# An innovative retention canal – a case study

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**Abstract.** The publication presents the solution of an innovative retention canal, which is used as a part of the drainage network and constitutes an alternative to traditional retention reservoirs. A selected case study was described where various variants of the drainage system were analyzed. This example shows the main advantages of a retention canal solution.

## 1 Introduction

One of the effects of urban development is an improvement of standards for the functioning of technical infrastructure, including drainage systems. At the same time, there is an intense increase in the coverage of sealed areas. All this results in an increase in the intensity of rainwater outflows of existing and emerging sewage systems, as well as changes in the inflow of water to receivers. In many cases, there is unfavorable pressure phenomena of sewage flows in sewage pipes, the lack of possibility of discharging sewage from the city area or the hydraulic overload of rivers and lakes.

Problems of excessive sewage flows in sewerage networks can only be solved to a limited extent using devices and facilities for discharging rainwater to the ground. The main obstacle is the lack of appropriate land for the construction of such facilities, the high costs of land purchase and rainwater pollution [1], which requires the use of often expensive technologies for their treatment. In many countries, incentives and legal coercion are carried out to enforce the use of objects for rainwater management [2-6], their introduction into the ground [7-9] and field retention [10], roof [11-13], using reservoirs of various sizes and types [14-15] and in sewer systems [16-17].

In the cases of many cities, a significant problem is the lack of sufficient areas for building large reservoirs. Then one of the technically possible solutions to be applied are tubular tanks built into existing collectors or built next to them in the form of a bypass.

The publication presents the solution of a retention canal, which is the subject of the patent application [18] and the analysis of the case study of its application.

## 2 Construction and calculation of a retention canal

A retention sewer is a fragment of a properly designed rainwater system or a combined sewage system where the periodic retention of sewage is anticipated.

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The retention canal consists of separated retention segments located in relation to each other in a series system. Between the retention chambers, inspection chambers are located where there are piling partitions. In the lower part of these partitions, flow openings have been located, which allow the flow of sewage in non-atmospheric periods and reduced flows of rain sewage volume. On the other hand, in the upper parts of piling seams there are emergency overflows of sewage operating when the emergency discharge of water reaches the retention chambers. The diagram of the detector canal according to the developed solution is shown in Figure 1, and Figure 2 shows an example of a piling made in a sewer with a diameter of 2400 mm.

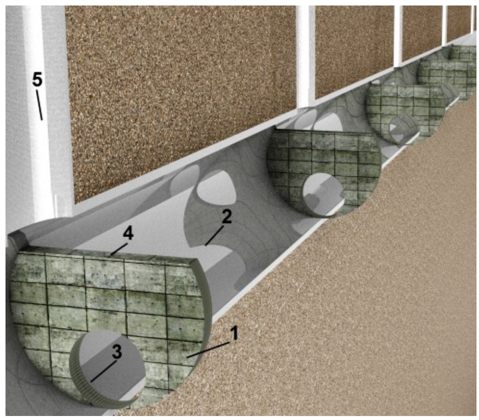


**Fig. 1.** Retention canal model. 1 – piling partition, 2 – storage segment, 3 – through-flow holes of piling partitions, 4 – emergency overflow of piling partition, 5 - piling partition chamber.

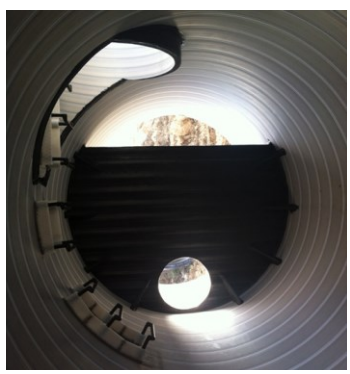

**Fig. 2.** A piling partition on a sewer with a diameter of 2400 mm.

The calculation of the retention capacity of a canal with regard to the flow part is based on mass balance equations for wastewater flowing in and out of individual canal segments. For this purpose, specially dedicated calculation programs that simulate the flow of sewage through a system of ducts work the best. They use the flow models according to the dynamic wave described in the system of de Saint-Venant equations. The course of hydraulic processes in the canal intended for sewage storage in rainfall periods is complex and depends on a number of construction parameters, in particular on the canal capacity, size and distribution of piling partitions and flow openings, as well as canal drop [19]. Equally important are the factors associated with the selection of rain models, which are suitable for calculating the design parameters of this type of objects. It should be noted that there is a substantial difference in the precipitation of rains accepted for dimensioning sewer pipes of standard drainage networks from networks equipped with retention canals [20-21].

The problem of selecting the design parameters of retention canals is of fundamental importance for the assessment of the financial effects of their application and the selection of the most advantageous investment option.

