of how both situations occurred and lessons learned.

Through effective and ambitious initiatives in the past decade, the City of Copenhagen has achieved the following goals:

1. Good bathing water quality in the harbour with three harbour swimming-pools and plans to establish more. Good bathing water quality at remaining coastal shores.
2. Improved environmental status at the harbour where more species of fish have been released for fisheries and consumption.
3. A diverse animal and plant life in the lakes of Copenhagen.
4. Clear improvement in environmental conditions of *Utterslev Mose (bog)* with accompanying watercourses.

Point 1. Through targeted initiatives, the extent of relief wastewater at the harbour during rainfalls has been considerably reduced in order to comply with the EU Bathing Water Directive. On the basis of an advanced, model-based warning system, three harbourswimming-pools have been established.

Point 2. By cutting-off wastewater from CSO to the ports, the heavy metals load has been reduced so that a number of species of fish have now been released for fisheries and consumption. At the same time, the load of nutrients has been reduced so that the water is clear and eel grass can grow down to 6 to 7 metres depth.

Point 3. Through effective regulation of water flows and by establishing decentralised treatment of polluted lake water, as well as restoration of the lakes in Copenhagen, it was possible to improve the environmental condition so that the lakes today have clear water with a view to the bottom and diversified benthic vegetation.

Point 4. Through initiatives aimed at CSO, environmental conditions of *Utterslev Mose* have improved significantly. Biodiversity has increased and the marsh is close to meeting the goals of the water plans on good ecological quality.

The following are examples of goals which have not been successfully achieved despite initiatives:

1. Establishment of reservoirs in the last major CSO to the ports has been delayed due to technical difficulties. The City is considering disinfecting a partial flow of the discharge in order to save reservoir volume. It is difficult to find a sufficient area for the reservoir in a densely populated area. The new requirements to bathing water quality have meant that the reservoir must be built significantly larger than initially planned. It is not possible to identify individual parts which could have led to compliance with the plan. Future planning of large projects should incorporate experience from this project.
2. Goals of the City stating that all species of fish in the ports must be edible have not been achieved. This is due to increased contents of heavy metals in fish meat stemming from a large pool of heavy metals in the bottom sediment of the ports. The City has successfully limited further additions to the sediment but an economically sustainable solution for removal of the sediment has not yet been found.
3. The water in the lakes of Copenhagen is now so clear that rooted aquatic

plants thrive in the lakes. Because of a nutrient salt pool in the lake sediment there are now so many aquatic plants that sailing is nearly impossible, and at times, there are problems with smell because of rotting plant material. This problem has meant that the City at least once in the summer period has had to fish out the majority of the aquatic plants. This will achieve a net removal of nutrients which over the years will contribute to achieving a natural balance in the lakes.

4. Uncertainties in model calculations and lack of knowledge of detailed sewer conditions have meant that completed initiatives to CSO for *Utterslev Mose* have been insufficient. Therefore further reservoir capacity in the catchment area must be established. The assessment is that the situation could hardly have been avoided but that in planning there should be room for iterative approaches in order to achieve the goals.

Plans to meet or revise key targets for the future and proposed approach to achieve these.

Today very few properties in the City of Copenhagen do not have sewers. These are mainly houseboats and garden associations where overnight stays only take place in a limited part of the year. The plan is for housing associations and houseboats to install sewers over a 12-year period in order to prevent illegal and inappropriate discharges/seepages of wastewater.

The City of Copenhagen has adopted the Copenhagen Climate Adaptation Plan which describes the risk of harm to the city on account of a changed climate and provides solutions to address climate change. Several of the solutions provided are about management of storm and wastewater. These are the two main principles of climate change adaptation of the city:

- Climate proofing of sewers by bypassing stormwater which is subsequently managed locally either through seepage to the groundwater or by discharge to the recipient. The current estimate based on hydraulic models and the forecasts for the climate of the future shows that in the long term 30% of stormwater must be detached from the sewer and managed locally in order to maintain the current service level of the sewer.
- Systems for management of rainfall during cloudbursts must be established for the purpose of protecting the city against big losses due to flooding. These include a wide range of methods for diversion of the water during cloudbursts to areas where the rain will not do harm. These are squares, sports facilities, parks, etc. for temporary storage of stormwater. Another method is to establish fairways or gutters which can discharge water to the ports.

In 2010 and 2011, Copenhagen was affected by historically heavy downpours which caused extensive damage to the city. This development corresponds to the forecasts for the climatic developments, cf. UN Climate Panel IPCC. However, the development might be quicker than anticipated. Therefore Copenhagen will be revising the climate change adaptation plan every four years to ensure the foundation of future planning in relation to climate change are continuously up-to-date.

In connection with the most recently concluded budget agreement it was decided to launch a cloudburst plan. The aim of the plan is to reduce damage to the city because of heavy rainfall. Initially the plan includes projects where solutions are self-evident, as well as establishment of solutions in areas where the damage is

particularly serious. The plan also includes establishment of a comprehensive emergency management service which is to manage serious and sensitive areas until permanent solutions can be set up. There will be initiatives over a number of years until the city can be considered "climate proofed".

At the same time, it was decided to allocate funds for the commencement of a water partnership with the City of Copenhagen, City & Port Development, Copenhagen Energy and a number of knowledge institutions as well as private enterprises with the purpose of developing and testing intelligent, innovative and future-proofed water solutions in the large urban development area, *Nordhavn*.

If the projections for global warming and increasing water levels in the seas are correct, the risk of damage to the city as a consequence of storm surges from the sea will be the biggest challenge as soon as in 30-40 years.

Analyses drawn up by the City of Copenhagen in connection with Copenhagen Climate Adaptation Plan show that damage to the city from a storm surge could give rise to costs which justify investment in securing against this storm surge damage.

Copenhagen Climate Adaptation Plan proposes establishing protection for the existing city by constructing dykes and dams. In order to ensure the possibility of building these installations, areas must already be set aside for construction. Then the extent of protection can be adapted to the pace of climate change.

Download Copenhagen Climate Adaptation Plan at
<http://www.kk.dk/sitecore/content/Subsites/CityOfCopenhagen/SubsiteFrontpage/CopenhagenClimateAdaptionPlan.aspx>