# BLUE-GREEN FINGERPRINTS IN THE CITY OF MALMÖ, SWEDEN

Peter Stahre

Malmö stad

VASYD

# Blue-green fingerprints in the city of Malmö, Sweden

## Malmö's way towards a sustainable urban drainage

Peter Stahre

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# Foreword

The concept of sustainable urban drainage was introduced in the city of Malmö already in the late 1980:ies. Over the two decades the new drainage concept has been applied in Malmö, the technique has gradually been developed and further refined. This applies both to the physical planning and to the preferences regarding the technical configuration.

The intention with this book is to describe Malmö's transition from a traditional urban drainage in buried pipes towards a sustainable urban drainage in open systems. The transition that took 5–10 years was not problem-free. Many barriers and obstacles had to be overcome on the way. Most of these were of institutional nature. One important factor for a successful result was the trustful and prestige-less cooperation that gradually developed between the top management of the technical departments, especially between the managers of Malmö Water and the department of Parks and City environment.

18 facilities in Malmö designed according to the concept of sustainable urban drainage are described. The facilities were implemented in the period of 1989–2008. When analyzing the facilities you can clearly see that the view on sustainable urban drainage has gradually changed in Malmö over the years. In the beginning of the period local ponds and wetlands were the most common technical configuration. Today Malmö strives in the direction of multi-functional regional eco-corridors. This change of view is a result of the process of constant learning, and is based on the experiences that were gained from the implemented facilities.

The idea to compile this book came up during discussions I had in 2006 with my friend Tom Liptan, Portland OR. We both share the experiences that the way towards a sustainable urban drainage is not always so easy and that it often takes unexpectedly long time.

The work with this book was financed by the regional water utility company VA SYD. For helping me to review the text I want to direct a special thank to Ulf Thysell, VA SYD, to Arne Mattsson, Malmö Public Works and to Louise Lundberg at the Scandinavian Green Roof Institute.

Malmö in June 2008

*Peter Stahre*

# Content

# Introduction

## The shift towards a sustainable urban drainage

The drainage of stormwater from urban areas is traditionally accomplished by constructing storm sewers, through which the urban runoff is conveyed directly to the receiving water. Urban drainage was before the 1970's basically a matter of getting rid of the stormwater as quickly as possible. In the 1970's more attention was drawn to the quality dimension of the urban runoff. The pollution content in stormwater and its impact on the receiving waters became a major concern. Measures were taken to protect the receiving waters from being polluted by the urban runoff. In the 1990's the concept of sustainable development was introduced. In this concept the social dimension of the urban drainage came into focus.

The transition from traditional to sustainable urban drainage is illustrated schematically in *figure 1*. The characteristic feature of sustainable urban drainage is that quantity and quality aspects of the runoff are handled together with various social aspects of the drainage. In the sustainable approach, stormwater is looked upon as a positive resource in the urban landscape.

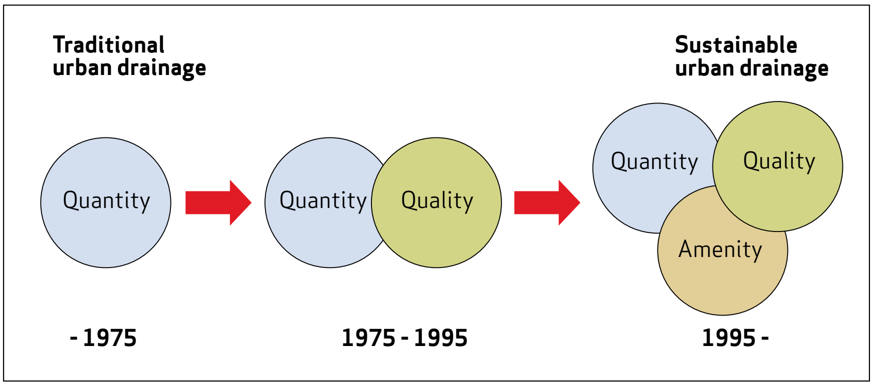


*Figure 1. Schematic illustration of the on-going transition towards a sustainable urban drainage*

The time spans indicated in the figure can vary very much between different cities and countries. It must be emphasized that the transition towards a sustainable urban drainage is an ongoing process in many countries.

## Sustainable urban drainage practices

Sustainable urban drainage is most often accomplished by means of open or partly open drainage systems. These utilize nature's own way of handling rainwater, e.g. infiltration, percolation, surface runoff, slow drainage in open systems as well as detention in ponds and wetlands. The facilities are characterised by the fact that the stormwater is often visible during the runoff. As illustrated in *figure 2*, sustainable urban drainage facilities can be categorized in four groups.

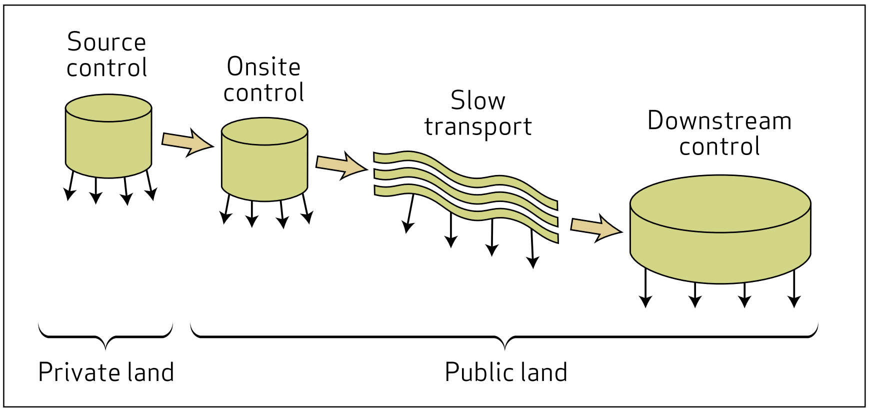


*Figure 2. Facilities for sustainable urban drainage can be categorized in four groups.*

The category "source control" refers to small-scale facilities where the handling of stormwater takes place on private land. Source control can for example be accomplished through vegetated roofs (moss/sedum), infiltration on lawns, permeable pavings, rain gardens, local ponds etc.

The category "onsite control" includes different small scale facilities on public land in the upper parts of the drainage system. In contrast to source control, onsite control facilities are by definition the responsibility of the municipality. Onsite control of stormwater can for example be accomplished through permeable pavings, green filter strips, rain gardens, surfaces especially prepared for temporary flooding, ponds etc.

The category "slow transport" includes different systems for transport of the stormwater in open drainage systems. Slow transport of stormwater can for example take place in swales, ditches/creeks, canals etc.

"Downstream control" comprises different large-scale facilities for temporary detention of stormwater in the downstream parts of the drainage system. Downstream control of stormwater can for example be accomplished in large ponds, wetlands, lakes etc.

It must be emphasized here that the same technical configuration may occur in more than one of the four categories. This is for example the case for permeable pavings and ponds.

## Planning for a sustainable urban drainage

Urban storm drainage is the responsibility of the city. As traditional stormwater facilities (pipes and detention tanks) are located underground, the design and construction can be carried out by the city's drainage department without any involvement of other technical departments in the city.

When sustainable urban drainage is concerned, the water is made visible in the urban environment and sometimes also available for the citizens, e.g. open drainage corridors and ponds. In the design of sustainable drainage facilities a variety of other aspects than just the drainage purpose must be considered. As sustainable drainage facilities constitute an integrated part of the city environment, they must be planned accordingly. In practice this means that one must involve experts from different disciplines in the city administration in the planning and design of the facilities. Examples of such expertises are planning architects, landscape architects, drainage engineers, street and traffic engineers etc. Experiences have shown that these experts do not always cooperate very well. The big challenge in this type of integrated planning is to overcome the institutional barriers that exist between the different city departments. In addition it is very important to learn to handle inputs from residents and other stakeholders which are not part of the city administration.

*Figure 3* give some examples of aspects that can give added values to sustainable drainage facilities. It is quite obvious that the planning of sustainable drainage facilities is much more complex and time-consuming than planning of traditional underground stormwater facilities. The key to success is that the planners and engineers involved in the planning process are very open-minded and flexible regarding the possibilities offered by the concept of sustainable urban drainage.

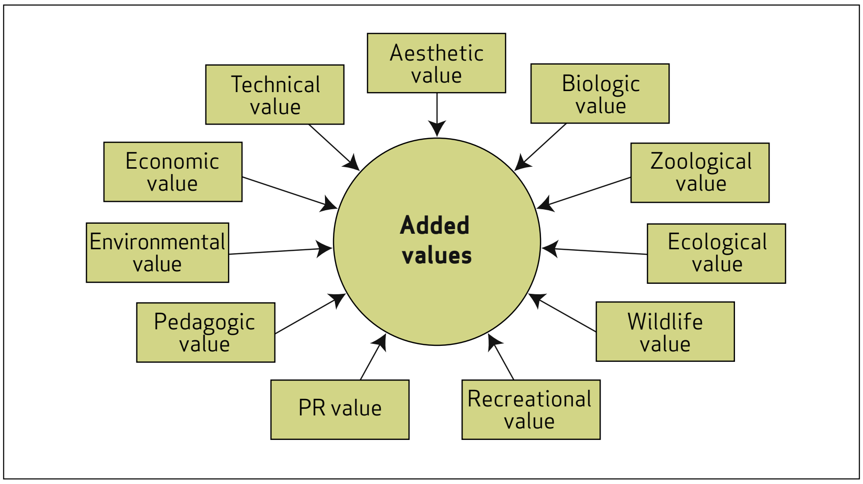


*Figure 3. Examples of aspects that can give added values to a sustainable urban drainage*

The initiative to implement a facility for sustainable drainage often comes from the drainage department. This is quite natural as the drainage of stormwater has always been the responsibility of this department. When implementing large-scale sustainable drainage projects, the drainage department most typically makes alliances with the departments of parks, recreation and city planning, which often have an active interest in the added values that the new sustainable drainage systems can give to the city environment.

The basic principles that applies to planning of sustainable urban drainage has been described in more detail by Stahre (2006)[1]

[1] Stahre P. Sustainability in Urban Storm Drainage. Swedish Water 2006 (www.svensktvatten.se/sustainability)

# Sustainable Urban Drainage in the City of Malmö, Sweden

## Organizational framework in the city of Malmö

The city of Malmo is situated in the southwest of Sweden at the straight of Öresund just opposite Copenhagen in Denmark, see *figure 4*. Malmö has more than 280 000 inhabitants and is expanding rapidly.


*Figure 4. The city of Malmö is situated in the southwest corner of Sweden*

In Sweden the local authorities have a very strong influence on the physical planning. The situation can in practice be considered a municipal planning monopoly. In contrast to many other countries private developers' influence on the comprehensive planning is rather weak in Sweden.

The urban drainage in Malmö is in the hands of Malmö Water, which is part of the publicly controlled regional organization VA SYD.

The planning of facilities for sustainable urban drainage is in Malmö carried out in close cooperation between the technical departments in the city. Besides Malmö Water the main actors in the city planning in Malmö are:

- Malmö Planning Authority (comprehensive planning, detailed planning)
- Malmö Public Works (parks & city environment, street & traffic, maintenance)
- Malmö Real Estate Authority
- Malmö Environmental Protection Authority

Examples of stakeholders outside the city administration that are often involved in the planning and implementation of sustainable urban drainage projects are private developers, residents, schools, media, non-profit associations etc.

## How it all started

The city of Malmö introduced the concept of sustainable urban drainage already in the late 1980's. This was mainly a result of Malmo Water's active interest in finding new technical solutions for detaining peak flows in the urban runoff from new settlements ("quantity control"). The main problem at that time was to protect the downstream conveyance system from being overloaded during periods of heavy rainfall.

The first installation in Malmö which was implemented according to the principles of sustainable urban drainage was the "Toftanäs Wetland Park" in the eastern outskirts of city. The project was implemented in 1989–1990.

The idea of implementing an integrated park and drainage facility was at the beginning met with great scepticism among the other technical departments in the city. A lot of arguments were brought up against such a solution. The main reason for the resistance seemed to be that such a solution had not been applied in the city before. The planning department was at the beginning very doubtful but finally accepted to try the new ideas. Thanks to the support of the department of Parks & City Environment the project could be realized.

It shall be mentioned that the "Toftanäs Wetland Park" was implemented in a period when environment and ecology were only beginning to emerge as important issues in Sweden. The project was put forward as an innovative example of a new modern drainage concept. The new approach was however not fully accepted by all officials in the city administration.

## The transition towards a sustainable urban drainage

The implementation of the "Toftanäs Wetland Park" became a success. The facility attracted a lot of interest within Sweden as well as internationally. This attention encouraged Malmö Water to continue the development towards a more sustainable urban drainage. The 1990:ies to great extent became a period of transition, during which the technical skills and the experiences of the new approach were gradually improved. Most important during this transition period was that the institutional barriers between the technical departments in the city step by step were overcome.

In the first half of the 1990:ies there was still a resistance against the new drainage ideas within some of the technical departments in the city. For example some individuals did not like the idea that engineers from Malmö Water interfered in and even influenced the planning. There were even some doubts about the new drainage concepts within Malmö Water.

The transition towards a sustainable urban drainage in the city of Malmö was not problem-free. A key to success was that Malmö Water in alliance with the department of Parks & City Environment managed to carry out a number of successful drainage projects. This would not have been possible without an active involvement by the top management of the two departments.

In the second half of the 1990:ies, other departments in the city began to accept the new drainage concept and got more actively involved in the process of implementation. By the end of the 1990:ies the new ideas were more generally accepted throughout the city administration. Thus it took almost 10 years to develop an understanding and a positive cooperation among the different city departments involved in the planning. The time was now ready to draw the conclusions of the experiences of sustainable urban drainage that had been gained over the years.

