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Bioretention systems for rainwater management in the area of roadways

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Abstract

At the level of the Cluj-Napoca municipality, especially in the peripheral areas, there is a pressing problem related to the management of rainwater on the roadway, caused by the lack of drains and gutters. The result is the stagnation of rainwater (polluted with tars, hydrocarbons, detergents, oils) on the roadway or nearby green spaces. In the context of the sustainable development of the city, to increase the aesthetic and environmental value of urban areas, bioretention systems are an essential element in the collection and management of rainwater. To reduce the negative effects and reduce pollution, nature-based systems (it uses the natural processes that occur in the soil and the interaction between vegetation and microorganisms) can be implemented. To function properly, these systems require specific stratification and vegetation - associated with the area's microclimate and soil structure. The purpose of this research was to study the integration of a bioretention-rain garden system, on Soporului street, Cluj-Napoca city, on the north-west side of the green space for the protection of traffic routes. Bioretention is based on natural principles and soil qualities and is designed to capture and filter excess water from rainfall. The numerical modeling program RECARGA was used to evaluate the system's feasibility. The results show that the bioretention system can be viable in the studied area bringing multiple benefits. Based on dimensioning and numerical modeling, using data related to the characteristics of the studied area, we appreciate that this type of system can become functional in the evaluated location and that it can be implemented in other areas as well - particularly recommending its inclusion on streets that are undergoing rehabilitation or construction.

Introduction

The overall strategy for urban drainage has evolved from being pipe-based, which only encompasses stormwater quantity control, to being composed of a more multifunctional nature-based blue-green infrastructure [6, 14]. Blue-Green Infrastructures (BGI) are nature-based solutions by which urban planners can address the impact of urban growth and climate change while providing a wide range of ecosystem services [3]. The bioretention system is a stormwater management system that involves the use of plants and soil to filter, retain and reuse rainwater, and it does not allow water to drain quickly from the land surface, which can lead to flooding and soil erosion. The management of urban rainwater becomes a matter of great importance following the expansion of urban areas, due to monthly precipitations that keep their values and impervious areas that are in continuous growth. In the context of the need for sustainable city development, to increase the aesthetic and environmental value of urban areas, bioretention systems are an essential element in the collection and management of rainwater. The general benefits of bioretention systems are health aspects, water protection [15], they provide a habitat for the local ecosystem, they reduce the urban heat island effect it can recharge the aquifers, improve urban green infrastructure, decreasing peak flows [4], improve site landscaping [5] and the water resulted can be reused in irrigation or laundry cleaning [12]. The design details are very specific for this type of storm water management. It is necessary to determine the infiltrative capacity of the native soil and make a soil mix (sandy loam or loamy sand) [5].

Material and method

The site under study is located in Cluj-Napoca city, in a very dense neighborhood (Gheorgheni). For a better understanding of the current state of the selected site, a serious of analysis were conducted to reach a conclusion regarding the future interventions. Using direct observations methods and evaluating the traditional drainage system the following problems were reported: at the beginning of the implementation of the water management system, the built-up area was much smaller than at the moment. Therefore, the percentage of surface runoff has become much higher. On days with precipitation, water stagnates in the green areas related to the roadway, for several days. The importance of the intervention on the rainwater management system in this area is given by the continuous evolution of the area. This inconvenience does not only affect the aesthetic side of the area, but also influences the quality of life and air due to the pollutants present in surface runoff (heavy metals, sediments, oil, hydrocarbons, etc.) [7, 8, 9]. To reduce negative effects and pollution, bioretention cells can be implemented. The evaluation of system readiness can be identified with the numerical modeling program RECARGA [1, 2]. With RECARGA is possible to design and analise bioretention cells. The results show that the bioretention system can be viable in the studied area bringing multiple benefits. Based on dimensioning and numerical modeling, using data related to the characteristics of the studied area, we appreciate that this type of system can become functional in the evaluated location and that it can be implemented in other areas as well - recommending in particular its inclusion on the streets that are in the process of rehabilitation or construction [2].

