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RAINDROP - Development of guidelines for stormwater management

RAINDROP – Développement des guides techniques pour la gestion des eaux pluviales

Sieker, H.* , Aftias M.** , Dusek O. *** , Suchanek M.**** , Vitek J.*****

*Ingenieurgesellschaft Prof. Dr. Sieker mbH, Rennbahnallee 109A, 15366 Hoppegarten bei Berlin, Germany (h.sieker@sieker.de)

**YDRONOMI Consulting Engineers, 32, Evias St, Vrilissia, Athens, 15235, Greece (m.aftias@ydronomi.com)

***Jednatel DUIS s.r.o., Srbská 1546/21, 612 00 Brno, Czech Republic, (dusek@duis.cz)

****DHI Hydroinform a.s., Na vrších 5, Praha 10, 100 00, Czech Republic, (M.Suchanek@dhi.cz)

*****JV t Vh s.r.o, Kosmakova 1050/49, 61500 Brno, Czech Republic, (vitek@jvprojektvh.cz)

RESUME

Le projet RAINDROP est financé dans le cadre du Programme Interreg IIIB CADSES de l'UE. Les partenaires participants sont les villes de Karviná (CZ), Kupferzell (D), Vsetin (CZ), Trencin (SK) and Aharnai (GR). L'objectif principal du RAINDROP est de créer des guides techniques et du savoir faire pour la gestion des eaux pluviales dans les pays de la zone Centrale Adriatique, Danubienne et Sud Est (CADSES). Tous les partenaires participants communiquent à titre égal les résultats de leur propre projet sur deux différentes tâches: a) développement d'un plan d'aménagement pour les eaux pluviales et b) implémentation des BMPs pour la gestion des eaux pluviales. Les résultats seront fusionnés dans un concept de gestion des eaux pluviales plus ample, applicable à travers la région de CADSES.

ABSTRACT

The RAINDROP-Project is funded within the EU-Interreg IIIB-Programme CADSES. Partners are the cities of Karviná (CZ), Kupferzell (D), Vsetin (CZ), Trencin (SK) and Aharnai (GR). Main goal of RAINDROP is to create guidelines and knowledge for stormwater management (SWM) in the Central Adriatic Danubian South East States (CADSES region). All project partners will provide on an equal basis their project results on two different tasks: a) development of a stormwater master plan and b) implementation of stormwater BMPs. These results will be merged to a more general SWM concept, applicable throughout the CADSES region.

KEYWORDS

BMP, Integrated modelling, Masterplan, Stormwater

1 INTRODUCTION

Stormwater management is becoming a more and more important affair in Europe. The Article 5 report for the lower Rhine area in Germany for example shows that emissions from combined sewer overflows and separate systems are a significant source for river pollution. For some substances, e.g. heavy metals, stormwater originated emissions are even a multiple of effluents from municipal wastewater treatment plants (MUNLV 2005).

Traditionally, stormwater is drained as quickly as possible from urban areas into receiving waters. If problems with flooding and water quality caused by stormwater discharges occur, planners usually try to reduce them with end-of-pipe measures. In contrary, modern stormwater management approaches see rainwater as a valuable resource. Pollution of stormwater should be minimized by source control techniques, infiltration, retention measures are applied to stabilize the water balance and mixing stormwater with wastewater should be limited to the heavily polluted part.

Nevertheless, so far no legislation or guidelines for stormwater management are provided by the European Union. National rules, if available at all, are varying a lot among the member states. Therefore the main objective of the RAINDROP project, funded by the Interreg IIIB-CadSES Programme, is developing a SWM guideline, to be used not only locally or nationally but in the whole CADSES region (Central Adriatic Danubian South East States, Figure 1).



Figure 1 : CADSES-Region

The five project partners from the Czech Republic, Slovakia, Greece and Germany work in parallel on two different tasks:

- a) Development of stormwater master plans and
- b) Implementation of stormwater BMPs.

From the results, a general SWM concept applicable throughout the CADSES region and elsewhere in Europe will be derived. Goal of the Raindrop project are a codification of methodology for master planning and guidelines for the choice of SWM strategies.

2 STORMWATER MASTER PLANNING

2.1 Sewer-network database

As a base for the stormwater master plan, a geo-database with information about the sewer network, connected areas (Figure 2), sanitary wastewater flow and other data is set up for each partner city. In this chapter the data of the municipality of Kupferzell processed with MikeUrban and ArcGIS serves as an example.