## Development of a stormwater policy for Malmö

In the late 1990:ies the city of Malmö started the work with drawing up a policy document describing the general principles for managing stormwater in the new sustainable way[2]. The content of Malmö's stormwater policy will here be described very briefly.

### Basic principles

In the policy document it is emphasized that stormwater must be taken into account very early in the planning process. To achieve the best results there must be an open and trustful cooperation between the different stakeholders in the planning. It is pointed out that the main features of the drainage scheme should be outlined already in

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[2] Stormwater Policy. City of Malmö. 2000 (in Swedish)

the city's comprehensive plan or in extensions of this plan. The ambition in the comprehensive plan should be to lay out open drainage corridors on public land, to which the stormwater runoff from new developments could be diverted. The following detailed plans must among others focus the elevation of the ground in order to get an effective drainage of the new settlement.

One basic idea in Malmö's stormwater policy is that quantity issues (flows and volumes), quality issues (pollutants) and various social aspects (amenity and multiple use) should be dealt with in one connection.

## General goals

Based on the basic principles outlined in the policy document the following general goals were identified for the management of stormwater in Malmö:

- The natural water balance shall not be effected by the urbanization
- Pollutants shall to greatest possible extent be kept away from the urban runoff (source control of pollutants)
- The drainage system shall be designed so that harmful backing up of water in the existing drainage system is avoided.
- The drainage system shall be designed so that part of the pollutants in the runoff are removed along its way to the receiving waters.
- Stormwater shall wherever possible be looked upon as a positive resource in the urban landscape

The ambition with the new drainage approach is that experts from different disciplines in the city administration shall be actively involved in creating additional values to parks, recreation areas and other free spaces in the urban environment.

## Concluding remarks

The adopted stormwater policy for the city of Malmö outlines in more general terms, the way that has been chosen to achieve an ecologic, economic and aesthetic sustainable stormwater management in the city. The policy document presupposes an extensive cooperation between the technical departments in the city as well as with other stakeholders in the planning process. Important in the policy is the ambition that stormwater shall be looked upon as a positive element in the urban environment.

The above described policy document for the stormwater management in Malmö was adopted in the year 2000. It took however 2–3 years before the ideas of the policy document was fully applied in the planning of all new developments in the city. As a result of the policy, the problems of urban drainage became more generally recognized by the different technical departments in the city. Thanks to the policy document the communication between the departments involved in the planning was facilitated.

## Stormwater directives for the city of Malmö

As the interest for a sustainable urban drainage increased, the city officials asked for more detailed directives about the stormwater management in the city. A project group, with representatives from the city's technical departments was commissioned to work out detailed directives. This mission was completed in the early 2008 and the new directives were accepted by the politicians in 2008[3].

When working out the stormwater directives the ambition was to describe the subject in such a way that it could be easily understood by officials in all technical departments as well as by local politicians. The directives are intended to serve as a "communication platform" for all actors involved in the planning and design of open drainage facilities. The new directives covers the following issues:

- Responsibilities of different actors
- Planning procedures
- Design considerations
- Classification of stormwater
- Classification of receiving waters
- Preventive measures

There is a separate section in the directives that is describing the roles and responsibilities of the different city departments. To have an unambiguous and clear documentation of the responsibilities for every phase in the planning and implementation of sustainable urban drainage is of utmost importance to avoid confusion and misunderstandings. The directives cover the responsibilities for planning, design, implementation and maintenance.

The special features of the city's comprehensive and detailed planning when sustainable urban drainage is concerned, is described in more detail in the directives.

A special section is in the directives is dealing with design considerations for open stormwater facilities. The recommendations given there are based on the experiences in the city of Malmö and will be continuously updated.

The actual pollution content in the stormwater is of course of great importance for the choice of treatment measures. In this section an attempt has been made to categorize stormwater based on its pollution characteristics. The categorization has been made in rather general terms and is just indicating the type of treatment that may be necessary in different situations.

[3] Stormwater directives for the city of Malmö, 2008 (in Swedish)

The receiving waters for the stormwater runoff varies in Malmö from small watercourses with very low flows to the straight of Öresund with very large flows. In the management of stormwater it is of course necessary to consider the status of the receiving waters. In the stormwater directives a categorization of all receiving waters was made. The intention is that this categorization shall serve as a base for decisions on the need for treatment of stormwater.

The most cost-effective and sustainable way to reduce pollutants in stormwater is to set in preventive measures at the source. In the stormwater directives there is a separate section dealing with pollutions at the source. A specified list is presented of those substances and materials that should not be admitted in the city environment. There is also a list of activities that can effect the pollution content in the stormwater and on which special demands are set up.

As already mentioned the first version of the stormwater directives was adopted in 2008. The intention is that the directives shall be continuously updated as the knowledge and experiences increase. The ambition is to have a "living" web-based document.

# Overview of Implemented Facilities for Sustainable Urban Drainage in Malmö

Over the years many sustainable urban drainage projects have been implemented in Malmö. On the following pages a number of these projects will be described in more detail. The selected projects illustrate how the approach with sustainable urban drainage has developed from the end of the 1980:ies until today.

A list of the projects that have been included in this report is presented in *table 1*.

*Table 1. Overview of the described sustainable urban drainage projects in Malmö*

| Ref | Name | Year of implementation | Type of facility |
|---|---|---|---|
| 1 | Toftanäs Wetland Park | 1989–1990 | Wetland, controlled flooding |
| 2 | Sallerupsvägen | 1992 | Pond, meandering creek, root zone |
| 3 | Kasernparken | 1992–1993 | Pond, reedbed |
| 4 | Amiralsgatan | 1995–1996 | Ponds |
| 5 | Husie Lake | 1996–1997 | Detention lake |
| 6 | Olof Hågensens wetland | 1997 | Wetland, controlled flooding |
| 7 | Vanåsgatan | 1999 | Swales, inverted traffic bumps |
| 8 | Svågertorp | 1998–2001 | Soakaways, ponds |
| 9 | Limhamnsfältet | 1998 | Swale |
| 10 | Augustenborg | 1998–2005 | Green roofs, canals, swales, ponds, permeableble pavings, controlled flooding |
| 11 | Bo 01 housing exhibition | 2000–2002 | Open canals, rain gardens, water artwork |
| 12 | Fjärilsparken | 2000–2004 | Eco-corridor (regional swale) |
| 13 | Elinelund recreation area | 2001–2002 | Ponds, filter walls |
| 14 | Gottorpsvägen | 2001 | Ponds, filter wall |
| 15 | Vintrie | 2002–2003 | Series of detention ponds |
| 16 | Annestad | 2005 | Detention canal, controlled flooding |
| 17 | Växthusparken | 2005 | Eco-corridor (open watercourse and pond) |
| 18 | Tygelsjö eco-corridor | 2004–2007 | Eco-corridor (wetland, watercourse and ponds) |

The locations of the projects listed above are shown in *figure 5*. The numbers on the map refer to the reference numbers in the first column in *table 1*. They are also used in the following descriptions of the facilities.

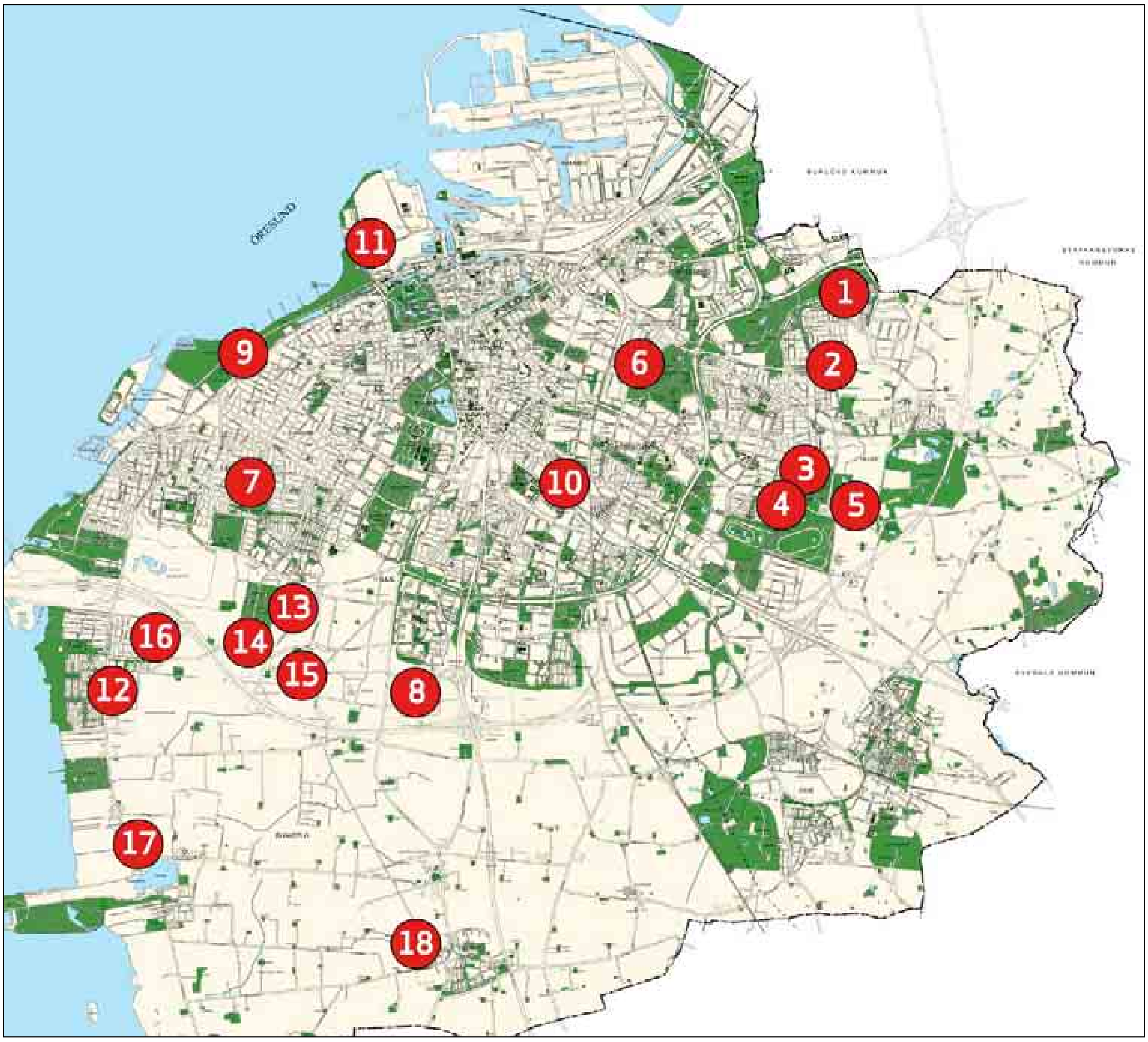


*Figure 5. Location of the sustainable urban drainage projects in Malmö listed in table 1.*

# 1. The Toftanäs Wetland Park

## Introduction

In the year 1988 the planning of a new development in Toftanäs in the east of Malmö was started. The development, which covers an area of about 60 hectares, was planned for commercial purposes. In direct connection to this development an area of about 18 hectares was set aside for single family houses.

The stormwater runoff from the new development had to be drained through an existing residential area to the small watercourse Risebergabäcken. An existing pipe could be used for conveying the water to the watercourse. The estimated spare capacity of this pipe was however only about 500 l/s. The expected runoff from the new development was calculated to be in the order of 1600 l/s. The capacity of the existing pipe was therefore not enough to handle the whole flow from the new development. To handle the flow the construction of a 1 km long pipe with the dimension of 1 000 mm would have been required.

As an alternative to the construction of a new conveyance pipe, Malmö Water suggested that a detention pond was constructed within the new development. The city's department of Planning was not very enthusiastic about the idea of having an open pond within the new development. They preferred a conventional solution based on the construction of a conventional pipe system.

To gain additional support for the idea of detaining part of the runoff in an open system, Malmö Water approached the city's department of Parks & City Environment. Together the two departments developed the vision of the "Toftanäs Wetland Park". The basic idea was to create a wetland reserve as a new element in the urban environment. In the promotion of the vision special emphasis was put on the environmental aspects of the facility and its added new values to the city environment, such as an increased biodiversity. It would also become a connection zone between the new commercial area and the adjacent housing area. The vision of the Toftanäs Wetland Park was accepted by the city's department of Planning and the detailed design of the facility could start.

## Design and implementation

The Toftanäs Wetland Park was created by excavating an area of about 3 hectares of former farmland to a depth of about 3 metres beneath the ground level. More than 60 000 $m^3$ of soil was excavated and transported away from the area, see *figure 6*.

In the excavated area a wetland was constructed. *Figure 7* shows the general layout of the Toftanäs Wetland Park. The stormwater that is entering the facility first passes an inlet pond, which serves as a sediment trap for heavier material. From the inlet pond the water runs in a low flow channel, which is meandering through the excavated park to the outlet. To stimulate aquatic life in the water, a series of deeper sections (pools) and sections with stone fillings (riffles), were arranged in the low flow channel. At the downstream end of the channel an outlet pond was constructed. The water level in the wetland park is controlled by a regulation structure at the outlet.

The wetland park was only partly designed as a wetland with a permanent pool of water. The rest was designed as a dry pond, which is flooded during wet weather conditions. The reason for this design was the ambition to facilitate public access to the wetland park during dry weather conditions. In the wet part of the park three "islands" were created. These give a good view of the wet parts of the park. *Figure 8* shows an aerial view of the facility during winter conditions. The construction of the Toftanäs Wetland Park was completed in 1990.