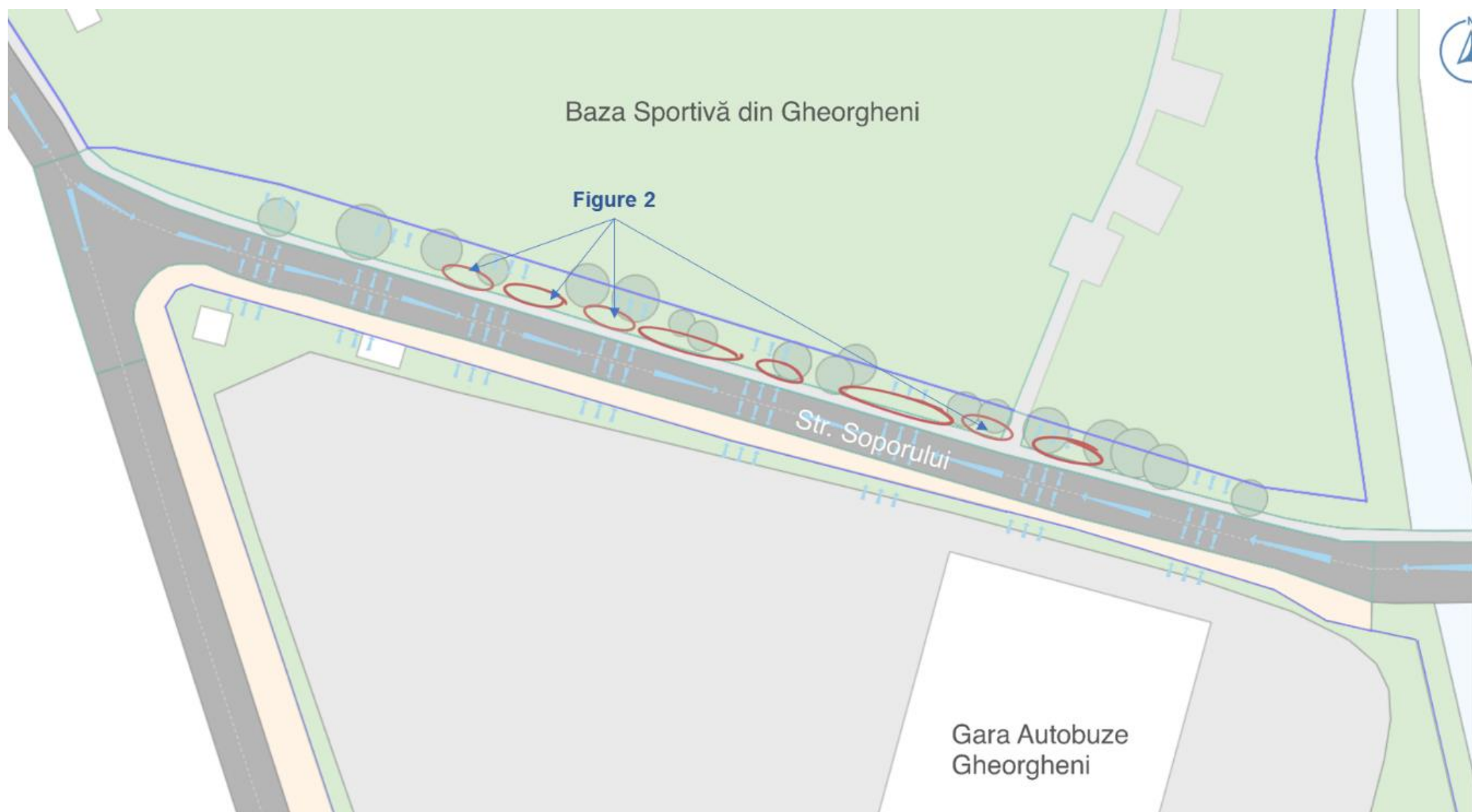


Figure 1. Studied area



Figure 2. Different areas form the site with stagnant water

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Results and discussions

In order to see if the system is dimensioned according to the conditions of the studied site, the number of hours in which the water stagnates, and the number of overflows will be observed (if it is exceeded - rainwater or wastewater is rejected into the surrounding environment => surface water pollution). Thus, the results related to the two different types of stratification, that incorporates a drain or not, will be compared. In the case of bioretention systems without a drain, water stagnation can be observed for around 60 hours without the possibility of overflow.

