Hydroinformatic tools application supports non-traditional ways of stormwater disposal

Application des outils hydro-informatiques pour la recherche de solutions alternatives de gestion des eaux pluviales.

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RESUME
En raison de l’absence de tout système de gestion des eaux pluviales et d’un niveau élevé de la nappe phréatique, la région du village de Hrncire recense un nombre élevé de cas d’inondations de caves, même à la suite d’événements pluvieux modérés. Les eaux de ruissellement provenant des zones urbanisées sont drainées vers des ruisseaux qui font partie d’une zone naturelle protégée qui est caractérisée par le régime hydrologique particulier. Pour Hrncire, c’est le concept de drainage des eaux pluviales qui a été recommandé, dans le but non seulement de limiter les dégâts occasionnés aux bâtiments privés et de favoriser le développement de la région, mais aussi, de préserver les caractéristiques hydrologiques des espaces naturels environnants. Plusieurs solutions alternatives de drainage ont été adoptées puis évaluées au moyen d’outils hydro-informatiques.

ABSTRACT
Absence of the stormwater drainage system and high levels of ground water table in case area of Hrncire village cause flooding of cellars after moderate rainfall events. Stormwater from urbanized areas is drained into small creeks, that are part of the protected natural zone, characterized by the specific hydrologic regime. For Hrncire the stormwater drainage concept was to be recommended with the aim not only to limit the damage to private property, caused by insufficient stormwater drainage, and to enable the development of the area, but also to preserve to high degree the hydrological characteristics of the bordering natural areas. Several alternatives of drainage with non-traditional features were conceived and evaluated by means of hydroinformatic tools. Use of the advanced modelling concepts can be effectively used to support the application of the non-traditional stormwater management.

KEYWORDS
Disposal ; drainage ; modelling ; stormwater ; study.
1 BACKGROUND AND AIMS OF THE WORK

In the village Hrncíře (approx. 50 ha of urbanized area, detached houses), situated at the borders of the capital Prague, only the foul flow vacuum sewerage system was constructed.

Absence of the stormwater drainage system and high levels of underground water table in this area, where quick development is taking place, cause problems for private property (flooding of cellars after moderate rainfall events) as well for local streets.

Stormwater from urbanized areas is drained mostly in a natural and distributed way into several minor watercourses with low capacity, that are part of the protected natural zone „Hrncíře meadows“ (approx. 8 ha), characterized by the specific hydrologic regime (high groundwater levels and periodical floods). All the water from the drainage flows into the closing profile, which lies at the lowest point of the protected area.

The aim of the work, commissioned by the local authority, was to create several alternatives of stormwater drainage for the village Hrncíře and to evaluate the best solution to meet 3 goals:

- To enable the development of the area;
- To eliminate the flooding of cellars;
- To preserve the hydrological character of the protected natural zone.
Due to the local conditions it was not possible to use in bigger scale classical deep sewers and the use of non-traditional ways of stormwater had to be taken into account. At the same time it was necessary to use advanced modelling techniques to get deeper insight into the hydrological processes than it is usual in traditional project tasks.

2 METHODS / TECHNIQUES USED

After the discussion with investor it was decided to base the selection of the best alternative on the long term hydrological modelling of water levels' fluctuation for the area of protected natural zone, as an indicator of stability of living conditions for protected flora and fauna. That implies that extensive amount of data had to be collected. Because of tight budget it was not possible to go into extensive measurement campaigns and it was necessary to rely mostly on available information from historical records.

2.1 Field surveys

At first the current status of the drainage system was assessed as the basis for building of reasonable alternatives for future. Accordingly the very detailed field surveys and photo documentation of drainage system components were carried out. The current drainage consists predominantly of shallow ditches; only limited stretches are piped and some of them are located on private grounds. The location of drainage system elements as well as small watercourses were surveyed.
2.2 Data collection, supplementary measurements

As mentioned before, extensive amount of data had to be assembled from different sources for the whole natural catchment (approx. 146 ha):

- Topological data
- Historical rainfall and evapotranspiration data for several years
- Data on vegetation and land use
- Available data on fluctuation of the groundwater level
- Data on geology and characteristics of the ground
- Flood records for the recipients as well as for the private grounds

Because the data collected did not give enough information for the model to be used with enough confidence, the supplementary measurements had to be carried out – namely, collection of ground samples and evaluation of retention curves and hydraulic conductivity was carried out for 5 more locations in the vicinity and within the natural protection zone.

