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Urban Stormwater Management Demonstration Projects in the Emscher Region

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Abstract
The river Emscher is located in Western Germany in one of Europe's most densely populated and industrialized areas. Due to the impact of mining activities from the beginning of the 19th century onwards and the related subsidence of extensive areas the Emscher system was developed as an open sewer system in which freshwater as well as wastewater flows.
With the ceasing of the mining activities in the 1980's the opportunity for a restoration of the Emscher catchment was given. The Emschergenossenschaft as the regional water board started this 4.4 billion € project in the 1990's and it is expected to last at least two more decades. Major components of the new Emscher system will be treatment plants and large trunk sewer parallel to the rehabilitated rivers.
Stormwater management plays an important in the restoration process: Due to the high level of urbanization the flow regime of the Emscher is strongly influenced by stormwater runoff. In addition, overflows of the dominant combined sewer system are causing water quality problems and hydraulic stress.
Aware of these problems, the Emschergenossenschaft introduced new source oriented stormwater management strategies at an early stage. Since the 1990's many pilot projects for BMPs have been realized. With good experiences, in 2000 the phase of catchment wide implementation had been entered.
The paper will describe actual USWM projects in the Emscher region. Beside of four actual demonstration projects, the project "15/15" will be explained. Within this unique project the water board Emschergenossenschaft and it's 17 member municipalities signed a contract to disconnect 15% of the catchment area connected to the combined sewer system today in the next 15 years. The experiences made very clear that the success of new stormwater management strategies is not only a technical question but also depends on socio-economic aspects.

Keywords: Stormwater Management, Emscher, River restoration, Urbanization, Hydraulic stress, Socio-economic aspects, Infiltration, Trench-Trough system

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1 Introduction

The river Emscher is located in Western Germany in one of Europe's most densely populated and industrialized areas. Due to the impact of mining activities from the beginning of the 19th century onwards and the related subsidence of extensive areas the system was developed as an open sewer system in which freshwater as well as wastewater flows.
With the ceasing of the mining activities in the Emscher Region in the 1980's and the following ceasing of the associated subsidence of the ground the opportunity for a restoration of the Emscher catchment was given. The Emschergenossenschaft has started the restoration of the system in the 1990's and it is expected to last at least two more decades (Petruck, Beckereit et al., 2003). Major components of the new Emscher system will be treatment plants and large trunk sewer parallel to the rehabilitated rivers.

Figure 1: The Emscher before and after the restoration process

Stormwater management plays an important in the restoration process: Due to the high level of urbanization (more than 40 %) the flow regime of the Emscher is strongly influenced by stormwater runoff. In addition, overflows of the dominant combined sewer system are causing water quality problems and hydraulic stress.
Aware of these problems, the Emschergenossenschaft introduced new source oriented stormwater management strategies at an early stage. Since the 1990's many pilot projects for BMPs have been realized. With good experiences gained from these projects, in 2000 the phase of catchment wide implementation had been entered. Today, the Emscher region can be referred to as one of the frontrunners in Urban Stormwater Management (USWM).
This paper describes actual USWM projects in the Emscher region. Beside of four actual demonstration projects, where different stormwater management BMPs are going to be implemented, the project "15/15" will be explained. Within this unique project the water board Emschergenossenschaft and it's 17 member municipalities signed a contract to disconnect 15% of the catchment area connected to the combined sewer system today in the next 15 years. The experiences made very clear that the success of new stormwater management strategies is not only a technical question but also depends on socio-economic aspects.

2 USWM in the context of the Emscher rehabilitation

The Emscher catchment area (Figure 2) has twice undergone radical structural change in the past 100 years. The discovery and exploitation of the region's enormous coal deposits quickly led to large-scale coal mining, a dense network of iron and steel plants and all the other apparel of heavy industry.