## Positive values of the Toftanäs Wetland Park

The vision of the Toftanäs Wetland Park was to form an interesting wetland reserve with a rich flora and fauna. The different values of the new wetland park will here be described in more detail:

### Technical values

One important goal with the Toftanäs Wetland Park was to get enough storage volume to detain stormwater from the new development during wet weather conditions, so that the available capacity of the downstream conveyance pipe is not exceeded. The detention is accomplished by restricting the outflow from the facility to a predetermined base-flow. When this flow is exceeded the water level in the wetland will rise. The volume between the minimum and maximum water levels in the wetland constitutes the effective detention volume.

By designing the detention facility in the form of a wetland it is possible to get some treatment of the stormwater. The effectiveness of the Toftanäs Wetland Park, with respect to removal of pollutants was followed up in the period 1990–1996. During the first year a net outflow of nutrients from the facility was observed (negative removal rate). The following years the average yearly removal rates gradually increased to 22–29 % for nitrogen (N-tot) and to 20–50 % for phosphorus (P-tot). The removal rates showed big seasonal variations. During the vegetation season the removal rates for both nitrogen and phosphorus amounted to about 50 %. In the winter season the pollution removal was considerably lower.

After having been in operation for 3–4 years without any maintenance, a decrease of the removal rates was observed. This was due to erosion of accumulated sediments from the inlet and outlet ponds and from the low flow channel. The conducted measurements of the pollution removal efficiency of the facility indicate the importance of regular sediment removal.

*Figure 6. Excavation work during the construction of the Toftanäs Wetland Park*

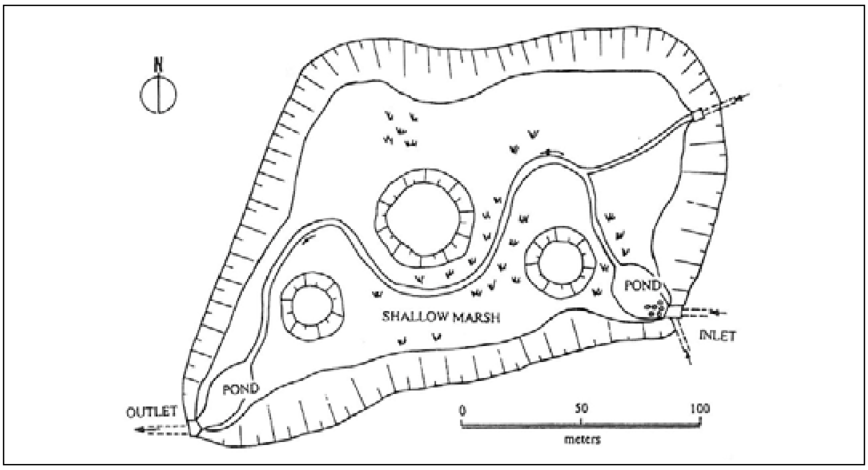


*Figure 7. General layout of the Toftanäs Wetland Park*

*Figure 8. Aerial view of the Toftanäs Wetland Park in winter time*

## Biologic values

As already mentioned the Toftanäs Wetland Park was designed as an extensive park area. The city's department of Parks & City Environment was responsible for the detailed design of the facility. Experts from the Swedish University of Agricultural Sciences were also involved. Special emphasis was in the design put on selecting plants and vegetation suitable for the wet environment in the facility. Vegetation was planted both as seeds and cuttings.

Both planted vegetation and spontaneous established vegetation developed very well in the wetland environment. On the side slopes of the wetland a variety of meadow flowers and different types of grass have established. The gentle slopes make it very easy to access the wetland park. This zone forms a natural link to the surrounding development. *Figure 9–11* show examples of the rich vegetation that has established in the Toftanäs Wetland Park. The wetland park has no doubt become a positive contribution to the surrounding development and given it great added values in the form of an increased biodiversity.

In the wetland park a rich fauna has developed. This includes among others an interesting aquatic microfauna. The Toftanäs Wetland Park has also developed to a sanctuary for birds, with a very rich bird life Occasionally ornithologists arrange bird watching tours within the wetland park.

## Economic value

An evaluation has been made of the total costs for implementing the Toftanäs Wetland Park. In summary the evaluation shows that the costs for construction of the wetland park are in the same order as the costs would have been for the construction of a conventional drainage system within the development. The main economic benefit lies in the effects of the flow detention that is achieved in the wetland. Through the detention, the hydraulic load on the downstream system was reduced so much that the whole runoff from the Toftanäs area could be handled in the existing downstream conveyance pipe.

If the development in Toftanäs had been designed with a conventional drainage system without any detention, it would have been necessary to build a new pipe from the wetland park to the receiving water Risebergabäcken. As this is a distance of about 1 km it would have resulted in considerably higher costs (about 30 %) than the selected design with a wetland park.

*Figure 9. Flower-meadow on the gentle slopes of the Toftanäs Wetland Park*

*Figure 10. Inlet pond and wetland in the Toftanäs Wetland Park*

*Figure 11. Wetland vegetation in the Toftanäs Wetland Park.*

## Maintenance

The yearly maintenance of the Toftanäs Wetland Park include among others regular cutting of the meadow vegetation and thinning out some of the trees that grow within the facility. These measures are necessary to control the very nutritious environment in the wetland park.

As indicated by the measurements of the pollution removal in the wetland it is necessary to have regular maintenance of the facility. It is necessary to remove the sediments from the inlet pond every 3–4 years and from the outlet pond every 5–6 years.

The responsibility for the maintenance of the Toftanäs Wetland Park has been formalized in an agreement between Malmö Water and the city's department of Parks & City Environment. According to this agreement Malmö Water takes the responsibility for the inlet and outlet structures and the inlet and outlet ponds while the department of Parks & City Environment takes the responsibility for the green part of the facility.

# 2. The Sallerupsvägen Drainage Corridor

## Introduction

The main road Sallerupsvägen in the east of Malmö was in 1992–1993 extended further eastwards. In this connection it was necessary to take measures to handle stormwater not only from the new road but also from some future new developments in the area. In total stormwater from about 62 hectares of impervious surfaces had to be taken care of. The runoff was to be discharged into the small watercourse Risebergabäcken. As the Risebergabäcken was already heavily overloaded it was necessary to introduce measures to detain the stormwater runoff from the new areas and possibly also to reduce the pollution content in the water.

For the new road there were also demands on reducing the traffic noise. The departments of Parks & City Environment, Street & Traffic and Malmö Water together came up with the idea to create a drainage corridor along a 400 metres long noise reduction wall. The basic idea was to mass balance the two facilities so that no additional soil material was needed for the construction work.

The first couple of years the new drainage corridor was only fed with stormwater from the new road. After some years additional stormwater from the planned new settlements was diverted to the Sallerupsvägen Drainage Corridor.

## Design and implementation

The goal with the Sallerupsvägen Drainage Corridor was to establish a nature reserve, which besides biologic values would give both detention and treatment of the stormwater runoff. To accomplish this, the corridor was built up of an inlet pond, a meandering creek and a constructed root zone, see *figure 12 - 13*.

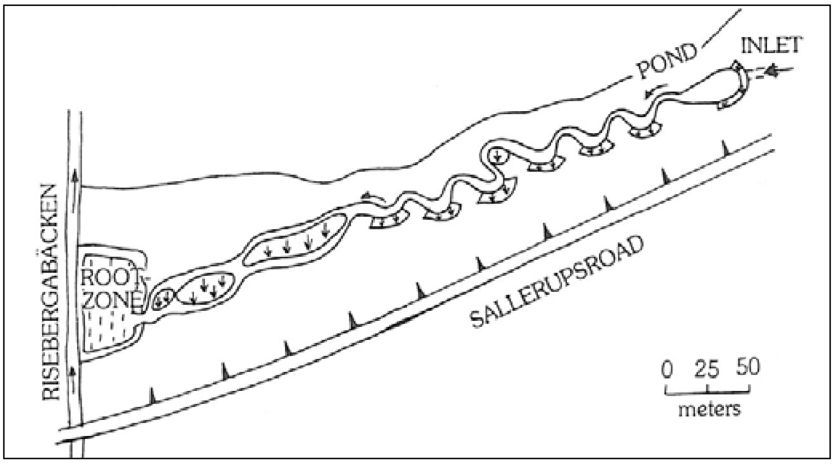


*Figure 12. General layout of the Sallerupsvägen Drainage Corridoor*

The surface runoff from the new road and from the adjacent new settlements is discharged into the inlet pond, which is located at the upstream end of the drainage corridor. The pond serves as a sediment trap for heavier particles in the water, see *figure 14*.

From the inlet pond the water runs through a meandering creek. At the downstream end of this creek "vegetation islands" have been created with water on both sides. As the transport of the water through the meandering creek is quite slow, some of the pollutants in the water is taken up by the vegetation.

At the downstream end of the drainage corridor the water from the meandering creek is discharged into a constructed root-zone facility, see *figure 15*. This has a total area of 0,2 hectares. It is built up of a soil bed, which is located under a controlled groundwater surface. The soil bed is planted with water plants (Phragmites australis, Thypha, Iridaceae, Phalaris arundinacea). These plants have the capability of taking up nutrients and heavy metals from the stormwater. The root-zone facility is located just at the edge of the watercourse Risebergabäcken. To protect the root-zone from erosion a layer of stabilizing macadam has been arranged just before the water reaches the watercourse.

## Positive values of the Sallerupsvägen Drainage Corridor

### Technical values

The inlet pond and the meandering creek give a pre-treatment of the water as well as an effective equalization of flow variations before it reaches the root-zone facility. The treatment efficiency of the root-zone is to great extent dependent on how much water is actually passing through the active root layer. Water that runs on the surface does not undergo any treatment.

When water is entering the root-zone the finer particles in the water will be filtered out. Some of the toxic substances are degraded in the aerobic, anoxic and anaerobic zones in the facility. Heavy metals are fixed to organic particles. Organic materials are degraded and nitrogen is turned into gas form by denitrification.

The expected pollution removal in the facility is estimated to be 25 – 50 % for heavy metals, 50 % for N-tot, 50 % for organic material and 25 % for P-tot. It must be emphasized that these are theoretical figures. No measurement of the treatment efficiency of the facility has been carried out so far.

### Biologic values

The Sallerupsvägen Drainage Corridor has developed to an exciting nature reserve with a rich flora and fauna. The meandering creek is running through the valley, which was created by the massbalancing when the noise reduction wall was built up. The abundant vegetation give the drainage corridor its unique character and a good protection for the birds and other animals.

*Figure 13. Aerial view of the Sallerupsvägen Drainage Corridor.*

*Figure 14. The inlet pond of the Sallerupsvägen Drainage Corridor*

*Figure 15. Overview of the root-zone facility at the downstream end of the Sallerupsvägen Drainage Corridor*

# 3. The Kasernparken Pergola Pond

*Figure 16. View of the Pergola Pond in the Kasernparken*

When developing a new residential area within the former military campus LV4 in the east of Malmö there was a need to reduce the stormwater runoff before being discharged into the small watercourse Risebergabäcken. The new settlement was developed in 1992 - 1993. On an initiative of the department of Parks & City Environment it was decided to create a park on the slopes down to the Risebergabäcken. The new park – the Kasernparken – was laid out to form an integrated part of the green corridor that had been established along the Risebergabäcken.

The stormwater from the new development is discharged into a small circular detention pond. The pond has at the shores a water depth of about 0,2 metres. The deepest part of the pond is in the middle, where the water depth is 0,5 metres. The bottom of the pond is covered with a rubber cloth. This design has for some years caused maintenance problems, which have to do with the development of natural gas in the soil layer under the cloth.

At the northern side of the pond a meeting point for the residents was arranged with benches, tables and a pergola. A wooden platform gives the visitors direct access to the pond, see *figure 16*.

The outflow from the pond takes place through a small weir construction. The water that is leaving the pond runs out onto an area covered with natural reed, where it is detained and filtered on its way to the watercourse Risebergabäcken.

# 4. The Amiralsgatan Detention Ponds

*Figure 17. The western pond at the Amiralsgatan*

When the main road Amiralsgatan in the east of Malmö in 1996 was extended further eastwards, it was necessary to take measures to reduce the impacts of the stormwater runoff. The main reason for this was that the receiving water – the small watercourse Risebergabäcken – was heavily overloaded. The situation was discussed by the departments of Street & Traffic, Parks & City Environment and Malmö Water. The solution that came up was to detain the stormwater runoff in two ponds located on either side of the crossing point between the new main road and the Risebergabäcken. In total the ponds will be fed with stormwater from an area of 18 hectares. Hereof 3 hectares represent the new road and 15 hectares an existing commercial development. The two ponds will dampen the peak flows in the runoff and also give the water some treatment before it is discharged into the watercourse Risebergabäcken.

*Figure 17* shows an image of the western pond. Stormwater from the road surfaces is running over the grass covered road banks. To increase the infiltration, the upper soil layers of the road banks has been mixed with sand, peat and limestone. In this layer some of the pollutants in the surface runoff are catched. Having passed the road banks the water is running in a vegetated swale along the road and via a pipe into the pond. It can be mentioned here that a quick and spontaneous development of some exotic water plants from South Africa was observed in the pond.

# 5. The Husie Lake

## Introduction

Historically many wetlands in Sweden have been drained out in order to create more land for agricultural purposes. One such area is located in the district of Husie in the east of Malmö. The area in question was some hundred years ago a lake, which eventually was drained out. Later it was for several decades serving as a military training field.

In the mid 1990:ies the idea of recreating the lake was launched by Malmö Water and the department of Parks & City Environment. There were other reasons than just historic to spend money on recreating the former lake. The overall vision was to promote a more sustainable development by introducing new ecological elements in the city environment. The ambitions were:

- To give the citizens better opportunities to enjoy nature in their neighbourhood
- To make water more visible in the landscape
- To increase the biodiversity in the area
- To establish a water body, which could be used for detention of stormwater
- To improve the water quality in the downstream water system

The Husie Lake constitutes an important part of the superior green infrastructure and strengthens the visual impression of a coherent green corridor in the eastern outskirts of Malmo.