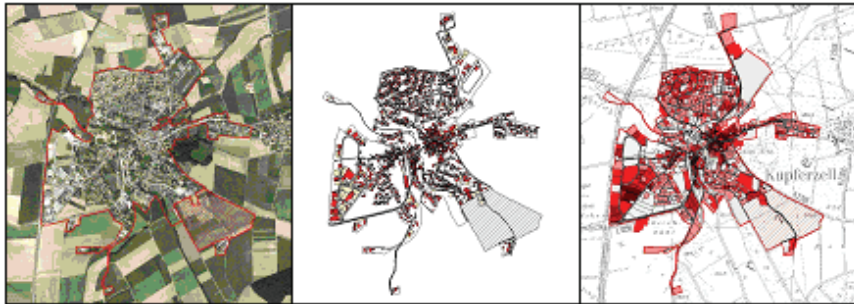


Figure 2 : Degree of imperviousness (right) derived from aerial photos (left) and cadastral data (middle)

2.2 Negotiation of design objectives with decision makers

In a stormwater master plan, usually multiple objectives have to be considered:

- Hygienic conditions
- Flood protection
- Water quality aspects (emissions, total loads, hydraulic stress)
- Management of water resources
- Minimization of investment and operational cost
- Adaptability to system changes (climate change, demographics change, etc.)

Because only for some of these objectives concrete threshold values are defined (e.g. overflow frequency of storm sewers by CEN 752), indicators and target values for the other objectives have to be negotiated with local water authorities. In Kupferzell for example, overflow frequency, total annual loads and the impact of stormwater runoff on the one-year-flood as an indicator for hydraulic stress have been agreed.

The flexibility of a drainage system to cope with system changes is a new criterion, which is taken into account only recently. An approach for measuring adaptability is shown in chapter 2.6.

2.3 Rainfall-runoff-modelling for assessing the present situation

To quantify deficits of the present situation, rainfall-runoff- and pollution load models as well as hydrodynamic sewer models are used. In the case of Kupferzell, for the rainfall-runoff- and pollution transport process the source and flux model STORM-SEWSYS (Ahlmann et. al., 2005) is used. In STORM not only the runoff in the urban areas but also the rainfall runoff process for the rural part of the river catchment is simulated. This is necessary to quantify the impacts on river water quality, especially hydraulic stress. Hydrodynamic sewer modelling is carried with the software Mouse (DHI).

The main receiving water for Kupferzell is the river Kupfer, a relatively small brook with a catchment of approx. 56 km² (Figure 3). The simulations have shown that hydraulic stress is presently the biggest threat for water quality in the Kupfer.

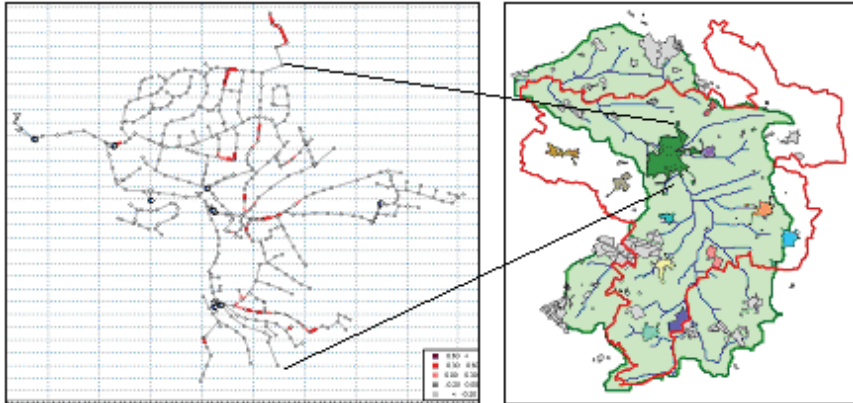


Figure 3 : Catchment of the Kupfer (right) with location of urban drainage system (left).

2.4 Analysis of potentials for SWM and scenario development

As mentioned in the introduction, traditional stormwater master plans usually “react” on deficits with local measures, e.g. if frequent overflows in sewer are determined then the pipe will be enlarged or if water quality problems occur then a treatment will be built. This “linear” approach will not lead to optimal solutions in a multiple objective planning process.

An integrated planning approach follows a different strategy (Sieker et. al., 2005). Because of the complexity of urban drainage systems even experienced engineers cannot predict the effect of measures on the multiple objectives. Therefore different planning-scenarios are developed, their impacts regarding *all* objectives are simulated with models and finally an optimized solution is derived in a multi-criteria assessment. In such an integrated planning approach it is necessary not to exclude unconventional or seemingly “bad” scenarios too early. If a scenario is objectively not good, the multi-criteria assessment will proof it. Therefore, scenario development plays an important role.

For Kupferzell, different stormwater management scenarios have been developed by using a GIS-based expert system called FLEXT (Jin et. al., 2005). With this tool, maps showing the potentials for different infiltration and retention measures are prepared. Based on these maps scenarios for the disconnection of impervious areas from the combined sewer system are developed. Other scenarios include soil filters for treatment of CSO and increased WWTP capacity. In addition scenarios with conventional measures like CSO-tanks and retention pond are considered.