Figure 2: Location of the Emscher catchment, former heavy industry

This period of industrialization resulted in large quantities of wastewater, which initially were simply discharged into existing watercourses, a fact which caused epidemics such as dysentery, cholera and typhus. As the economic development of the region was directly associated with an efficient drainage system, the Emschergenossenschaft was founded in 1899 as an initiative of the region's municipalities, industry and mining. The objective was the creation of a drainage system, which would ensure safe disposal of the wastewater. Later, wastewater treatment became another responsibility of the Emschergenossenschaft (Becker and Raasch, 2002).
An underground sewer network was not a proper solution due to the extensive mining activities. Pipes would have been damaged quickly as a result of mining subsidence, and it would have been extremely difficult and costly to repair them. Instead, an open sewer-system was preferred. For this purpose, the watercourses in the Emscher catchment, including the Emscher itself, were lined with concrete bed elements and straightened to provide the hydraulic capacity necessary. For financial, water-management and hygienic reasons, this system remained the only rational solution for a continuously growing region for many years. Today of course, this system satisfies neither ecological, social, aesthetic nor water- management criteria.
Since mining activity has migrated to the north, subsidences are increasingly diminishing. Therefore, the discharge of wastewater in an underground sewer system has become possible in the Emscher region. In the early 1990s the decision for the restoration of the Emscher system was taken. Major aims of the restoration are:

– Ecological improvement of watercourses
– Safe wastewater transport and treatment
– The prevention of flooding and improvement of the water balance
– Integration of the restructured Emscher into the area
– Providing space for recreation

It is estimated that the project will take about another 20 years to be completed. A total expense of about 4.4 billion € is estimated. Currently about 1 billion € has been spent for the construction of treatment plants and the restoration of some smaller creeks (Petruck, Beckereit et al., 2003).

Although the new system is more or less a large combined sewer system – it includes large combined sewers parallel to the Emscher and its tributaries – stormwater BMP play an important in the project. The Emscher catchment (total size 865 km²) has a very high level of urbanization: approx. 266 km² (30%) are impervious area. Runoff from sealed surfaces is discharged mostly without any retention into the municipal sewer systems. Because of economical and operational reasons, the hydraulic capacity of the new collectors had to be limited. As a consequence, combined sewer overflows (CSOs) have to be built, which strongly influence the flow regime and the water quality of the Emscher. With the new system the Emscher and its tributaries will be free of wastewater flow, but not of combined sewer overflows. Peak flow after heavy rainfall will still be much higher than in natural watercourses (Figure 3) while on the other hand base flow might be minimal due decreased groundwater renewal.

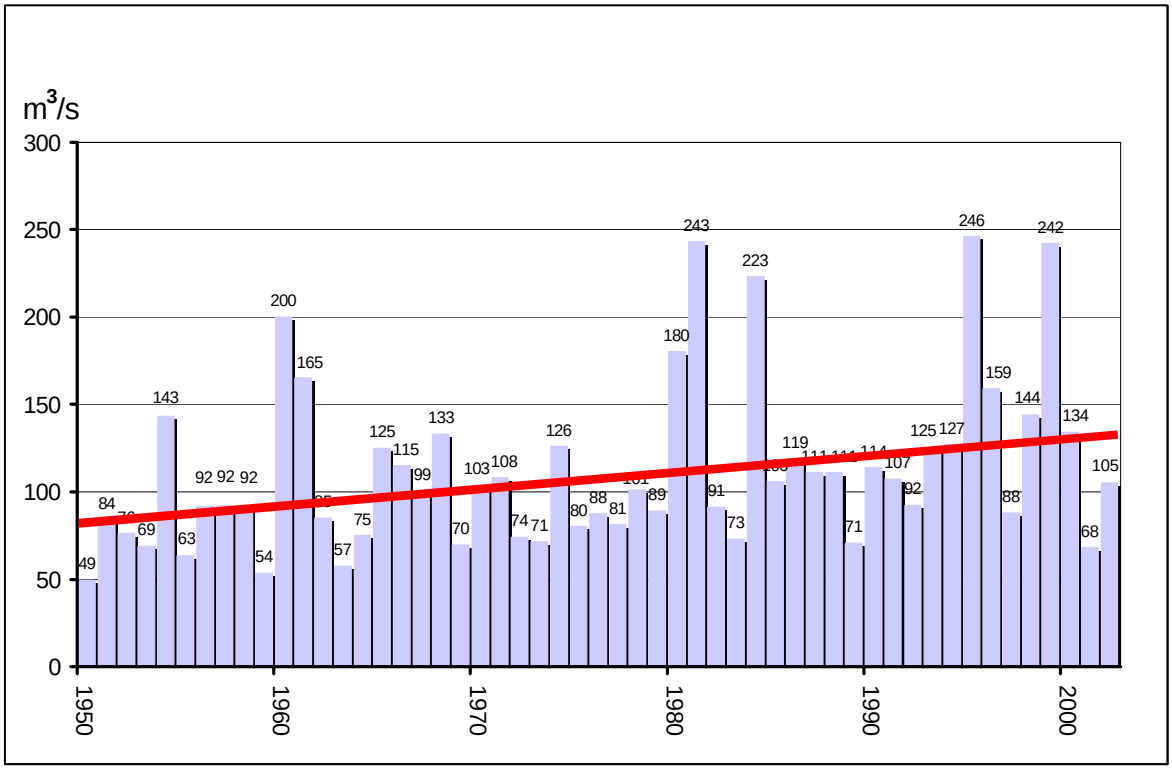

Figure 3: Increase of peak flow in the Emscher in the last 50 years (Becker, 2005)