## Design and implementation

The planning of the new lake and its surroundings was carried out according to the principles of sustainable development. This means that the planning was pursued in close cooperation with the citizens of the district of Husie, who got the opportunity to influence the development of their immediate surroundings. Contacts were also established with different environmental interest groups, which were invited to take part in the planning of the facility. The experiences of the planning process were very positive from all involved parties.

The Husie Lake was excavated in a natural lowland. The size of the lake is about 4 hectares and the water depth varies between 0,1–2,0 meters. The excavated material was used for landscaping the area around the lake. Meandering channels were created at the inlet to the lake. Some small islands were constructed in the lake as well as some wetlands along the shores. *Figure 18* shows a schematic layout and *figure 19* an aerial view of the Husie Lake.

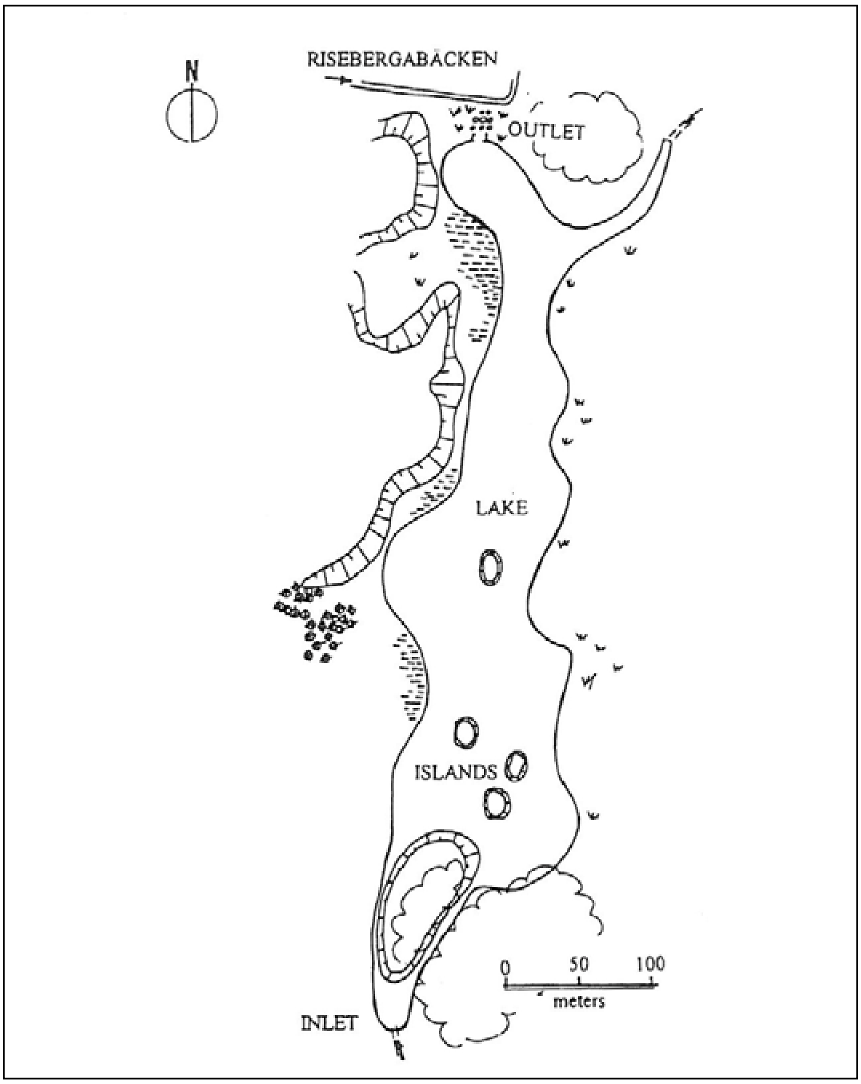


*Figure 18. General layout of the Husie Lake*

*Figure 19. Aerial view of the Husie Lake*

The original open character of the Husie Lake area was maintained and new trees were only planted in a few isolated locations. The vegetation around the lake is mostly plants naturally occurring in Swedish wetland environment, e.g. Yellow Iris and Marsh Marigold. One interesting element in the completion of the Husie Lake project was that children from schools in the neighbourhood were invited to plant some of the wetland vegetation along the shore of the lake. This initiative was very popular and was given a lot of attention in the media. The outlet from the lake is built up of big granite blocks, see *figure 20*.

The construction of the Husie Lake was completed in1997. The costs for the realization of the project was shared between Malmö Water and the department for Parks & City Environment.

## Positive values of the Husie Lake

### Technical values

The catchment area of the Husie Lake amounts to about 100 hectares. Most of this area is today undeveloped. In the future new residential areas will be developed just east of the lake. As the receiving water further downstream has limited capacity, measures must be taken to detain the runoff from the new developments. For that purpose quite a large storage volume was needed. As already mentioned the idea of reconstructing the old lake came up when the interests of Malmö Water was combined with the interests of the city's department of Parks & City Environment.

The detention is attained by the natural water level variations in the lake. As the size of the lake is quite large (about 4 hectares) the water level variations will be very limited. In addition to the detention effect, the stormwater that is discharged to the lake will undergo some treatment.

### Recreation values

As mentioned before the new lake was planned to form an integrated part of the superior green infrastructure in the east of Malmo. Already from the beginning the Husie Lake became a popular recreation area with a very rich flora and fauna. A place with a good view of the lake was arranged on the top of a hill on the western side of the lake, see *figure 21*.

To facilitate the access to the lake, walking paths and footbridges were arranged around the lake, see *figure 22*. These were laid out along the shores of the lake in order to display the variety of flora and fauna at the lake.

*Figure 20. The outlet structure of the Husie Lake.*

*Figure 21. Wiew of the Husie Lake from the west*

*Figure 22. Walking path around the Husie Lake*

## Pedagogic values

School classes from the district of Husie are frequently making excursions to explore the nature and wildlife around the Husie Lake, see *figure 23*. A teacher in one of the schools in the district has laid out a nature trail for school children and has written guidelines for where to go and what to see. The trail has become very popular and is today frequently used by many schools in the district.

A folk high school in the neighbourhood has as part of their education, been following up the water quality of the Husie Lake. Water samples are taken from the lake and analysed.

*Figure 23. School excursion around the Husie Lake*

# 6. The Olof Hågensen Wetland

*Figure 24.Overview of the Olof Hågensen Wetland*

In the planning of upgrading the sewer system in the east of Malmö, the need for corrective measures in the local street Olof Hågensens Allé was identified. By detaining part of the stormwater runoff the risks for basement floodings further downstream could be reduced. A detailed study of the local conditions showed that the necessary storage volume could be created by excavating an existing green area close to the stormwater system.

Malmö Water and the department of Parks & City Environment jointly worked out a design where a small wetland was created off-line the stormwater system on a level about 2,5 metres below the surrounding ground. The total area of the piece of land that was used for the wetland was about 0,3 hectares.

At the inlet to the wetland facility a weir structure was constructed, which decides at which water level in the pipe system, stormwater will be diverted to the wetland. To avoid erosion problems the area around the inlet was reinforced with granite stones. Through the bottom of the wetland there is a low flow channel with the purpose of directing the flows to the outlet. Water is drained from the wetland area by gravity through a choked outlet. The whole area is planted with wetland vegetation. *Figure 24* shows an overview of the Olof Hågensen Wetland.

# 7. The Vanåsgatan Swale

## Introduction

Onsite detention of stormwater is often an effective way of protecting combined sewer systems from being overloaded. Here will be described how onsite detention has been used for handling the runoff from the local street Vanåsgatan in the southwest of Malmö.

An evaluation of the hydraulic conditions of the sewer system showed that the existing combined sewers were overloaded. An evaluation of different alternatives for upgrading the system showed that the situation would improve significantly if the runoff from the street surface could be disconnected from the system.

Malmö Water and the department of Parks & City Environment came up with the idea to create a swale along the street, to which all surface runoff from the street could be diverted. Such a solution was possible as there was an existing green buffer strip on the northern side of the street. This buffer strip was prevoiusly planted with well developed willow trees (salix alba). The willow trees had over the last decade caused severe problems with tree root intrusion in the sewer system. These resulted in repeated sewer blockages and basement floodings in the area. By taking away the trees the problems with tree root intrusion in the sewer pipes could be solved.

The idea to divert the stormwater from the street to a swale along the street was presented to the department of Street & Traffic. In the discussions with this department it turned out that they at the moment were considering to introduce measures to reduce the traffic speed in the street. Among the alternative they had considered can be mentioned traffic bumps, road blockages etc.

## Design and implementation

The concept that was chosen for handling the street runoff from the Vanåsgatan was to let the stormwater run out onto a meandering swale which was excavated in an existing green buffer strip along the northern side of the street. The existing willow trees were taken down and replaced by smaller trees and bushes with less aggressive tree roots. *Figure 25* shows an aerial view of one section of the street after the completion of the new drainage system.

The green buffer strip with the meandering swale has a total length of about 500 metres and a width of about 5 metres. The bottom of the swale lies about 0,3 meters below the street level. The slopes of the swale are very gentle, see *figure 26*. The ground conditions along the swale were investigated and found suitable for infiltration of stormwater.

*Figure 25. Aerial view of one section of the Vanåsgatan Swale*

*Figure 26. View of the Vanåsgatan Swale*

Most of the surface runoff from the street that reaches the swale will infiltrate. For exceptional runoff events arrangements have been made to let excess water in the swale run out into an existing park at the downstream end of the Vanåsgatan Swale.

One problem that had to be solved was how to divert stormwater from the southern side of the street to the swale on the northern side. It was decided to construct a number of "concave" traffic bumps in the form of depressions in the street surface. These were necessary because the elevation of the street has its maximum in the middle of the street.

*Figure 27. Close up of one of the concave traffic bumps in the Vanåsgatan*

*Figure 28. Warning sign for "concave" traffic bumps*

*Figure 27* shows one of the inlets from the "concave" traffic bumps to the swale. The implementation of the Vanåsgatan swale was completed in 1999.

The open drainage system in the Vanåsgatan has become very appreciated by the residents living in the street. The system has proved to be very effective in solving the sewer problems in the area. Since the new system was implemented no basement floodings has occurred.

The concave traffic bumps has also proved very effective – almost too effective – to slow down the traffic. Cars that exceed the speed limit are immediately punished by bumping into the street when passing the traffic bumps. The lesson learnt for the traffic engineers is that "concave" traffic bumps should be made with more gentle slopes.

# 8. The Svågertorp Business Centre

In the middle of the 1990:ies the first plans were laid out for establishing a new business centre in the district of Svågertorp in the south of Malmö. The new business centre, which has a total area of about 100 hectares, was planned to contain a cluster of large department stores and wholesalers. The main access to the area is by car and large parking areas were therefore needed.

It was quite obvious that the management of stormwater from all impervious areas within the development was likely to become a problem. The city therefore decided to set up special restrictions for the runoff of stormwater from private properties. Thus all property owners were forced to reduce the rate of runoff from their respective property by applying different measures for local disposal of stormwater, see *figure 29*. In addition Malmö Water worked out a drainage scheme for slow transport of stormwater on public land.

Most of the stormwater from the Svågertorp Business Centre is collected in a system of stonefillings located on both sides of the streets in the area. The bottom of the stonefilling is provided with drainage pipes through which the water in the filling material is continuously drained off. On the top of the stonefillings vegetated depression storages were created, see *figure 30*. The purpose with these is to get some additional storage volume for the most extreme runoff events. Under normal condition there is no standing water in the depression storages.

*Figure 29. Runoff from a parking areas is diverted to stone fillings*

The whole of the Svågertorp Business Centre is drained to the west. The water from the slow drainage system is discharged into two open detention ponds located at the western edge of the area, see *figure 31*. Having passed these ponds the water is discharged into the natural creek Vintriediket. The overall goals for the drainage system are to reduce the total runoff from the Svågertorp development to a level close to the runoff from the area before it was developed and to reduce pollutants from parking areas and roads.

The concept of slow drainage that has been applied in the Svågertorp Business Centre has worked out very well. So far there has been no problems with the drainage even during the most extreme runoff events. It is obvious that the drainage concept that was chosen for the new development in many respect is superior to a traditional drainage system with stormwater pipes.

*Figure 30. Depression storages along one of the streets in the Svågertorp Business Centre*

*Figure 31. Detention pond at the western edge of the Svågertorp Business Centre*

# 9. The Limhamnsfältet Recreation Field

Drainage of stormwater in open systems is in Malmö also applied for upgrading of the city's existing combined sewer system. The basic preconditions for this solution are firstly that the stormwater from a selected area can be captured before it enters the combined sewer system and secondly that there are suitable green areas that can be used for handling the collected stormwater runoff.

In the district of Bellevue in the west of Malmö most of the sewers are of combined type. At the western edge of the district there is however an isolted area with duplicate sewer system. The stormwater from this area was discharged into combined sewers and caused overloading of the system. An analysis was made of the possibility to make the isolated duplicated pipe system active by diverting the stormwater out onto the adjacent Limhamnsfältet Recreation Field. It was found that only a shorter section of new pipe was needed to disconnect the stormwater from the existing combined sewer system. Besides, the preconditions for handling the stormwater runoff within the recreation area were very good.

The possibility of diverting stormwater out onto the Limhamnsfältet Recreation Field was discussed between Malmö Water and the department of Parks & City Environment. The two departments jointly worked out the detailed design for a new open drainage system. Stormwater from the isolated duplicated area was led in a new stormwater pipe out onto the recreation field. At the end of the pipe a swale with very gentle slopes was constructed. The swale runs along a pedestrian path at the western edge of the recreation field to an existing small wetland, see *figure 32* .

