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Quantifying Low Impact Development Measures in Water Resources Management-A Case Study

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ABSTRACT: With increasing interests in using Low Impact Development (LID) to tackle water management problems, it is vital to stress the importance of an integrated view of design rainfall and design flow together with quantified assessment of these LID measures. There are different considerations how LID measures are implemented based on different views of the storm water management (SWM) philosophy. A case study on how design rainfall and design flow for LID are implemented, is conducted with the help of two numerical models. Each LID measure can be evaluated and used in scenario analyses for quantifying its drainage, infiltration and retaining characteristics.Different LID measures can also be tested and evaluated for a given input and/or boundary conditions. Besides, water and response sensitivities of different LID measurescan be evaluated for variousrainfall conditions. Finally, the role of design rainfall and design flow can becompared under different scenarios in order to clarify its importance in quantitative evaluations of LID components for the future.

The catastrophic floods, which occurred in Europe in the beginning of the 2000s, led to ratification of the EU Flood Directive (EUFD) in 2007. The directive stresses mainly capacity building issues such as that a clear organizational structure has to be in place, that flood risk analyses have to be carried out, and that flood management plans have to be made. In Sweden, the early development of concept of BMP and Green Infrastructure started already in the 1980s when the dual system was considered in urban water management. Several Swedish cities haveduring the latest two decadessuffered from severe urban flooding problems, especially in larger cities like Gothenburg (year 2005, 2006, 2008, and 2011) and Malmö (2007, 2010, and a huge event in 2014).

In Sweden, the Intensity–Duration–Frequency (IDF) relationship plays a central role in SWM practice,combined with a dynamic evaluation of the objects concerned in terms of hydrology, hydraulics and existing as well as planned infrastructures (Dahlström, 1979). The practice in China is quite different, as it is based mainly on steady state flow with relatively fixed recurrence period (often below 3 years) for precipitation.In line with the recent nationwide campaign for “Sponge City” solutions, a lot of effort have been put in finding sustainable management model for future cities. It is therefore of great interest to compare the effects of these solutions in China and Europe. With this starting point and with the fact of increasing threat from climate change and rapid urbanization process, we need to adopt a more holistic

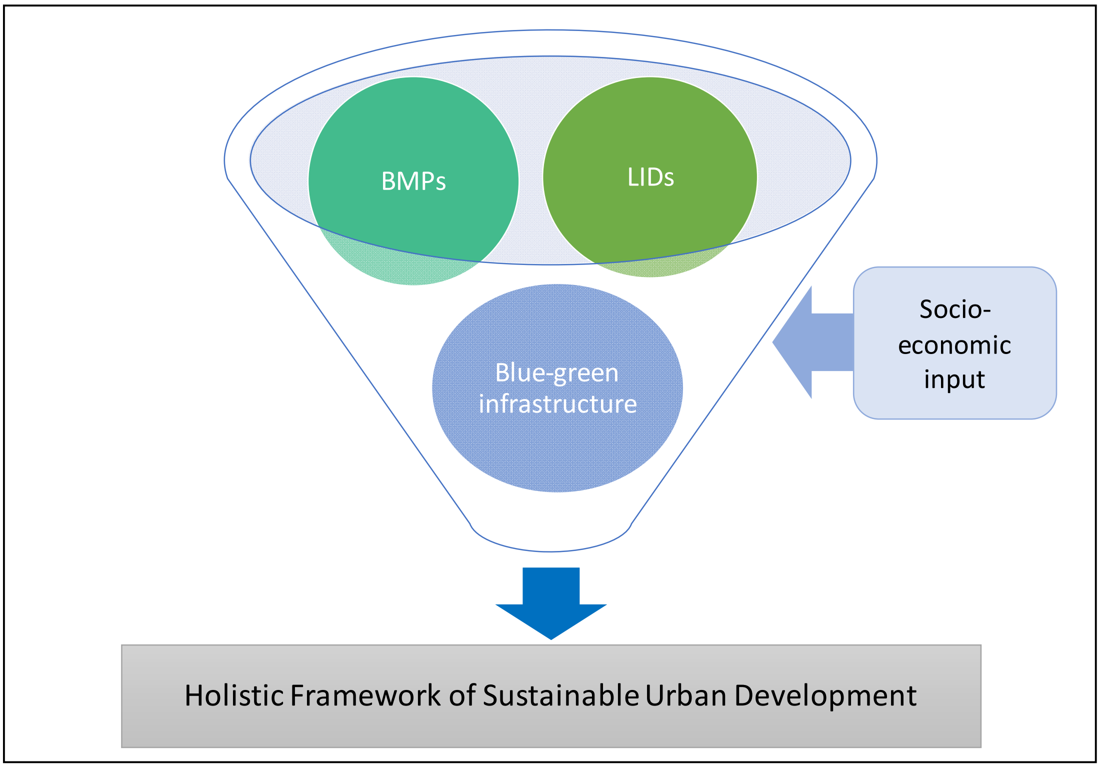

Figure 2.A Holistic Framework of Sustainable Urban Development for SWM.

view in future SWM. One concept of this holistic view is presented in Figure 1, where the combination of LIDs, BMPs together with integrated blue-green infrastructure should be considered by taking into account other factors such as the socio-economic situation.