# 3 Case study

## 3.1 Localization an characterization of an area and objective of the analysis

The area covered by the investment is a district in a city located in the south-eastern part of Poland. The catchment is dominated by single-family housing, villas and gardens. The total catchment area is F = 126 ha, and the average surface runoff coefficient is $\Psi = 0{,}31$. The catchment is surrounded by roads with high traffic, which limit the possibility of making additional passages under the roads towards the rivers which are the sewage receivers. The area is characterized by large land falls and a complex sculpture of the surface. The investment area does not have a fully functional drainage system covering the entire surface of the drainage system. As a result, especially in the lower parts of the catchment, there were problems with the flooding of buildings and roads. The catchment is presented in figure 3.

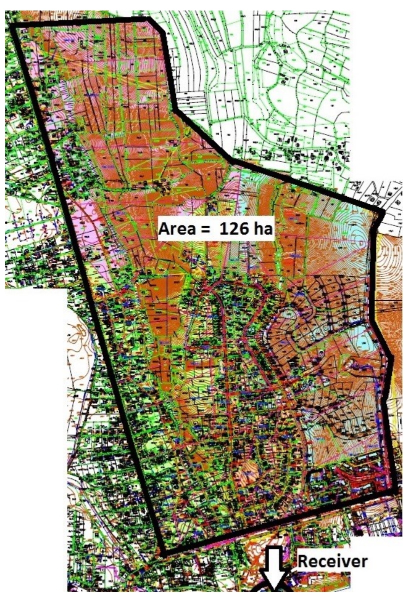


**Fig. 3.** Situation of the catchment.

## 3.2 Hydrodynamical model

In order to accurately reflect the conditions of rainwater drainage from the area covered by the planned investment in the hydraulic analysis, the software used for modeling the hydrodynamic catchment and storm water management systems was Model 5.0 (SWMM).

In the research, a hydrodynamic model was developed defragmenting the catchment into 72 parts with areas ranging from 0,08 to 13,04 ha and distinguishing 168 pipe sections.

Separate hydrodynamic models have been developed for distinguished investment variants, taking into account their specificity and an analyzed solution to the problem solution.

A selection of the cross-section sizes of canals and an analysis of their hydraulic capacity was made in accordance with the investor's guidelines for rainfall with a duration of 10 minutes with the assumption of rainfall probability p = 50%.

It was determined taking into account the local climatic conditions referring to the average annual rainfall, that the assumed rainfall for simulation tests and dimensioning of the sewerage network will cause outflow from the basin with a maximum intensity of 150 $dm^3/s$ ha.

## 4 Variants of the drainage system

Three investment variants were adopted for the analysis:

- Variant A - making an additional transition with a sewer collector with a diameter of 700 mm along with relieving the currently operating canal passing under the national road,
- Variant B - modernization of the passage with a sewage collector along with the increase of its diameter to 1200 mm using a trenchless method in order to improve the hydraulic throughput,
- Variant C - execution of the retention canal on the main sewer collector to limit inflow to the collector passing under the road while leaving it without modernization. The diagram of investment variants is shown in figure 4.

All variants meet the hydraulic requirements. The project assumed that passing of outflows arising for rainfall with a probability of occurrence of 20% and durations of 10 to 120 min without their being accumulated in sewers. Thus, the diameters and falls of sewers were selected in order to maintain gravitational flows on all sections of the network. Figure 5 shows the profile of sewage systems with a retention canal at the time of a critical filling occurrence.