2.5 Modelling of impact for different scenarios

Next step in an integrated planning process is the quantification of impacts for *all* scenarios on *all* indicators. This is done mainly by the two simulation models STORM-SEWSYS and MOUSE already used to identify present deficits. STORM-SEWSYS is especially suitable for this task because a large variety of stormwater BMPs and also source-control measures can be mapped easily (IPS 2006). In addition, a life-cycle-cost-assessment (LCCA) tool is used to quantify economical impacts.

2.6 Evaluation and assessment of scenarios

With the impacts of the different scenarios a decision matrix (Figure 4) is filled. This matrix –also called Matrix of Alternatives (MoA) – is implemented in the Daywater ADSS (Förster et. al., 2004) and serves as the base for the decision making process. If desired, multi-criteria-analysis can be applied to identify good scenarios or to exclude objectively bad solutions. Nevertheless, in most cases the matrix itself will be the result engineers present to decision makers.

Indicators		I1	I2	I3	...
Weights		30%	25%	10%	...
Scenarios	S1	+	4	25	...
	S2	--	...	13	...
	S3	++	2.5	17	...

Figure 4 : Decision matrix

3 IMPLEMENTATION OF STORMWATER BMPS

3.1 Construction of a semi-central trough-trench-system in Kupferzell

In 2005, the municipality of Kupferzell started to develop a new residential area for approx. 100 houses. Different solutions for the stormwater management had been investigated during the design phase:

- Conventional storm sewer system with a end-of-pipe retention pond
- Decentralised system with on-site infiltration and retention systems
- Combination of decentral stormwater measures (“two layer cisterns” used for rainwater harvesting and retention) with a semi-central trough-trench system

The City council voted for the third solution, which has been implemented in 2005. Figure 5 shows the cascade of trough-trench elements located in the green corridor.



Figure 5 : Semi-central trough-trench-system in Kupferzell

3.2 Design of SWM measures in Acharnai

The municipality of Acharnai lies in the NW part of the Athens basin. The city expanded rapidly and in an uncontrolled manner from a little village of 2,000

inhabitants in the early 1900's to a city of 120,000 in the year 2000. The last of a series of migration waves brought to the city in the early 1990's around 20,000 Greeks from the former Soviet Union.

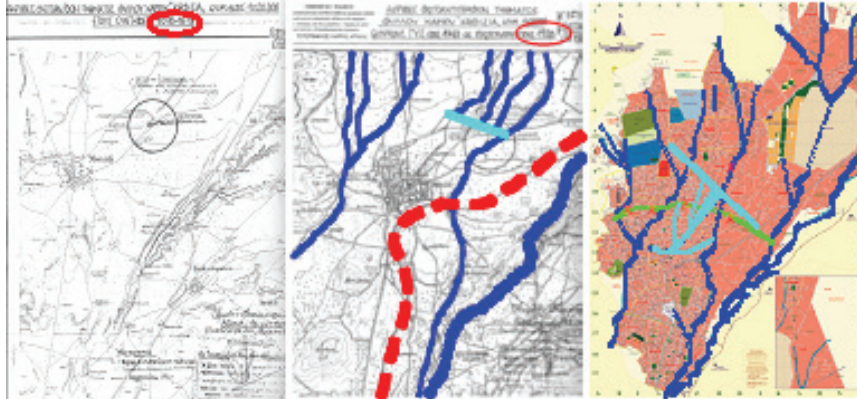


Figure 6 : Evolution of Acharnai and its hydrographic network from 1880 to 1928 and 2000:
Natural streams (blue lines) are landfilled and/or replaced by streets (cyan lines).

The city has no stormwater drainage system due to a series of obstacles:

- The area is one of the most economically impoverished of Athens
- Priority was given to supplying water and separate sewer system which actually covers 100% of the city
- Lying upstream in the Athens basin, storm water from Acharnai is drained through natural streams towards the low-lying and flood risk prone urban areas of Athens. When the Acharnai municipality sought to construct a traditional end-of-pipe stormwater drainage network, the Central Stormwater Management Authorities of the Athens Region did not issue the required permit due to concerns raised over the eventual aggravation of the conditions to the downstream areas.

In view of the situation, Acharnai turned to BMPs to solve its severe flooding problems without imposing any additional burden to the downstream municipalities. In the context of the Raindrop project, a series of pilot-scale BMPs concentrated in one location (Agia Triada square) were designed, in order to demonstrate the efficiency of such solutions. More specifically, the following set of BMPs were designed to act "in series" with stormwater overflowing from one system being sent to the next/downstream one in a series of steps:

- STEP1: The surface runoff is entering through the street to the Porous pavement of 250m³ for retention and infiltration.
- STEP 2: The excess volume is directed to the retention tank of 1500m³.
- STEP 3: A pumping scheme with a max capacity of 0.5m³/s is emptying in a controlled manner the tank towards both sides of the Trough Trench of 300m³.
- STEP 4: The excess outflow flows freely to the street.

