The Storm Water Drainage and Treatment Systems at the “Gazela” Bridge in Belgrade, Serbia – A Case Study

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INTRODUCTION

Because of anthropogenic climate change and rapid urbanization, cities are faced with many problems caused by heavy precipitations. There are a lot of terms which describe sustainable urban water drainage systems, but the common outcome is how to achieve a better way to manage stormwater in urban areas i.e. how to upgrade existing infrastructure in order to cope with a number of challenges which modern cities are faced with.
Sustainable urban drainage systems (SuDS) techniques which are commonly used are:
attenuation - facilities that provide flow control through attenuation of stormwater runoff, e.g. green roofs, detention basins, etc.
infiltration – infiltration trenches and filter strips, permeable surfaces, etc.
stormwater harvesting – collecting stormwater and possibility for using it for different purposes
Types of SuDS
Source control measures deal with run-off at, or close to, the surface where rainfall lands.
Site control measures manage the surface water run-off from larger areas, such as part of a housing estate, major roads or business parks.
The run-off from larger areas can be channelled to a site control measure using swales (shallow drainage channels) or filter drains.
Regional control measures downstream of source and site controls deal with the gathered run-off from a large area. These systems use the same principles as smaller scale SuDS, but can cope with larger volumes of water.
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METHODS

The “Gazela” bridge over the Sava River in Belgrade on the highway E75 was constructed in 1970 and reconstructed from 2010 through 2012. The bridge is located within the protected area of the Belgrade potable water supply system, so the constraints for storm runoff discharge are severe. The total drainage area, which includes bridge deck and access roads, is 65.000 m^2. Design of the bridge drainage project was based on the 10-year design storms. Before the reconstruction of the bridge stormwater was conducted directly in the Sava river. Pollutants that settle on the impermeable surfaces during dry periods are washed together with the atmospheric pollutants during rain events. Some of them are:

Lead - Part of EU countries and US States prohibit the use of lead in wheel balancing weights
Copper - Released mainly from brake pads
Zinc - Released from tires and guardrails surface consumption
PGEs - Diffused from catalysts exhaust system

It was necessary to design the new concept for stormwater evacuation from the bridge but taking into account downstream boundary conditions, that is, capacity of existing stormwater sewers and pumping stations. The new concept means that the part of the storm runoff from the bridge is conveyed to the Belgrade Sewer System (BSS), and another part to the treatment facilities with a retention and infiltration basin. The discharge into the BSS sewer pipe is limited to 140 L/s. The retention/infiltration facility accepts the pass-over flow above 140 L/s, while the hydrograph peak is 630 L/s, and the total volume is 200 m^3. In the design are taken real and design 10 year return period rainfall events. Accounting for recommendations of the international experience, the rainfall depths of 5 to 60 minutes events are estimated using the observed rainfall depths at the “Vracar” meteorological station.

RESULTS

The reservoir, for design conditions and constructed/installed equipment, would be emptied in 6.5 hours. Initially, the steady infiltration is imposed at the location of the facility. As the aquifer is mostly confined, it is expected that influence of infiltration is quickly transferred towards the wells.
A pollution tank and equipment for measuring the quality and quantity of water (SWERM®) are to be installed in the second phase. That means that in the emergency cases, polluted water will be stored in the pollution tank and groundwater will be protected from pollution. It is also envisaged construction of two piezometers in the vicinity of the drainage system

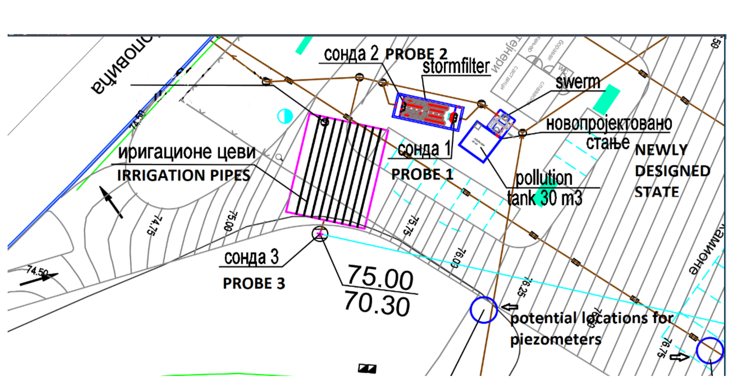

Figure 4. Disposition of the system in the final phase

The groundwater recharge by collected and pre-treated runoff from the Gazela Bridge will be continually monitored in the next phase. Monitoring program includes construction of piezometers between the infiltration facility and existing wells, as well as in the background area. Continual observation of groundwater level is designed, with water quality sampling on the two weeks frequency basis. The extended list of water quality parameters will be monitored in accordance with Serbian legislation for drinking water quality.