Malmö is the third largest cities in Sweden, with increasing challenges of growing urban area and climate change induced water problems. Various LID measures(mainly open water systems, as shown in Figure 2) are aimed to minimize risks of flooding, increased pollution transport and deteriorating ecosystem. Simple LID measures mostly in form of different open canal systems were constructed in Malmö 15 years ago to tackle the urban drainage problems, combined with green-roof solutions to increase the ecological and visual values of the area. A comparison

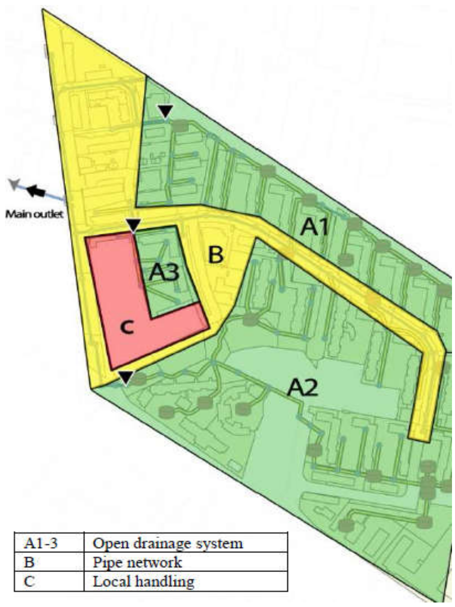

Figure 1. Open storm water solutions in Augustenborg, Malmö City(Shukri 2010)

study was conducted to compare the simple LID with the piped system (Shukri, 2010). It was concluded that the more or less regular floods were stopped for normal years. Villarreal et al. (2004) found further that the system could handle a design rainfall of up to 10 years return period without problems since the system with theexisting LIDwere proven to work efficiently during some large events. However, On the 31st of August 2014, an intense rainfall hit Malmö (Figure 3, top part). Almost all of the city were affected and about 3,000 properties were reported flooded. Streets, houses, underground garages and even the hospital were flooded. It fell 80–120 mm over Malmö, which corresponds to a return period of 50 to ~200 years. In Augustenborg, the maximum intensity reached73 mm/h and most of the rainfall (100 mm) fell within 3.5 hours (Figure 3). This extreme rainfall event provided valued field data to examine various SWM solutions including LID. In a qualitative study, Theland (2014) found that the areas with open solutions performed in general better in reducing the flooding compared with traditional piped drainage areas.

In the current study, the performance of the existing simple LID measures and scenario-based sitting management for new LID measures are implemented based on above event. Based on Shukri (2010), cross-section based open system components are modified and included at the study area (230,000 m^2) in order to test the initial rainfall events before 31st August 2014.19 of the major cross-section based components (canals, ditches, onion gutters and swales) are displayed in Figure 3 (dark coloured cylinders). The test run of this setup, in the modelling system of MIKE URBAN, confirmed that the open system performed better compared to traditional pipe based system for the August 2014 flood event. However, for the largest rainfall intensity, which occurred around 8:30 on the 31stof August, the model of the open system showed at most 15 flooding points. These flooding points are illustrated in Figure 3 (red triangles). This indicates that the existing simple LID solutions at Augustenborg are insufficient in

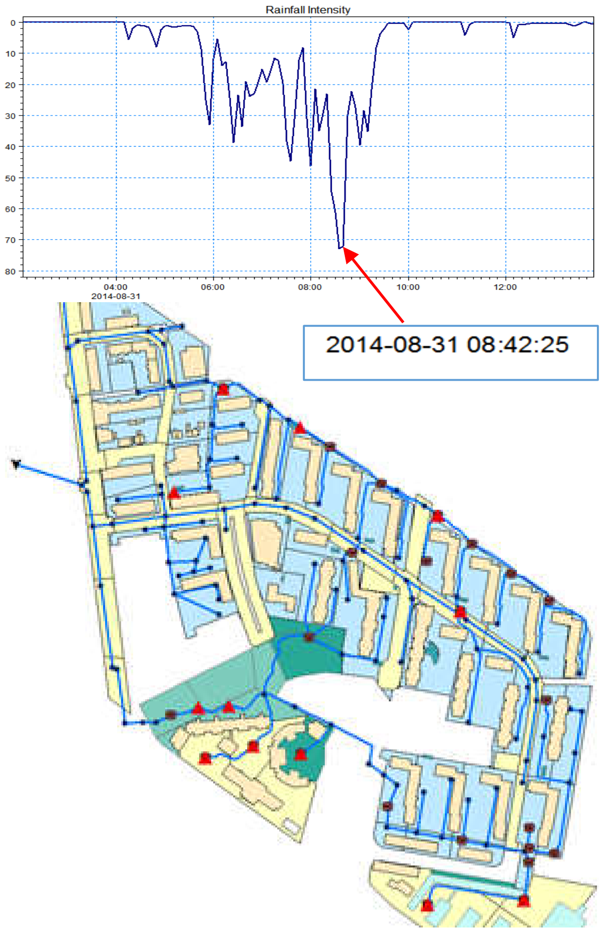

Figure 3. Augustenborg area with open water system; the red triangles show the flooding points for 2014 event (top part) and the brown cylinders shows simple LIDs.

handling huge events similar to that of 31st August 2014. Additional measures, perhaps even more effective LID measures, need to be proposed. A better design of basement windows, garage drive-ins, and other structures that might let water into the buildings, might also be suitable.

In a first attempt, a number of LIDs of types like bio-retention ponds, rainfall barrels and vegetation swales, are tested with the hydraulic modelling software MIKE URBAN. The purpose is to show how well the areas with an open stormwater system, containing detention in ponds and temporarily flooding, infiltration, green roofs, lawns and parking,arefunctioning during extreme rainfall. It isalso provided actual, up to date scenarios for demonstration and dissemination purpose for various stakeholders. The initial simulations show positive effects in term of reduced flood risk. But the difficulties here are how to optimize the selection, design, placement with scenario-based sitting managementas well as the dimensioning calculations in order to meet then future needs. It should also be interesting to compare the Malmö case with relevant Chinese cases in the next step.

KEY WORDS: LID,open stormwater solution, Sponge city, Blue-green infrastructure.

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