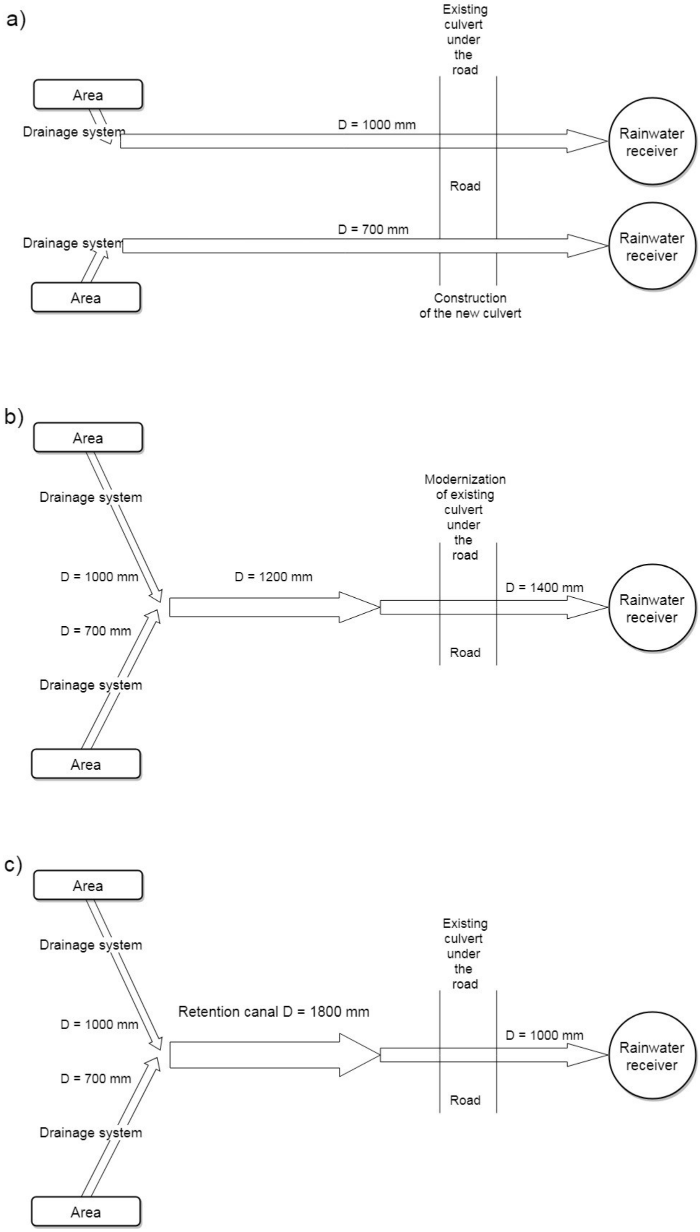


**Fig. 4.** Variants.

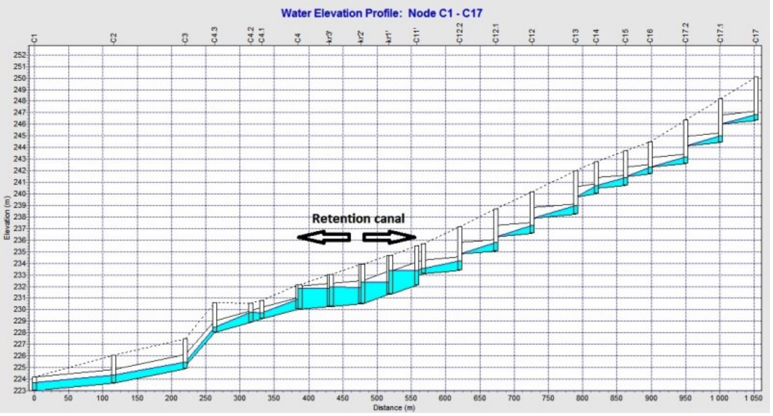


**Fig. 5.** A network profile with a retention canal.

## 6 Costs analysis of variants

For the developed investment variants, cost estimates have been prepared, taking into account all the costs of preparatory and construction works. A summary of these costs is shown in figure 6.

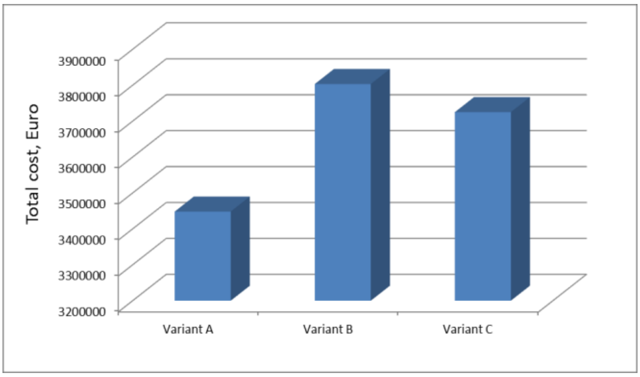


**Fig. 6.** Total cost of Variants.

An analysis of the investment costs allows concluding that all variants are characterized by their similar value. The difference between the most inexpensive variant (Variant A) and the most expensive one (Variant B) is around 10%, and between Variant A and Variant C around 8%. Therefore, these are minor differences, and taking into consideration the environmental and hydraulic criteria, as well as an impact on surroundings, they do not have to be a decisive factor in selecting the most favorable option for the investor.

Variant C, thanks to the use of a retention facility, additionally allows limiting the temporary outflows of sewage to the receiver, which is beneficial in terms of both the hydrological and ecological aspects.

## 5 Summary

Based on the conducted technical and financial analysis, it is proposed choosing Variant C as the best concept for drainage of rainwater. This variant is characterized by considerable hydraulic flexibility and does not require intervention in the existing system of outlet collectors from the analyzed catchment. In addition, it is possible to regulate the intensity of rainwater runoff during their accumulation in the separated parts of the retention canal which, thanks to the use of an effective hydraulic system, allow the design of the sewage system to adapt to changing flows, resulting from changes in catchment management in the future.

As the conclusions drawn from the investments so far, retention canals are fully functional and effective ways of storing wastewater in sewerage networks. In many cases they are a much cheaper alternative to traditional concrete storage reservoirs. Thanks to the use of ready-made pipes, they have significantly shorter investment periods, which can also be an important factor from an investor's point of view.

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