It should be emphasized that from all other bridges along the aquifer of the Sava River drainage water is discharged, either directly into the Sava river or into the ground without any treatment, as well as pollutants in the runoff. Monitoring is to be used for assessment of all assumed parameters aiming at reliable further modelling of infiltration effects on groundwater regimes and water quality. Developed model will be further utilized for analyses of ground water regime along the Sava River.

DISCUSSION

During the designing phase of drainage system of the bridge, numerical model has been developed. Runoff was simulated using SWMM software. Adopted runoff coefficient value was 1. The designed inlets’ capacity was tested in Hydraulic laboratory (Institute of Hydraulic and Environmental Engineering).
For additional treatment of the “first flush” of polluted runoff 30 barrels with capacity of 60 L/s were set. The reservoir, for design conditions and constructed/installed equipment, would be emptied in 6.5 hours. Initially, the steady infiltration is imposed at the location of the facility. As the aquifer is mostly confined, it is expected that influence of infiltration is quickly transferred towards the wells.
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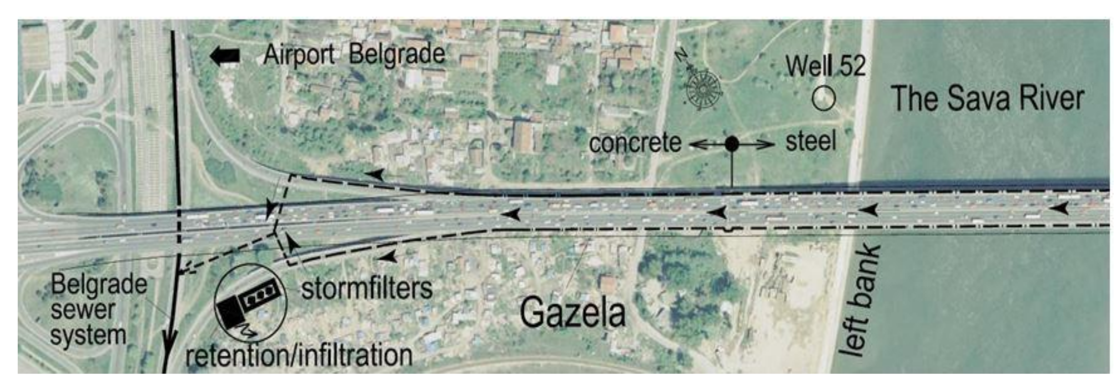

Figure 1. Retention in the constriction phase

Figure 2. Retention in the constriction phase

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Figure 3. An aerial view of the part of the Gazela Bridge over the Sava River and drainage, treatment and infiltration system at the left bank

CONCLUSIONS

Project execution provided high improvement of previous drainage system consisting of holes in the bridge structure. Those holes were in function for more than 40 years for discharge water from the bridge to the ground which was polluted by either transportation pollutants from the deck or by washed-off constituents of the steel and concrete construction. Lots of usual polluters and several unusual, such as high iron - Fe concentration were found within the preliminary soil under the bridge inspection. under the bridge by decreasing surcharge of the bridge structures.
This is a concrete example when wider team, including researchers and design engineers, investors and municipality management were willing to coordinate responsibilities and tasks to achieve reliable, efficient and sustainable modern promising solution in urban environment. Potentially also to pave the way of mitigate of certain climate change aspects by twofold philosophy, smoothing and balancing the changes of decreasing of the ground water level on one side, and increasing of extreme rainfall runoff events, on the other.
The monitoring activities acquired continuously pH, turbidity and electric conductivity values in order to establish a relationship with the stormwater runoff composition. The start of a rain event remarkably influences electric conductivity and turbidity values, meanwhile pH remains practically unaltered.

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