*Figur 32. Wetland area at the downstream end of the swale on the Limhamnsfältet Recreation Field*

# 10. The Eco-City Augustenborg

## Introduction

The settlement of Augustenborg was developed in the 1950's by Malmö's housing company MKB. The area is built up of 3–6 storeys apartment blocks. All flats were equipped with bathroom and refrigerator, which at the time of development was the utmost of modernity in this type of housing area. The settlement of Augustenborg became well-reputed and was pointed out as a model for modern living in Sweden. The size of the settlement is about 20 hectares and the number of inhabitants amounts to around 3000. Within the settlement there is among others one school, one public park and a workshop area for the city of Malmö.

In the 1970's the standard of the flats in the settlement were getting out of fashion and people began to move away from the area. As a result the social status of the Augustenborg settlement started to deteriorate. After a decade the previous renowned settlement turned into a problem area. Since the mid 1990's the MKB housing company has been working systematically to restore the tarnished status of the area – an effort that among others resulted in the project "Eco-city Augustenborg".

The "Eco-city Augustenborg" project, which started in 1998, is a partnership between the MKB housing company and the City of Malmö. The goal with the initiative was to transform Augustenborg into a socially, ecologically and economically sustainable settlement. The project is an excellent example of how the ideas of sustainability can be applied in urban renewal. One important element in the project was to get the residents interested and actively involved in the upgrading of the settlement.

The "Eco-City Augustenborg" project includes a number of different innovative initiatives. One is the implementation of a sustainable stormwater management. The lead partners in this part of the project are the MKB housing company, Malmö Service Administration and Malmö Water.

## Drainage concept

All stormwater from the Augustenborg settlement is handled in a combined sewer system, in which stormwater and sanitary sewage water is running off in the same pipe. The combined sewer system was heavily overloaded, which resulted in frequent basement floodings during periods of intensive rainfall. The traditional way of solving the flooding problems would have been to upgrade the existing combined system to a duplicate sewer system with separate pipes for stormwater and for sanitary sewage water.

In the "Eco-City Augustenborg" project it was decided to solve the problems with the overloaded sewer system in a more ecological way.

*Figure 33. Overview of the settlement of Augustenborg (ISS Landscaping)*

The basic idea was to take care of as much of the stormwater as possible near the source and to handle the excess water in an open drainage system. The big challenge with the chosen concept was to integrate the open drainage system in the existing urban landscape and to get the inhabitants to accept the new system.

As a source of inspiration for the design process the residents of the settlement were invited to give their views on how to accomplish an open drainage system within their settlement. With these ideas as an input, Malmö Water made a first layout of how to accomplish the open drainage. The design ideas were communicated with the residents and then refined and developed further.

Among the techniques that were applied for handling the stormwater within the settlement can be mentioned:

- Local infiltration on vegetated roofs, lawns, parking lots etc.
- Flow detention in ponds and on areas prepared for temporary flooding
- Slow transport in swales, ditches, canals etc

The present knowledge of the various techniques that were applied in the Augustenborg settlement is well established. The great challenge with the "Eco-City Augustenborg" project was to combine the different techniques and to integrate them in the existing settlement.

*Figure 33* shows an overview of the Augustenborg settlement. One can distinguish the following four parts of the new sustainable drainage system:

- Augustenborg botanical green roof garden (1)
- The central drainage corridor (2), (4), (6), (8), (10), (11)
- The Lönngatan drainage corridor (13), (14), (15), (16)
- Other examples of local disposal of stormwater (7), (9), (12), (17)

The numerical digits in parenthesis refer to their location on the map in *figure 33*. The different parts of the drainage system will in the following be described in more detail.

## The Augustenborg Botanical Roof Garden (1)

### Introduction

The city of Malmö has for many years taken an active interest in green roofs as a contribution to a more sustainable urban environment. There are many positive effects associated with vegetated roofs in the urban environment. One of these is green roofs' capability of reducing the runoff of rainwater.

As part of the "Eco-City Augustenborg" project the city's Service Administration in 1999 took the initiative to implement an experimental site for green roofs at the city's workshops in Augustenborg. The idea was to create a botanical roof garden – the first of its kind in the world – to demonstrate the use of the green roof technique in Scandinavia. The project was supported economically by the EU-Life program and by the Swedish Ministry of Environment.

The work with constructing the green roofs at Augustenborg started in 1999. Two years later the Augustenborg Botanical Roof Garden was inaugurated. The demonstration site consists of 9500 $m^2$ of green roofs divided in a large number of parcels. These are composed of different soil mixtures, plant mixtures, slopes etc. The Augustenborg Botanical Roof Garden is situated on top of several workshop buildings with flats roofs, see *figure 34–35*.

In *figure 35* the light blue colour indicate the part of the Augustenborg Botanical Roof Garden that is open to public and the orange colour the entrance building and footbridges within the demonstration areas. The light green colour indicates pilot areas that are used for different research activities. *Figure 36* shows an overview of one section of the Botanical Roof Garden.

### The Scandinavian Green Roof Institute

One important goal with the Augustenborg Botanical Roof Garden is to stimulate research and development of the green roof technology and to promote further use of green roofs in Scandinavia. As a framework for accomplishing this goal, the Scandinavian Green Roof Institute (SGRI) was established at Augustenborg. Among the activities of the Institute can be mentioned:

- International workshops and seminars
- Study visits for political and professional groups from all over the world
- Making knowledge about the use of green roofs available through a website (www.greenroof.se)
- Scandinavian Green Roof Award
- Facilitation of research activities at the Augustenborg Botanical Roof Garden

*Figure 34. Aerial view of the Augustenborg Botanical Roof Garden*

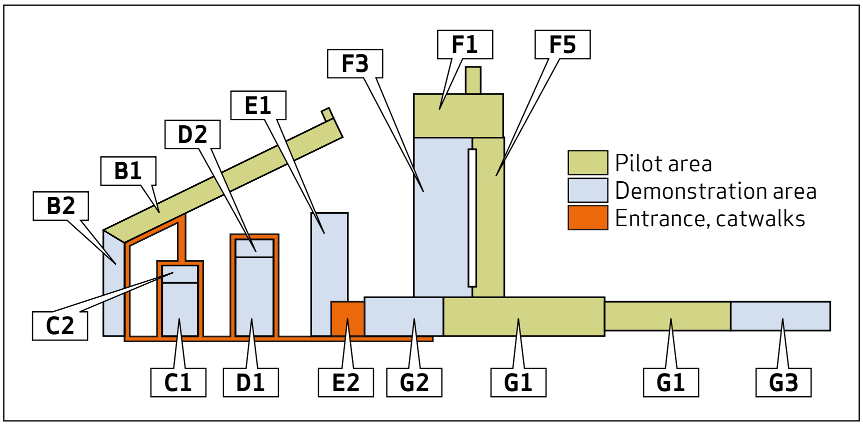


*Figure 35. Overview of the different sections of the Augustenborg Botanical Roof Garden.*

*Figure 36. Overview of one section of the Augustenborg Botanical Roof Garden*

A large number of research projects have been carried out at the Augustenborg Botanical Roof Garden by Universities and Research Institutes in the region. As examples can be mentioned studies of water quality and quantity of the runoff from the green roofs, studies of the development of birds and insects on green roofs, studies of different aspects of the technical design of green roofs etc.

The Scandinavian Green Roof Institute has also developed an educational program for preschool children called the "Water Safari". The children are equipped with headsets and walk along the path of the water, starting on the green roofs and following the open drainage system in the settlement of Augustenborg, see *figure 37*. At certain points on their way the children get sound experiences through the headsets explaining different features of water.

It can here also be mentioned that the Scandinavian Green Roof Institute together with the Swedish University of Agricultural Sciences, has developed an internet course covering different aspects of the green roof technology.

### Green roofs

One can distinguish between two main groups of green roofs – extensive and intensive green roofs. An extensive green roof has a very thin soil layer, which is covered with draught tolerant plants – e.g. sedum. Extensive green roofs require little or almost no maintenance. An intensive green roof has much thicker soil layers, and often looks like an ordinary garden, with trees and shrubs. This type of green roof needs the same amount of maintenance as a garden. As it is much heavier than an extensive green roof it can only be constructed on a roof that can carry the heavier load.

As mentioned earlier a green roof has the capability of reducing the runoff of the rainwater that falls on the roof. Research that has been carried out on extensive roofs at the Augustenborg Botanical Roof Garden shows that only 50 % of the rainwater on a yearly basis runs off from the roofs. The rest is soaked up by the vegetation cover and is evaporating. It must be emphasised that there are big seasonal variations in the runoff.

In Augustenborg Botanical Roof Garden a wide variety of different types of green roofs are displayed. *Figure 38* shows a section of the moss-sedum roofs which is the most commonly used green roof today.

*Figure 37. Preschool children taking part in the "Water Safari" at the Augustenborg Botanical Roof Garden*

*Figure 38. Moss-sedum roof at the Augustenborg Botanical Roof Garden*

*Figure 39. An inspirational roof garden with climbing plants and rolling hills designed by the Swedish landscape architect Monica Gora*

## Inspirational roof gardens

The Augustenborg Botanical Roof Garden is constantly developing and new concepts are being tested. During 2003 four inspirational gardens were built on one of the roofs. Two of these gardens are shown in *figure 39–40*. The main purpose of the inspirational gardens is to demonstrate how a green roof can improve the quality of life. This type of roof gardens can for example be applied at hospitals and homes for elderly people. Recent research on health gardens has shown that gardens have a remarkably good effect on people who are suffering from different stress related illnesses.

## Experimental ruderal roof garden

In order to increase the knowledge of the special flora and fauna that develop in brown field areas in the urban environment, an experimental ruderal roof garden has been created in the Augustenborg Botanical Roof Garden. The ruderal garden, which covers an area of 150 $m^2$, is designed to resemble the conditions at demolition sites, railway sidings, deserted industrial or harbour grounds etc, see *figure 41*. Both plants and insects and other small animals and birds that are adapted to such lands are getting rarer, as our cities are developing.

In the design of the ruderal garden special emphasise was put on maintaining the natural biodiversity. The ruderal garden shows that design for beauty and design for biodiversity not always go hand in hand. The intention with the ruderal garden is to inspire developers to use this type of "brown-field" roofs on the top of the buildings in order to stimulate the biodiversity.

*Figure 40. A herb garden with a comfortable veranda floor, raised flowerbeds, lavender hedges and ponds with trickling water was designed by the Swedish landscape architect Pär Söderblom*

*Figure 41. A ruderal "brown field" garden designed by the Swedish landscape architect Mårten Setterblad*

### The workshop canal

All excess water from the green roofs as well as the surface runoff from parts of the workshop yards is diverted to an open drainage canal which runs along one of the workshop buildings, see *figure 42*. The canal was designed to form a positive asset in the workshop area. At the downstream end the water is pumped from the canal to the central drainage corridor in the settlement of Augustenborg (see below). To get some treatment of the water, wetland weeds were planted in the canal.

## The Central Drainage Corridor

The Central Drainage Corridor in the settlement of Augustenborg is a system for slow transport of stormwater from the workshop area in the southeast to the southwest corner of the settlement, where the open drainage system enters a traditional stormwater system.

### The concrete drainage canal (2), (3), (4)

The first part of the Central Drainage Corridor was designed in the form of a very strict concrete canal. The reason for selecting this design was that the available space between the apartment blocks was limited. The canal has a width of 0,5 meters and a depth of about 0,6 metres. The total length of the canal is 100 metres, see *figure 43*. The canal is in the upstream end collecting water from the Augustenborg workshop area and from the adjacent apartment block.

Stormwater from the roofs of the apartment blocks along the drainage canal is diverted to the canal through especially designed so called "water drop" gutters. The name refers to the shape of the bottom of the gutter, which has the form of concrete water drops. The intention with the design was to increase the water velocity at the bottom and hereby making the gutters self-cleansing, see *figure 44*. The "water drop" gutters are designed by the artist Morten Ovesson who himself is a resident in the settlement of Augustenborg.

Half way down the concrete drainage canal a "mini-wetland" was constructed. Here water from the canal can flow out onto a small depression storage just outside the canal. The storage, which was planted with wetland vegetation, is only fed with water when the water level in the canal exceeds a predetermined level.

*Figure 42. All excess water from the green roofs is collected in an open drainage canal*

*Figure 43. Mini-wetland at the concrete canal in the upper section of the Central Drainage Corridor*

*Figure 44. "Water drop" gutter diverting water from the downpipes of the apartment blocks to the concrete drainage canal*

### The “double pond” (6)

At the downstream end of the concrete drainage canal, water is discharged into an area with two ponds, connected to each other by a shallow canal. The water level in the upper pond is about 0,4 metres above the water level in the lower pond. To circulate water between the two ponds a pump has been installed in the lower pond. The shallow canal that connects the two ponds is built up of small stone blocks. *Figure 45–46* show the upper pond and of the shallow canal.

Special arrangements have been made to try to avoid algae growth in the two ponds. With the above mentioned circulation pump a small water fall and a water fountain have been created in the upper pond. To get a natural treatment of the water in the ponds a vegetation filter has been arranged where the shallow stone canal enters the lower pond, see *figure 47.* In addition arrangements have been made by which fresh water can be added to the ponds.

The lawn between the two ponds is arranged as a flooding area. During extreme flow conditions the water level in the ponds will raise and the whole area will temporarily become one big pond. *Figure 48* shows one event when the area between the two ponds area was flooded. The storm frequency for the illustrated rain was in the order of 10–15 years.