3.3 SWM measures in Vsetin Microregion

In 2006 the municipality of Vsetin, the biggest city in the Microregion Vsetin, supported the development of scenarios for storm water management in a region

which is known for its heavy floods in the river Bečva caused by fast run-offs. SWM is supposed to become a part of municipal and regional planning as an integral part of flood prevention measures.

To demonstrate one of the possible measures, a trough-trench system pilot installation was built to deal with stormwater runoff from a big nursery school in Vsetín. The pilot is equipped with rainfall and run-off monitoring devices.

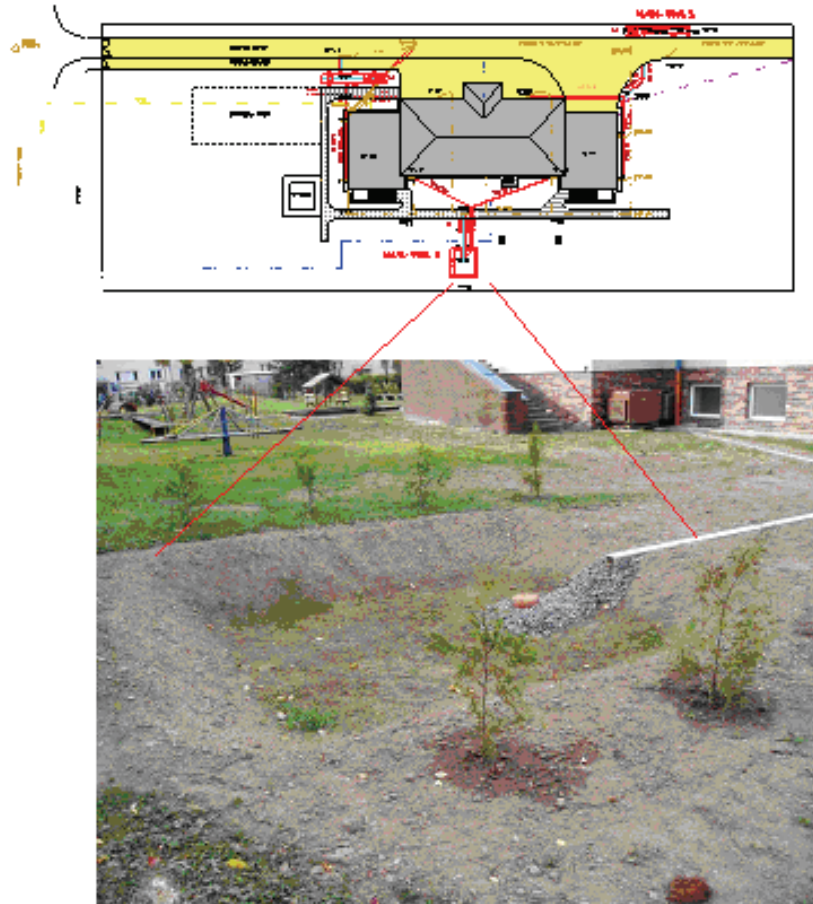


Figure 7 : Nursery school in Vsetín, Czech Republic

3.4 SWM measures in Karvina and Trencin

Similar to Kupferzell, Aharnai and Vsetin, stormwater BMPs are implemented in Karvina and Trencin. In Karvina a public building will be disconnected by infiltration devices.

4 DEVELOPMENT OF GUIDELINES

As a conclusion of the Raindrop project two guidelines will be developed.

4.1 Codification of methodology for stormwater master planning

The guideline for stormwater master planning will provide assistance for the major steps of an integrated planning process as shown for Kupferzell:

1. Sewer-network database: demand for data, requirements for models
2. Catalogue of planning objectives with corresponding indicators
3. Deficit analysis demonstrated with examples
4. Scenario development including analysis of potentials for BMPs
5. Modelling of impacts and life-cycle-cost-assessment
6. Assessment of scenarios by using a decision matrix

4.2 Guidelines for the choice of SWM strategies

With the experiences from the implementation of BMPs in the five partner cities, a guideline for the choice of stormwater BMP will be compiled. Due to the differences in five regions (climate, soil, topography), this guideline will be applicable in most parts of the CADSES region and also in other locations in Europe.

The guideline will provide assistance

- Selecting suitable stormwater BMP
- Design of selected stormwater BMP
- Information on maintenance

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