2.3 Building of models and modelling

The information collected was processed into the hydraulic models (MOUSE, MIKE11), that were used for the evaluation of the capacity of small watercourses and drainage elements (both open and closed) within the urbanized areas. Furthermore, the MIKESHE model was set up, describing the correspondence of ground water and water flowing in the drainage elements. This model covers the whole catchment (both urban and natural catchments), connected to the closing creek profile at the lower end of the natural protection zone.
Calibration of models was made on the basis of the available information on groundwater level fluctuation and the information about the time and extent of flooding.

The calculations were carried out for both the current state of the drainage system and for the future alternatives.

2.4 Evaluation of data and setting up boundaries for the alternatives

The collected data, evaluated capacities of recipients and the requirements specified from the side of investor and Environment Protection Department of the City of Prague were evaluated and the following conclusions were driven:

- The stormwater drainage should be carried out when possible by shallow drainage elements, preferably by grass-covered ditches. The other conditionally recommended ways of drainage for specific locations in the case area are shallow sewers or drainage directly on the street, where there are suitable conditions for that (streets with low traffic and limited connected area).

This conclusion reflects the need to keep the character of drainage as close as possible to the natural way of drainage as possible.

- It is not possible to increase the capacity of the recipients in the natural protection zone;

- The centralised disposal of stormwater (from private grounds and streets) by infiltration is not recommended mainly both due to the lack of space in the streets and generally very high groundwater levels in the case area;

- The local infiltration on private properties is generally not effective, but is to be considered location to location with taking into account supplementary surveys (local ground characteristics and groundwater levels);

- It is necessary to evaluate also the possibility to make use of the configuration of terrain and to transfer stormwater out of the catchment of the natural protection zone;

- Because of very limited capacity of local recipients it is necessary to optimize the scope of catchments, drained to different outlets and to design retention pond at the outflow to the lowest capacity recipient.
2.5 Setting up alternatives

Several alternatives for future drainage system were set up, all taking into account:

- maximal available extent of stormwater transfer out of the natural protection zone catchment
- maximum preference for open/shallow drainage elements

but differing in:
- the scope of catchments connected to different outlets within the catchment of the natural protection zone

As the result 4 alternatives with different scope of catchment connected to different outlets were created. The variability of catchment connections was enabled by gentle gradient conditions of terrain in the case area.

2.6 Principles for evaluation of alternatives

The evaluation was based on:

- the comparison of computed flow from stormwater outlets into the small creeks for alternatives of future state with the current state and the capacity of recipients

Clearly it is necessary to avoid changing the current frequency of flooding in the natural protection zone significantly.

- The long term comparison between the reported values of groundwater fluctuation within the natural protection zone.

The aim is primarily to avoid changing of long term water balance, which would lead to the negative influence on the flora and fauna.
3 RESULTS AND DISCUSSION

The results of the long term integrated sewer/aquifer simulation in 4 reference points of the natural protection zone show that when the non-traditional ways of stormwater drainage are preferred for draining the case area, the general pattern of groundwater fluctuation is not influenced significantly by the different distribution of catchments to outlets.

Example of the long term simulation results of groundwater fluctuation (depth under terrain in m) in point 2 of the natural protection zone for the current status of the system and the alternatives

Example of the groundwater level distribution in the modelled catchment and position of reference points in the natural protection zone
One of the alternatives (1A) was recommended as a basis for detailed design of the future drainage system, because it shows optimal distribution of catchments to the outlets from the point of view of limited capacity of recipients.

4 CONCLUSION

The study results show clearly the potential of the modelling techniques for the evaluation of influence of different stormwater drainage schemes, including the use of non-traditional ways of stormwater disposal, on long term hydrological characteristics of partly/fully urbanized catchments, which is exemplified by the groundwater table fluctuation.

Although the case area was relatively small, it was a rather time consuming and expensive business to put together all the data for the model building and calibration. Nevertheless according to our opinion the use of advanced modelling techniques, combining models of sewer system and models of flow in saturated and unsaturated zone is economically justifiable in case of drainage studies of sensitive areas, where groundwater levels can correspond in larger scale with the water level in sewer system, be it a study of a current system operating not properly (extensive I/O flows) or the design of a new drainage.

LIST OF REFERENCES


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