It can be mentioned that the “double pond” originally was designed in the form of one big wetland (“rice-field”). Because of stagnant water in the facility there were big problems with algae growth, which were not possible to handle in an easy way. The people living close to the wetland demanded that measures were set in to solve the problems. As a result of the discussions with the residents it was decided to rebuild the original wetland pond into the present “double pond”. It must be emphasized that a trustful cooperation with the residents is of utmost importance for a successful result.

*Figure 45. Water is led from the drainage canal to the upper pond*

*Figure 46. The shallow canal between the upper and the lower ponds.*

*Figure 47. Vegeation filter where the shallow canal enter the lower pond*

*Figure 48. Controlled flooding of the "double pond" during extreme wet weather conditions*

### The “cube canal” (8)

Having passed the outlet structure of the “double pond” the water enters the so called “cube canal”. The name refers to the shape of the bottom of the canal, which was designed with regular concrete cubes, see *figure 49*. The intention with this design was to give the water an irregular and exciting movement during the transport. The bottom of the cube canal is designed so that water vegetation could establish in the canal.

The “cube canal”, which has a total length of about 100 meters and a slope of about 5%, ends in the public park of the settlement of Augustenborg. At the point where the cube canal reaches the public park a small playing ground was established. The playing ground was designed in the form of a “delta” of small concrete cubes, on which children could jump over the watercourse, see *figure 50*.

*Figure 49. The cube canal from a frog perspective*

*Figure 50. Playing ground with cube stones*

### The "meandering creek" (10)

After having passed the cube canal the water runs out into a swale, which runs through the public park in the settlement. The swale has the same location as a historic creek some 40–50 years ago. When designing the swale the goal was to let it resemble a meandering creek. This was accomplished by constructing erosion protection structures in each of the bends of the swale, see *figure 51*.

During dry weather conditions and during rainfalls with normal intensities, the flow detention upstream in the system is so big that the there is no water running in the swale. Only during very heavy rainfalls there is a free water surface in the swale.

### The "delta pond" (11)

The meandering creek ends in a pond from which water is discharged into the municipal stormwater pipe system. The inlet to this pond was designed in the form of a stereotyped "delta", built up of concrete structures similar to the ones used in the meandering creeks, see *figure 52*. As the flow detention in the upstream part of the drainage system is so effective, the holding time in the outlet pond is normally very long. One effect of this is that the growth of algae in the pond is stimulated. As a result the maintenance need is quite big.

*Figure 51. The meandering creek through the public park*

*Figure 52. The inlet to the "delta pond" at the downstream end of the Central Drainage Corridor*

## The Lönngatan Drainage Corridor

The Lönngatan Drainage Corridor is an open system for slow transport of stormwater, which runs along the street Lönngatan in the northern part of the Augustenborg settlement. The backbone of this drainage corridor is a swale which has partly been designed as a raingarden. The ambition was to design the Lönngatan Drainage Corridor as natural as possible and not emphasize the purpose of drainage.

Stormwater is diverted to the Lönngatan drainage corridor through "water drop" gutters, which have been constructed in the open spaces between the apartment blocks. The "water drop" gutters have today become a signum for the whole settlement of Augustenborg.

### The upper part of the Lönngatan Drainage Corridor (13), (14)

The upper part of the Lönngatan Drainage Corridor is located east of the local street Grängesbergsgatan. This part of the corridor, which has a total length of about 200 metres, is designed as a swale. The swale is fed with stormwater from the residential blocks along the drainage corridor. The swale is leading to an open pond at the Grängesbergsgatan. From this pond there is a siphon pipe under the Grängesbergsgatan which connects the upper part with the lower part of the Lönngatan Drainage Corridor. To improve the water quality a pump is installed in the pond, with which water can be pumped to the detention pond located 50 metres up the Grängesbergsgatan. Hereby a circulation of the water in the ponds is accomplished.

### The lower part of the Lönngatan Drainage Corridor (15), (16)

The lower part of the Lönngatan Drainage Corridor runs from the local street Grängesbergsgatan and westwards. The total length of this part of the drainage corridor is about 300 metres. It starts with a natural swale, se *figure 53*. Further down in the system the swale is on a length of about 60 metres replaced by a canal built up of washed concrete stones, see *figure 54*. The reason for this design is space limitations because of an adjacent district heating system. The lower part of the Lönngatan Drainage Corridor ends in a pond, see *figure 55*. From the downstream pond water is pumped to the upper end of the canal. In this way a circulation of water in the pond is accomplished.

*Figure 53. The swale in the lower part of the Lönngatan Drainage Corridor*

*Figure 54. The canal section in the lower part of the Lönngatan Drainage Corridor*

*Figure 55. The pond at the downstream end of the lower part of the Lönngatan Drainage Corridor*

## Examples of local disposal of stormwater in the settlement of Augustenborg

In the previous sections the general features of the two main drainage corridors have been described. The two drainage corridors are part of the public stormwater system. In addition, a large number of facilities for local disposal of stormwater on private properties have been implemented in the settlement. In the following some examples of implemented measures for local disposal of stormwater are described.

### Permeable parking lot (17)

Along the local street Augustenborgsgatan near the entrance to the Augustenborg workshop area, a parking space was rebuilt in order to admit local infiltration of stormwater. The parking place was previously covered with asphalt. As a consequence the street trees were suffering from shortage of water. The asphalt layer was removed and replaced by a 0,25 metres thick layer of course gravel. The gravel was at the surface stabilized with a grid of hard polyethylene, see *figure 56*. The solution turned out very well and the street trees have now recovered.

### Green roofs on a home for elderly people (7)

On the top of a parking garage a home for elderly was built. In order to reduce the stormwater runoff is was decided to apply a green roof on the new building. Of special interest to mention is that the gradient of the roof is quite steep, see *figure 57*.

### Open detention in an "amphitheatre" in the Augustenborg schoolyard (9)

The school of Augustenborg was built in the early 1960:ies. Like the majority of schoolyards in Sweden from that time most surfaces were covered with asphalt. For pedagogic reasons it was decided to remodel the schoolyard and mark the runoff paths for the rainwater. It was also decided to construct a small amphitheatre for outdoor lessons, which in periods with heavy rain also could serve as a detention storage, see *figure 58*.

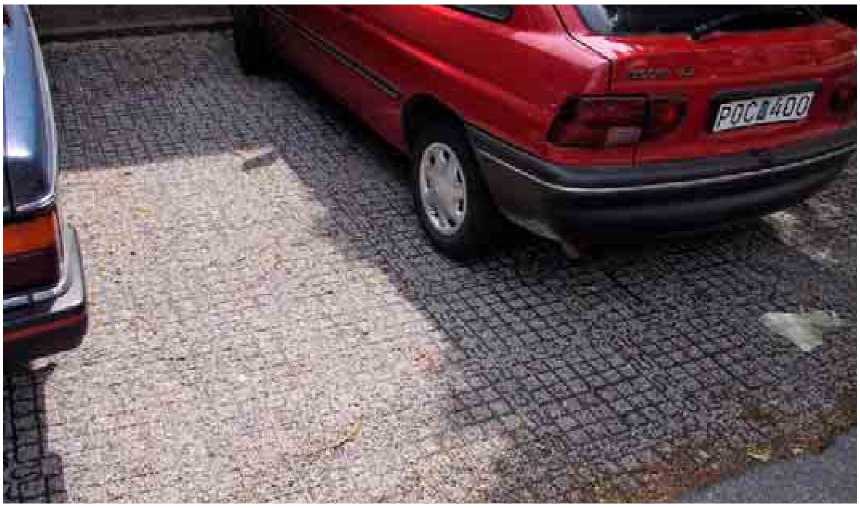

*Figure 56. Permeable parking built up of course gravel and stabilized with a grid of hard polyethylene*

*Figure 57. Green roof on a home for elderly people in the settlement of Augustenborg*

*Figure 58. Open detention in an "amphitheatre" in the schoolyard in the settlement of Augustenborg*

### Detention in local ponds (12)

In many places in the settlement small detention ponds have been constructed in the free spaces between the apartment blocks. The ponds receive surface runoff from the roofs of the buildings and from other impermeable surfaces. The ponds have become appreciated elements in the local environment of the Augustenborg settlement. *Figures 59 - 60* show two examples of local ponds in the settlement.

*Figure 59. A local detention pond located close to the public park in the settlement of Augustenborg*

*Figure 60. A local pond in one of the yards in the settlement of Augustenborg*

# 11. The Housing Exhibition Area Bo 01 in The Western Harbour

## Introduction

In the late 1990:ies it was decided that an international housing exhibition was to be arranged in Malmö in the year 2001. The selected location for the housing exhibition was on the western part of the former wharf area in the district of Western Harbour. The exhibition area is in the west delimited by the sea. In the eastern part of the area a saltwater canal was constructed, which is fed with sea water through a pump system. See *figure 61*.


*Figure 61. Overview of the housing exhibition area Bo 01 in the Western Harbour.*

The housing exhibition area was given the name Bo 01. The overall goal with the exhibition was to create a sustainable development with special demands on architectural quality, urban environment and technical infrastructure. By introduction of a so called green-area factor, the developers were encouraged to compensate the impermeable areas within the development with different types of green surfaces.

## Drainage concept

### Introduction

To plan a new development offers unique possibilities to apply innovative techniques for handling the stormwater runoff. The basic concept that was chosen for the Bo 01 area was to visualize the drainage by creating an open system with such qualities that it could give added aesthetic and environmental values to the area. The great challenge was that the whole area was very densely developed with very limited open green spaces.

Through mass-balancing, the central part of the exhibition area was elevated 2–3 metres above the ground level close to the water. Thus an elongated "height" was created parallel to the shorelines of the sea and the saltwater canal. In this way surface water from the area could run off by gravity.

From the highest point of the exhibition area rainwater is running off in small open drainage canals in the streets. The water from the western part of the exhibition area is led westwards and discharged directly into the sea. The water from the eastern part of the area is led eastwards towards the saltwater canal. Here the water is discharged into special collection chambers from where it can be pumped back to a number so called aquapoints located at the highest points of the exhibition area. By this arrangement it is possible to circulate rainwater in the system.

The intention with selecting an open canal system for handling stormwater was to explore the broad spectrum of positive values that are associated with water: the peace and harmony of a water environment, the glittering and reflections in standing pools of water and the splashing and murmuring of running water.

### Disposal of stormwater on private properties

As indicated before special demands were set up in order to get the private developers to reduce the stormwater runoff within the boundaries of their respective properties. The developers were encouraged to introduce permeable surfaces in the built environment and to detain the runoff before it enters the drainage canals in the streets. This was done by applying the so called "green area factor" system.

*Figure 62. A private yard within the housing exhibition area Bo 01*

Technical solutions favoured by this system are:

- Vegetation cover on top of the roofs ("green roofs")
- Vegetated walls
- Vegetated surfaces in the private yards
- Permeable gravelled surfaces in the private yards
- Ponds and wetlands in the private yards

The "green area factor" system has no doubt contributed to create attractive green lungs in the settlement and to an increased biodiversity. *Figure 62* shows one example of a private yard within the Bo 01 area.

### Drainage canals and ponds in the street environment

Small concrete drainage canals have been constructed in all streets throughout the whole exhibition area. In most streets there are two canals - one on each side of the street. The size of the canals varies depending on the sizes of the tributary areas that are connected to the system. The biggest canal has a width of 25 centimetres and a depth of 35 centimetres. The drainage canals are designed for rainfalls with a recurrence period of at least 5 years. In practice the runoff capacity of the new open drainage system well exceeds the 5-years storm.

Between the house walls and the drainage canal there is a 30 centimetres wide strip of coarse gravel. The side of the canal structure facing the house wall is about 4 centimetres higher than the side facing the street. Between the drainage canals and the streets there is a row of black concrete slabs with shallow groves. The intention with these is to give guidance to people with visual handicaps.

*Figure 63. Drainage canals in the housing exhibition area Bo 01*

*Figure 64. Detail of a drainage canal in the housing exhibition area Bo 01*

In street crossings and at the house entrances the drainage canals are covered with steel plates. Locations where the drainage canals make a bend and where downpipes from the roofs are connected to the canals have been marked with specially designed granite blocks, see *figures 63–64*.

At some locations in the canal system small ponds have been introduced. These ponds are planted with wetland vegetation in order to get a filtering effect on the water. They also give an additional biologic value to the very densely developed settlement, see *figure 65*.

*Figure 65. Vegetated pond in the canal system in the housing exhibition area Bo 01.*

*Figure 66. Collection chamber for stormwater located at the saltwater canal.*

### Collection chambers for stormwater at the saltwater canal

The drainage canals which run eastwards to the saltwater canal end up in especially designed collection chambers. These are built up of concrete and planted with wetland vegetation, see *figure 66*. From the collection chambers the stormwater can be pumped to so called aquapoints, which are located at the highest point of the exhibition area, see below. Through circulation of water between the collection chambers and the aquapoints, the presence and the enjoyment of water running in the development is emphasized. Only during periods with heavy rain water from the drainage canals is discharged into the saltwater canal.

### Aquapoint

In the central part of the exhibition area five so called aquapoints have been created. These have been designed as places for contemplation and inspiration. The water that is pumped to the aquapoints from the collection chambers at the salt water canal is flowing up from granite structures surrounded by small ponds planted with wetland vegetation, see *figure 67*. The aquapoints are the starting points for the drainage canals.

### Water integrated in works of art

To strengthen the impression of water in the housing exhibition area, it was decided to introduce some water related works of art in the settlement. These are located in the well frequented Scaniaplatsen and are displaying water that is running over big granite structures, see *figure 68–69*.