The Emschergenossenschaft started very early to implement a source oriented stormwater management strategy. Objective of this strategy called “Project 15/15" is to reduce runoff (volume and peak flow) by 15%. This leads to a higher ecological potential in the restored watercourses, reduces investments for combined sewer overflow buildings as well as maintenance costs and improves waterscape’s and urban environment, on-site stormwater management meets the demands of sustainable drainage concepts.

3 Project "15/15"

3.1 "The Rainwater Route"

Since the 1990's many pilot projects for USWM have been implemented with subsidies from the Emscher¬genossenschaft and the Ministry of Environment of the Federal State (Londong and Nothnagel, 1999). One of the first demonstration projects was the "Schüngel¬bergsiedlung" in Gelsenkirchen, part of International Bauausstellung Emscherpark (1989-99). The swale trench system shown in Figure 4 (left side) was built in 1992. This was the initial start-up of a 5-year competition fo disconnection projects which resulted in more than 50 projects all over the Emscher catchment. Up today, this number has more than doubled.

Figure 4: Swale trench system in Gelsenkirchen (left), disconnection in Bottrop (right)

The pilots were accompanied by several scientific studies regarding design, performance, operation and economical aspects (Kaiser, 2004). Also a lot of public relations work has been done. One example is the "The Rainwater Route", a combination of 17 positive examples from different cities in the region (Emschergenossenschaft, 1999). Figure 5 shows the route and photos of selected sites. With the good experiences gained from these demonstration projects, in 2000 the phase of catchment wide implementation has been entered.

3.2 Stormwater Management Information System (SMIS)

A Stormwater Management Information System (SMIS) has been developed as a supporting tool for the project "15/15". SMIS supports planners to identify areas that are appropriate for disconnection (Becker, Geretshauser et al., 2005).