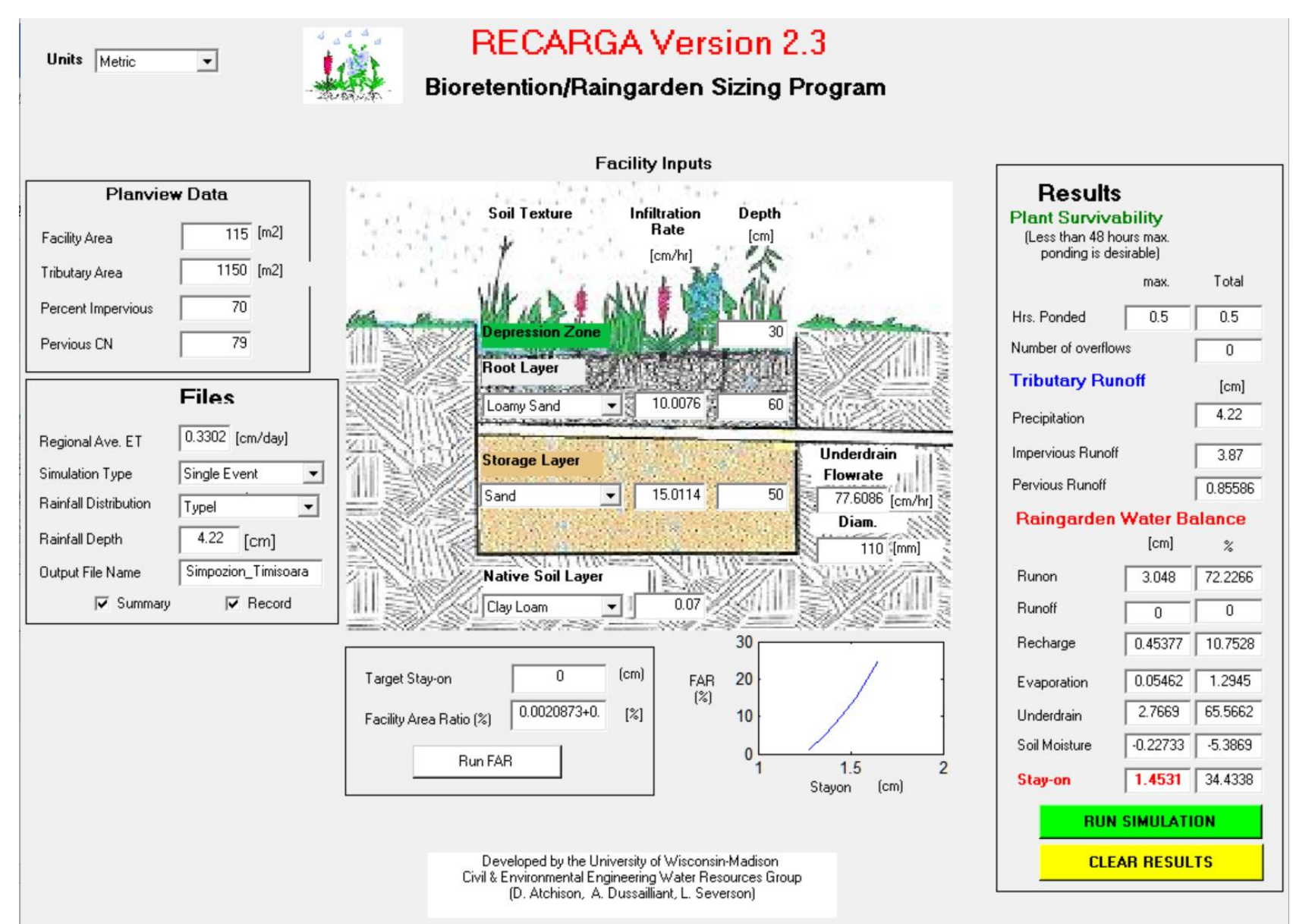


Figure 3. Interface of RECARGA

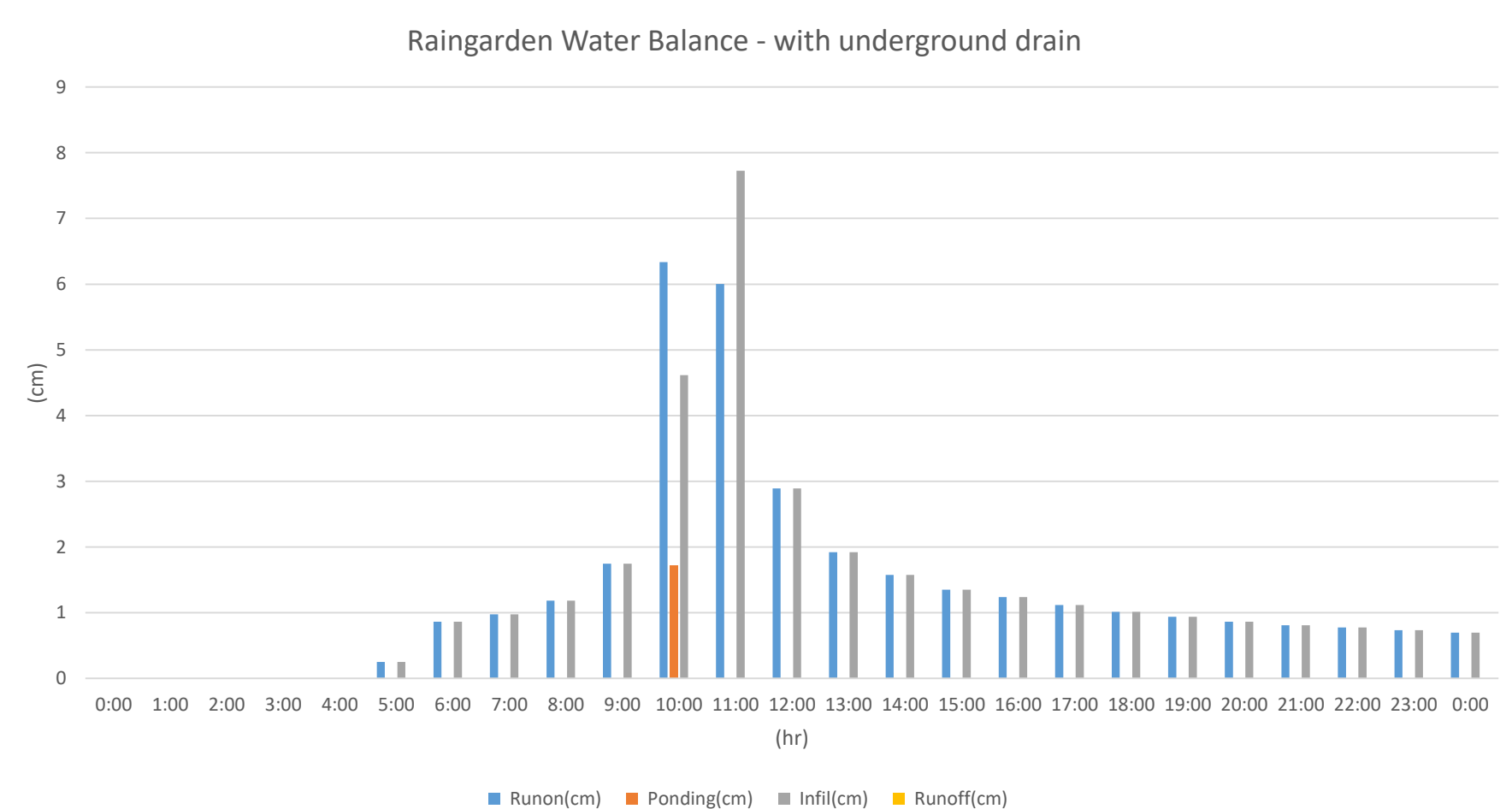


Figure 4. Raingarden Water Balance – with underground drain

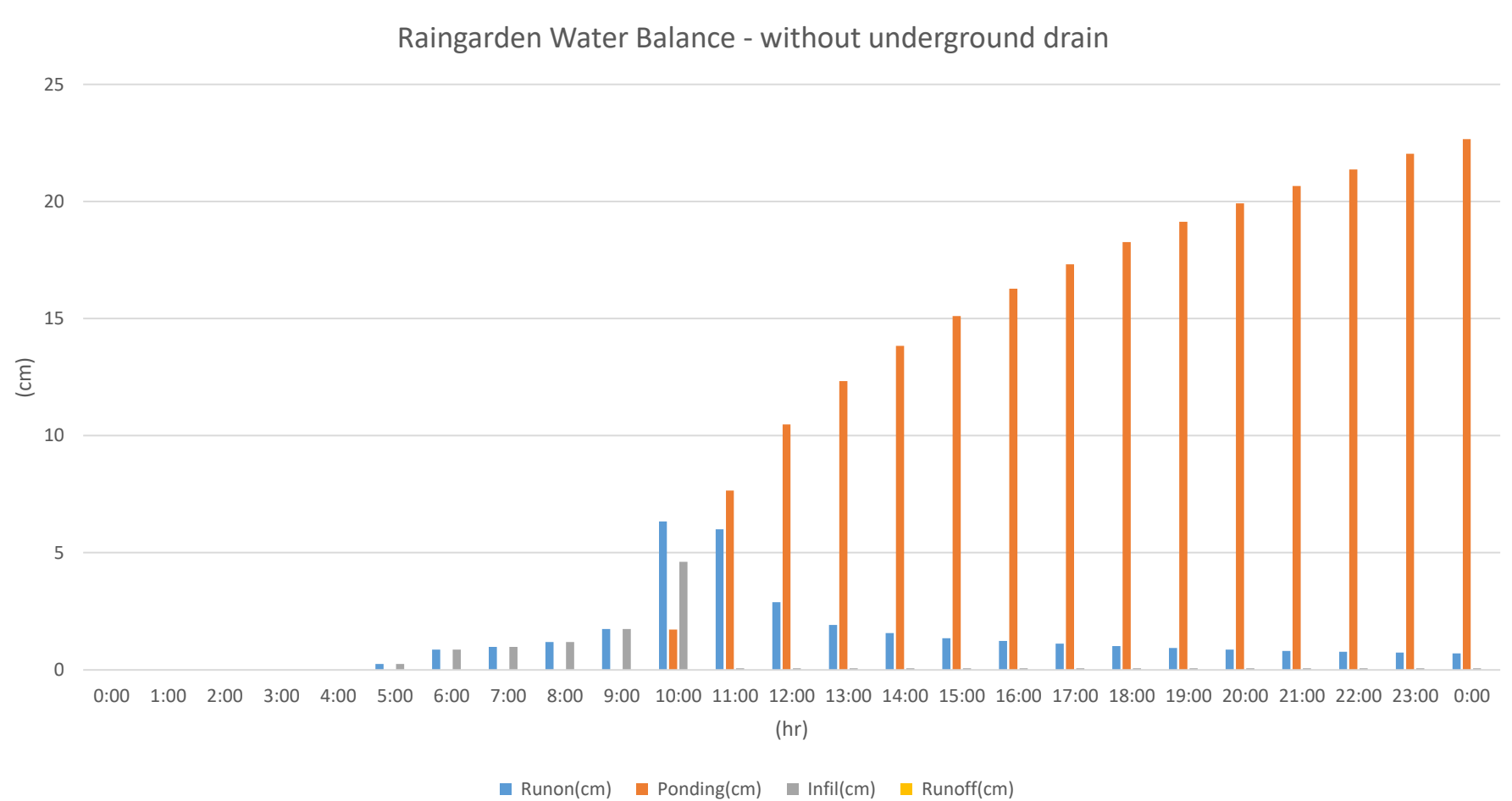


Figure 5. Raingarden Water Balance – without underground drain

Conclusions

The solutions that cities can adopt in the transition to urban sustainability are countless. The bioretention system represents a sustainable, aesthetic and qualitative alternative that presents many other advantages compared to existing traditional systems: reduction of peak flows, thus reducing the risk of flooding downstream of the system, reducing the flows that existing drainage systems must handle, using rainwater to improve urban green infrastructure, reducing the "heat island" effect in urban areas, recharging aquifers and improving water and air quality, minimizing the impact on the regime of water courses and reusing the resulted water (irrigation, laundry cleaning).

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