## Perception of the drainage system

### Interesting and beautiful urban environment

To get an opinion of what people think of the open drainage system in the Bo 01 area, a series of interviews were made with residents as well as with visitors to the area. Almost everyone is positive to how the aquapoints, the drainage canals and the open ponds have been arranged in the streets. Many people point out that the drainage system gives a unique character to the whole settlement. Among the things that seem to contribute most to the comfort and wellbeing can be mentioned:

- The aquapoints as places for rest and contemplation
- The sound and the glittering of water in the system
- The water vegetation in the ponds in the drainage system
- The illumination of certain sections of the drainage system at night
- The exciting way in which the water and granite structures is interacting

Many of the residents expressed that they would not like to be without the open drainage system. They mentioned that they would even be willing to pay extra for the open drainage system. Obviously they seem to have taken the system to their hearts.

A couple of interviews were also made with professional engineers, who in different ways had been involved in the development of the area. In their opinion one can question if an open drainage system within an urban settlement really is in accordance with current building standards. To be on the safe side they would have preferred a traditional pipe system for handling the stormwater.

*Figure 67. Aquapoint – a place for contemplation*

*Figure 68. Water integrated in art in the Bo 01 area*

*Figure 69. Water integrated in art in the Bo 01 area*

### Safety

Many people reflect over whether an open drainage system in a densely populated area is a safety risk or not. People may fall into the canals and get hurt, cars may drive into the canals and get damaged. An open drainage system may especially for disabled people become a barrier in the urban environment.

The conducted interviews with the residents in the settlement and with visitors to the area gave among others the following results:

- So far no accidents have occurred in connection with the open drainage canals.
- The granite blocks give a good guidance so that people does not come too close to the canals
- In all street crossings and at the house entrances the drainage canals are covered with steel plates in order to avoid accidents. This protection works very well.
- Along all drainage canals arrangements have been made to assist people with visual handicaps.

In summary people in the settlement don't see the open drainage system as a great risk in the urban environment. They think that the system is very clearly marked and that the protection measures that have been taken are sufficient.

### Litter and debris

In all open drainage systems there is a tendency that sand, litter and debris is accumulated. Most of this material are brought to the drainage canals by the wind. People seem to agree that the amount of litter and debris in the street environment has nothing to do with whether the drainage system is open or not. In an open system the litter and debris is more visible. In the case of a traditional buried pipe system the litter and debris would instead end up in gutters, hedges and other places.

According to the conducted interviews with the residents in the area, they don't find the drainage canals untidy and ugly. When they moved to the area the situation was worse but the situation was to great extent solved when waste paper baskets were set up in the settlement. The residents have observed that all construction activity within the area causes an increased amount of sand, gravel and also litter in the adjacent drainage canals. This is however a temporary problem.

## Maintenance of the open drainage system

The formal responsibility for the maintenance of the open drainage system is divided between the property owners and the city of Malmö. Thus the property owners are responsible for those parts of the system that lie on private land and the city for those parts that lie on public land. The two parties have delegated the daily maintenance work to the same private contractor. The maintenance contract includes the drainage canals, the blue-green elements in the drainage system, as well as the impermeable surfaces in the settlement.

According to the contractor the maintenance of the open drainage system with its blue-green elements is much more expensive than maintenance of traditional plantings. The blue-green elements cost between 100–200 % more to maintain than traditional plantings. Most of the maintenance work is spent on removal of trash and algae from the blue-green facilities and on cleaning the drainage canals.

The first couple of years, when construction activities were still going on in the area, there was a need for an intensive maintenance. The need for maintenance gradually decreased as the construction work was completed. A big portion of the maintenance work would have been necessary even if there had been no open drainage system. The maintenance routines are continuously updated as the experiences of the open drainage system is increasing.

Algae growth is a problem in most ponds. It can be mentioned that some development work is at present carried out in order to test techniques for preventing or at least limiting the rapid algae growth in the ponds.

# 12. The Fjärilsparken Eco-Corridor

## Introduction

In the comprehensive plan for Malmö from year 2000, a series of new developments were laid out on existing farmland about 1 kilometre inland from the coast in the south of the city. The coastline consists of a broad band of water meadows, which have the status of a nature reserve. Inside of this reserve there is a 0,5 kilometre broad band of single family houses. To handle the stormwater from the planned new developments further inland it was decided to create an open drainage corridor from the water meadows at the coast through the existing development and through the new developments – a total length of about 1,5 kilometres.

The vision of creating an open drainage corridor was developed in collaboration between Malmö Water, the department of Parks & City Environment and the department of Planning. The basic idea was to form a green corridor through the urban area, which could be used for park, recreation and drainage purposes – a so called "eco-corridor". The idea of establishing an eco-corridor was introduced already in the comprehensive plan for Malmö from year 2000. *Figure 70* shows a close-up of a map in the comprehensive plan. The green colour shows the locations of the planned eco-corridors in the southwest of Malmo.

The realisation of the Fjärilsparken Eco-Corridor was carried out in the following two phases:

- The western part of the eco-corridor through the existing development
- The eastern part of the eco-corridor through the planned new developments

## Implementation of the western part of the eco-corridor

### General

As mentioned earlier the western part of the eco-corridor runs through a 400–500 metres broad band of single family houses along the coast. The only possible location for the eco-corridor in this area was through the existing public park Fjärilsparken. To upgrade the park to a multi-purpose eco-corridor, there was an obvious need for a very careful and thorough planning, which had to be conducted with active involvement of the residents in the surrounding development.

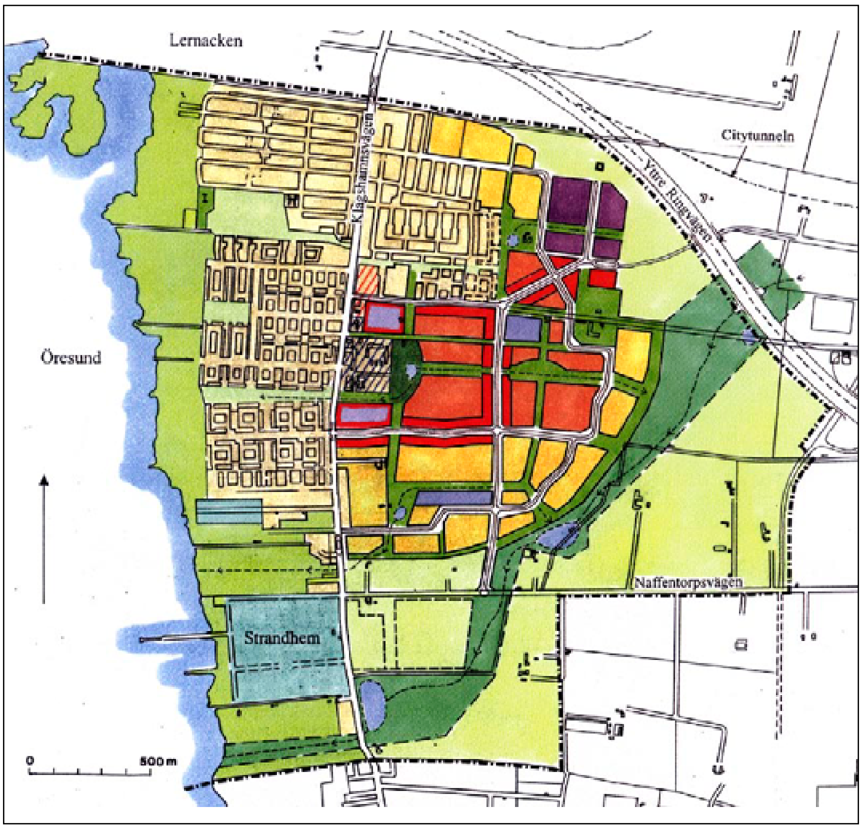


*Figure 70. Illustration of planned eco-corridors in the comprehensive plan of Malmo*

The plans for upgrading the Fjärilsparken was communicated with the residents at a series of meetings. Through discussions of the ideas and suggestions that were put forward during these meetings, the vision of a new exciting park took shape. The basic idea was to create a shallow natural water way, which runs through the park. The waterway will only carry water during wet weather conditions.

### Design and implementation

The water-way through the existing park Fjärilsparken was given the form of a shallow meandering creek with gentle slopes. Walking paths were laid out along the water-way including also small wooden bridges, benches, places to meet and a playing ground for children. The area around the water-way was planted with meadow vegetation. Previous traditional park lawns were transformed into flower meadows. *Figure 71* shows an aerial view of one section of the western part of the Fjärilsparken Eco-Corridor. *Figure 72–73* shows some images of the western part of the Fjärilsparken Eco-Corridor.

*Figure 71. Aerial view of one section of the western part of the Fjärilsparken Eco-Corridor*

*Figure 72. Meadow vegetation along the water-way through the western part of the Fjärilsparken Eco-Corridor*

*Figure 73. A place to cross the water-way during wet weather conditions*

*Figure 74. The constructed wetland at the downstream end of the western part of the Fjärilsparken Eco-Corridor*

At the downstream end of the Fjärilsparken Eco-Corridor, where the new water-way meets the existing nature reserve along the coast, a small wetland was laid out. This was planted with selected species of wetland vegetation. Special arrangements in and around the wetland has been made to attract people to the area, see *figure 74*.

The upgrading of the existing public park Fjärilsparken to an eco-corridor was completed in 2001. The work resulted in considerable added values with regards to among others accessibility, biodiversity, recreation, drainage etc. This phase of the project is an example of how the use of the city's existing green infrastructure can be broadened to include also the drainage of stormwater. Important factors for a successful result was both the cooperation with residents in the area and the cooperation between the different technical departments in the city.

The costs for realisation of the upgrading of the Fjärilsparken was shared between Malmö Water and the department of Parks & City Environment. Malmö Water financed all construction work related to the new water-way through the park while the upgrading of the green structure was financed by the department of Parks & City Environment. It is obvious that both involved parties as well as the residents in the area have gained a lot from the close cooperation in the implementation process.

## Implementation of the eastern part of the eco-corridor

### General

The eastern part of the Fjärilsparken Eco-Corridor, which has a total length of about 1 000 metres, was constructed on former farmland. The corridor runs eastwards about 400 metres, is making a bend to the north and is then continuing another 400 metres further eastwards. The eco-corridor has a width of about 50 metres. As mentioned earlier it was laid out already in the city's comprehensive plan. The main objective with the project was to form a green corridor through the new developments, which could serve as drainage path for stormwater as well as for park and recreation purposes.

To implement an eco-corridor through a new development will give the character to the whole area. It is of great importance that the corridor is established before the construction work for the new developments is started. One should start the work with the eco-corridor at least 1–2 years prior to the development of the new housing areas along the corridor.

### Design and implementation

The eco-corridor was given the form of a giant swale with a width of about 50 metres and a depth of 2–3 metres. This depth was needed to get gravity flow from the upstream end of the corridor. The design was maid so that flows from a 100-years storm could be handled in the system. For normal rainfall events only the bottom of the swale is utilized for the drainage of stormwater. For small rainfalls very little water is actually running off in the eco-corridor.

The sides of the eco-corridor were planted with trees and bushes and pedestrian and bicycle paths were arranged along the corridor.

*Figures 75–76* are illustrating different phases of the construction of the eastern part of the Fjärilsparken Eco-Corridor. *Figure 77* shows an aerial view of this section of the corridor.

### Concluding remarks

The design and implementation of the Fjärilsparken Eco-Corridor is a good example of how sustainable urban drainage can be integrated in the physical planning of the city. The idea of an open drainage corridor was introduced already in the city's comprehensive plan and the design and implementation was carried out with active involvement of all technical departments in the city. An important prerequisite for the successful result was that the planning period was extended over several years. This gave the involved parties possibilities to join forces and integrate their different expertises in the elaboration of a thoroughly worked out detailed plan for the eco-corridor.

*Figure 75. The construction work is starting at the downstream end of the eastern part of the Fjärilsparken Eco-Corridor.*

*Figure 76. The downstream end of the eastern part of the Fjärilsparken Eco-Corridor is completed.*

*Figure 77. An aerial view of the downstream end of the eastern part of the Fjärilsparken Eco-Corridor.*

# 13. The Elinelund Recreation Area

In the district of Hyllie in the south of Malmö a large new business and housing area is being developed. The area is situated about 5 kilometres from the coast. To be able to handle all stormwater from the new development it is necessary to reduce the rate of runoff considerably. Thus far-reaching demands on local disposal of the stormwater within the new development were set up. Furthermore different detention measures have been implemented along the path of runoff to the coast.

One section of the Hyllie development including the primary road Lorensborgsgatan, is drained via pipes to the Elinelund Recreation Area, which is situated at the western edge of the new development. In the recreation area two detention ponds connected in series have been constructed. *Figure 78* shows an aerial view of the two ponds and the adjacent small watercourse Elinelundsdiket.

The first pond has a water surface of about 0,3 hectares and a maximum water depth of about 1 metre. The sides of the pond are sloping gently down to the water surface. The water depth at the shores of the pond is limited to 0,2 metres.  At the outlet of the pond there is a weir structure which regulates the outflow, see *figure 79*. Water that is discharged over the weir is running through a 100 metres long open drainage canal to the second pond.

The second pond is smaller than the first one and has a water surface of about 0,1 hectare. This pond is situated about 1 metre below the first pond. Water can therefore flow by gravity from the first to the second pond. The western bank of the second pond is designed in the form of a so called filter bank, through which water can slowly filter out onto a constructed wetland, which was created between the pond and the small watercourse Elinelundsdiket, see *figures 80–81*.

The detention facilities in the Elinelund Recreation Area was designed to form an integrated part of the recreation area. One way of doing this was by arranging planting zones around the ponds. The implementation of the Elinelund Recreation Area took place in 2000–2002.