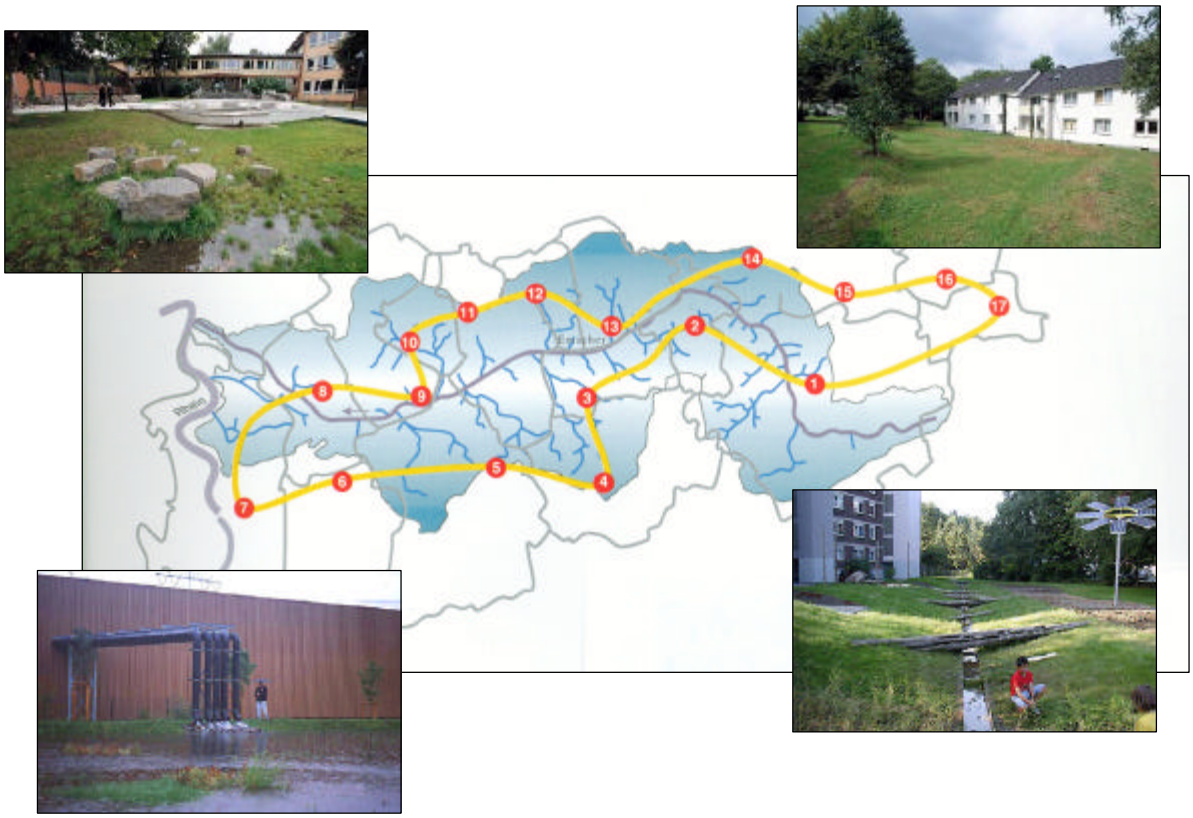

Figure 5: Stormwater route (photos: M. Kaiser)

The judgment of whether a local area is appropriate to be disconnected and which kind of measure is optimal is rather complex and involves analysing a set of influential factors. This judgment depends on not only relevant theoretical considerations, but also a large amount of practical experience and the availability of relevant data, as well. Such a judgment is an unstructured problem and relates to changeable knowledge. To fulfill this task, an expert system called FLEXT (Jin, Sieker et al., 2005) has been developed within the EU-DAYWATER project (Förster, Thévenot et al., 2004). With FLEXT different maps have been produced:

"Type of on-site stormwater measures" map: These map recommends one or more appropriate measures (e.g. different infiltration systems like "trough-trench system", connecting rainwater to nearby rivers, etc). The decision tree implemented in FLEXT is based on natural conditions (e.g. infiltration capacity, soil type, groundwater level, slope etc.).

"Disconnection potential" map: This map shows estimation for the impervious area that can be disconnected from the sewer system. The decision is mainly based on influences of different housing structures (type of houses, estates, roofs, gardens, slope etc..)
"Valuation" maps: maps where on-site stormwater measures are classified from "very valuable" to "not important", based on investigations of the present state of the sewer system (hydraulic overflow, present state of canals, groundwater level etc..).
All three maps are available in one Geographical Information System. Currently a web-based version of this GIS is under development. Together with other components like a database for disconnected areas or a cost-benefit-calculation tool they form the Stormwater Management Information System (SMIS).

3.3 Future Convention for Storm Water in the Emscher catchment

On October 31. 2005, the mayors and lord mayors of all 17 towns and cities of the Emscher catchment, their departmental heads, the Emschergenossenschaft and the Minister of the Environment of North Rhine Westphalia signed a “Future Convention for Storm Water in the Emscher catchment” (Stemplewski, Becker et al., 2006).

Figure 6: Stormwater Agreement for the Emscher River Area

With this document the partner committed themselves to disconnect 15 percent of clean runoff from connected to the sewer system within the next 15 years ("15 in 15”). Having the total impervious area of 266 km² in mind, this is a commitment for the disconnection of approx. 26.4 billion m³/a!

4 Demonstration projects

As described in the chapters before, there are many examples for sustainable stormwater management projects in the Emscher region. In coordination with the Emschergenossenschaft four different on-going projects have been selected as demonstration examples for SWITCH (Sieker et. al. 2006):

- In the settlement **Welheimer Mark** in Bottrop mainly roof areas will be disconnected to reduce runoff volume and peak flow
- while in the settlement **Klöcknersiedlung in Waltrop** the runoff from roads will be managed in "pocket wetlands" (figure 7) to minimize the hydraulic load of the combined sewer system
- The **Drainage-Infiltration-System (DIS) in Herne** is a pilot project for the combined management of stormwater and groundwater and finally
- **Lake Phoenix** should demonstrate how open water systems can be integrated into urban space

Information on other USWM projects in the Emscher region can be found on the website of the Emschergenossenschaft (www.eglv.de).

Figure 7: “Pocket wetlands” (Innodrain-system)

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