*Figure 78. Aerial view of the detention ponds in the Elinelund Recreation Area*

*Figure 79. Wiew of the first pond and the outlet structure*

*Figure 80. The filter wall in the second pond in the Elinelund Recreation Area*

*Figure 81. Overview of the wetland just downstream the second pond in the Elinelund Recreation Area*

# 14. The Gottorpsvägen Detention Ponds

In the southern part of the Elinelund Recreation Area between the Gottorpsvägen and the new railway line to Copenhagen, measures have been taken to dampen the stormwater runoff from the road surfaces and from the railway bank before it is discharged into the small watercourse Elinelundsdiket. Two detention ponds were constructed in the area.

## The eastern pond

The eastern pond, which was constructed in 2000, has a water surface of about 0,2 hectares. The pond is fed with stormwater from a section of the adjacent trunk road Lorensborgsgatan. The northern embankment of the pond is designed in the form of a filter bank, see *figure 82*. The filter bank, which is part of the pond structure, consists of a carefully graded permeable fill. The filtering process begins when the water in the pond rises over a predetermined level. For water levels below this level there will be no outflow from the pond.

The water that passes through the filter bank is flowing up on the downstream side of the filter bank, see *figure 83*. From here the water is discharged into the watercourse Elinelundsdiket, which is passing along the pond.

## The western pond

The western pond, which was completed in 2007, has a water surface of slightly less than 0,2 hectares. This pond is fed with drainage water from the railway embankment. The water that enters the pond is passing a vegetation filter, which has been applied across the pond, see *figure 84*.

The outlet of the pond is choked to reduce the runoff that is discharged to the watercourse Elinelundsdiket, which at this point is laid in a culvert.

*Figure 82. Wiew of the filter bank in the eastern pond at the Gottorpsvägen*

*Figure 83. Wiew of the wetland downstream of the eastern pond at the Gottorpsvägen*

*Figure 84. Wiew of the western pond at the Gottorpsvägen*

# 15. The Vintriediket Drainage Corridor

The city of Malmö is expanding very rapidly. Many of the new developments are located in the southern outskirts of the city, 3–4 km from the coast. To be able to handle all stormwater and convey it to the sea, special measures must be taken to detain the runoff. In the village of Vintrie, the small watercourse Vintriediket has been transformed into a facility for flow detention. Special efforts were laid down on designing the facility for recreation purposes.

The Vintriediket detention facility, which was constructed in 2003 - 2004, was designed in the form of a series of shallow detention ponds in the watercourse. *Figure 85* shows an aerial view of the upper part of the Vintriediket Drainage Corridor. In total there are 11 interconnected ponds. These are separated by 40 centimetres thick concrete walls. In the upper part of the wall a number of 40 centimetres wide openings were arranged. They serve as overflow weirs to discharge water from one pond to the other, see *figure 86*. The overflow openings are designed to discharge the maximum flow without the crest of the concrete wall being overflowed.

During heavy rainfall the water levels in the ponds will gradually rise, beginning with the ponds at the upstream end of the facility. The total volume of the Vintriediket detention ponds is 4 600 $m^3$, of which at least 1 600 $m^3$ can be used flow detention. As the ponds seldom are filled up to the level of the overflow openings, the detention volume normally is much bigger.

In the design of the Vintriediket Drainage Corridor it was not only the detention function of the facility that was taken into account. The goal was to create an attractive park and recreation environment adjusted to the special preferences of the residents in the village of Vintrie. The residents were invited to take active part in the planning of the facility.

One opinion that was brought forward in the planning was that the water in the ponds should be accessible for people in the area. It was decided to build a couple of wooden platforms, on which people could sit close to the water. To facilitate the access to these, wooden stairs have been arranged from the street level down to the platforms, see *figure 87*.

Two wooden foot-bridges were arranged to make it possible to easily cross the ponds. In addition, all of the above mentioned division walls between the ponds were designed so that they also could be used for crossing the ponds.

As a result of admitting people to come close to the water, special precautions had to be taken to avoid the risks for accidents. One example is that the water depth at the wooden platforms and the division walls across the ponds was limited to 20 centimetres.

*Figure 85. Aerial view of the upper part of the Vintriediket Drainage Corridor*

*Figure 86. Overflow openings in the concrete wall between the ponds*

*Figure 87. Wooden platforms in the ponds of the Vintriediket Drainage Corridor*

Another opinion that was brought forward in the planning of the facility was that measures should be taken to create interesting biotopes around the facility and in the ponds.

The northern side of the Vintriediket is gently sloping down to the ponds. Here meadow vegetation with a variety of grass and flowers was planted. To maintain a natural character, the meadow is only mowed once a year.

To stimulate the development of different types of aquatic life, the ponds were arranged with different water depths. Some of them are very shallow while others have a maximum water depth of up to 1 metre. Also, the bottom material has been varied between the different ponds. In some of the ponds the bottom material consists of limestone cross while in others the bottom consists of granite cross.

For recreation purpose a jogging path has been arranged along the meadow on the northern side of the ponds. Examples of activities that have developed spontaneously in the Vintriediket Drainage Corridor are: racing with model boats and breeding of fish.

# 16. The Annestad Detention Canal

The new residential area Annestad in the south of Malmö was developed in different phases. The first phase, which was completed in 2005, is located just north of the Gottorpsvägen. In the detailed plan for the area demands were set up that the runoff of stormwater must be reduced. To fulfil these demands local disposal on private land as well as onsite detention on public land within the settlement was required.

Local disposal of stormwater was in the Annestad development accomplished by letting the runoff from some roofs and other impermeable areas run out onto a series of vegetated swales, see *figure 88*.

The runoff that reaches the public stormwater system is detained in an open detention storage in the public park in the settlement. The storage is designed in the form of a 150 metres long vegetated canal. The canal is designed so that water during the most extreme runoff events can flood out onto the adjacent park area, see *figure 89*.

*Figure 88. Onsite detention in a swale within the settlement of Annestad*

*Figure 89. Detention in a vegetated canal in the settlement of Annestad*

# 17. The Växthusparken Eco-Corridor

In connection with the development of a new residential area in Klagshamn in the south of Malmö, a new public park was laid out. The general idea was to create an "eco-corridor", which runs through a series of new developments. The design and planning of the green corridor was done in co-operation between Malmö Water, the department of Planning and the department of Parks & City Environment. The first phase of the eco-corridor, which was named the "Växthusparken", was implemented in 2005. So far only the area south of the eco-corridor has been developed.

The Växthusparken Eco-Corridor has a width of about 40 metres and a total length of 400 metres. Through the western part of the corridor, a 300 metres long gently meandering open watercourse was constructed, see *figure 90*. Due to limited availability of land the watercourse had to be culvertized on a distance of about 50 metres. Direct upstream of the culvert a small detention pond was built, see *figure 91*.

To keep a continuous flow of water through the pond and the open watercourse a drainage culvert from the adjacent farmland has been connected to the inlet of the pond. The farmland drainage was previously conveyed in an old farmland drainage culvert.

*Figure 90. View of the meandering watercourse in the Växthusparken Eco-Corridor*

*Figure 91. The detention pond in the upstream end of the Växthusparken Eco-Corridor*

# 18. The Tygelsjö Eco-Corridor

## Introduction

In the mid 1990:ies the suburban village of Tygelsjö in the south of Malmö suffered from severe flooding problems. Due to limited capacity in the municipal stormwater system, part of the village was set under water. The main reason for the floodings was that the drainage of large areas of farmland east of the village was connected to the municipal storm water system. The urban drainage from the village is discharged into the small watercourse Tygelsjöbäcken which runs westwards to the straight of Öresund, a distance of about 4 kilometres.

The village of Tygelsjö has in recent years been expanding quite rapidly. In the planning of new developments north and west of the village, Malmö Water took the initiative to create an eco-corridor for handling the urban runoff. The eco-corridor handles both drainage water from the connected farmland east of the village and stormwater from the new developments. As a base for the detailed planning of the eco-corridor, an interdepartmental working group was set up with representatives from Malmö Water, the department of Parks & City Environment and the department of Planning. The group worked out preliminary plans for the design of the eco-corridor, which were later integrated in the city's detailed planning.

A simplified sketch of the eco-corridor is shown in *figure 92*. One can distinguish the following five sections of the Tygelsjö Eco-Corridor:

- The upper watercourse
- The wetland
- The big pond
- The lower watercourse
- The frog fond

The whole system was especially designed with the purpose of creating an attractive recreation area, easily accessible for the residents in the village of Tygelsjö. The different sections of the eco-corridor will here be described in more detail. The numeral digits in the text refer to the digits on the map in *figure 92*.

## The upper watercourse (1), (2), (3)

The eco-corridor starts east of the main road Tygelsjövägen. Here a new watercourse was created, which is meandering through a local park in the new development. Water is entering the watercourse through a wall of granite stone, which was designed to give the impression of an old stone bridge, see *figure 93*. The water that is discharged into the watercourse is drainage water from the above mentioned farmland east of the village. The watercourse is also fed with stormwater form the surrounding new development.

*Figure 92. Overview of the Tygelsjö Eco-Corridor*

*Figure 93. Water is entering the upper watercourse through a stone wall*

The local park in the new development has a width of 40–50 metres. The watercourse in the park has very gentle slopes and is thereby easily accessible for the resident, see *figure 94*. There are pedestrian and bicycle paths on both sides of the watercourse.

West of the main road Tygelsjövägen the watercourse and a pedestrian path run in narrow corridor – 15 metres wide and 450 metres long – along a farmland, see *figure 95*. As the gradient in this section of the eco-corridor is relatively big, a number of small barriers of granite stones have been built in the watercourse. This is to prevent erosion problems.

At the lower end, the long and narrow part of the eco-corridor opens up to give room for a tree grove. The intention with this is to create a refuge for animals from the surrounding area of flatland.

### The wetland (4)

At the downstream end the upper watercourse makes a bend and runs out onto a wetland area, see *figure 96*. The wetland is normally empty and only fills during periods of high flows. The water level in the wetland is determined by the water level in the big pond just downstream. When the water in the pond is rising, water is backed up onto the wetland.

The ambition was to create an interesting aquatic biotope with natural wetland vegetation. The wetland can easily be reached from the adjacent pedestrian path.

*Figure 94. The watercourse is meandering through the local park in the upper part of the Tygelsjö Eco-Corridor*

*Figure 95. West of the Tygelsjövägen the  watercourse runs in a narrow corridor along an existing farmland*

*Figure 96. The wetland in the Tygelsjö Eco-Corridor*

### The big pond (5), (6), (7)

With a central location in the Tygelsjö Eco-Corridor a big pond has been created. The pond and its surroundings have been designed with special emphasize on recreation, leisure and wildlife. Special arrangements were made to facilitate the use of the pond for education purposes.

The big pond has a water area of about 0,5 hectares. On the northern shore a beach has been created which has become an appreciated place to meet and rest, see *figure 97*. The beach is also the permanent meeting point for the "nature school" – an activity for small children organized by the city of Malmö. The children can at the pond discover water and its animals and vegetation. The water depth at the shores of the pond is very small.

In addition to the water coming from the above described upper watercourse, stormwater from the central parts of the village of Tygelsjö is also discharged into the pond. The water from the village enters the pond in two submerged pipes.

The outflow from the big pond takes place through a specially designed outlet structure, see *figure 98*. This is built up of reinforced concrete, covered with granite stones. At normal flow conditions the water is running out from the pond through a pipe at the base of the outlet structure. The level of this pipe decides the minimum water level in the pond. At extreme runoff events the water level in the big pond and in the wetland upstream the pond will rise to the level of the crest of the outlet structure, which is serving as an emergency spillway.

### The lower watercourse (8)

The lower watercourse is designed as a natural creek, which is meandering through a meadow landscape. This part of the eco-corridor has been set aside for recreation purposes. One of the new settlements in the village of Tygelsjö is located just south of the meadow. The lower watercourse runs about 4 kilometres to the straight of Öresund.

### The frog pond (9)

At a distance of about 250 metres downstream of the big pond a shallow pond with a water surface of about 0,4 hectare has been arranged. The pond has a water depth of 0,2 - 0,5 metres with some deeper parts in the middle. The frog pond is intended as a refuge for birds and other local wildlife. As the pond is an excellent breeding aquifer for frogs, it has been labelled the "frog pond". No pedestrian paths have been arranged in this area.

*Figure 97. The beach at the big pond in the Tygelsjö Eco-Corridor*

*Figure 98. The outlet structure in the big pond in the Tygelsjö Eco-Corridor*

# Concluding Remarks

The transition from a traditional urban drainage towards a more sustainable drainage concept is a long process. When you enter the path of sustainable urban drainage it will soon become obvious that the institutional barriers between the different stakeholders involved in the planning and implementation of the facilities often are unexpectedly high. For most people in the city administration it is much more comfortable to remain on more well known and reliable paths. To try new approaches is always associated with a certain risk. If you are not willing to take these risks and don't want to make any mistakes, it is probably better stay away from sustainable urban drainage.

To succeed with sustainable urban drainage you need an active support from the top managerial level in the city administration. The politicians and the managers of different city departments must have the courage to withstand the critiques that inevitably will come from the traditionalists in their respective organisations. In the city of Malmö it took 5–10 years to implement the concept of sustainable urban drainage and to get the new ideas more generally accepted in the city administration.

In this book 18 different sustainable urban drainage projects in Malmö are described. Over the 20 years period that the concept has been applied in Malmö the views on different technical solutions has gradually changed. In the beginning local ponds and wetlands were the most popular technical configuration. After about 10 years multi-functional regional eco-corridors came in focus, which today has become the most popular technical configuration in Malmö for urban drainage in new settlements. This type of solution has for example been implemented in the "Fjärilsparken Eco-Corridor" and "Tygelsjö Eco-corridor".

One reason for the increasing interest for open eco-corridors in Malmö is that this type of facility has a bigger drainage capacity than traditional buried pipe systems and therefore can be one way of meeting the effects of a climate change.

# BLUE-GREEN FINGERPRINTS IN THE CITY OF MALMÖ, SWEDEN

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