Integrating hydraulic modelling and GIS for wastewater systems management. A case study

B.F.V. Vieira*, A.M.V.S. Bárbara, E. Barbot**, J.M.P. Vieira*, J.L.S. Pinho***

*Centre for Territory, Environment and Construction, Department of Civil Engineering, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal, barbaravasquezvieira@gmail.com
**AGERE-EM, Braga, Portugal.

Abstract: The increasing costs related to operation and maintenance of urban wastewater systems has led to a special attention of utilities in promoting studies to address the key problem of water infiltration, inflow and improper connections entering the separate drainage networks. This is a common and hard to predict operational situation that needs to be identified and minimized as it negatively affects the managerial conditions of the network and the downstream wastewater treatment plant efficiency. The implementation of mathematical models for determining the hydrodynamics behaviour of dry weather and wet weather flows in sewers appears to be a sound methodology to identify the causes for those adverse management conditions. This methodology was applied in a small urban wastewater network of the city of Braga (Portugal). The free user program USEPA SWMM was applied with the integration of GIS information related to the wastewater collection system.

Keywords: Wastewater flow modelling; urban wastewater management; infiltration inflow

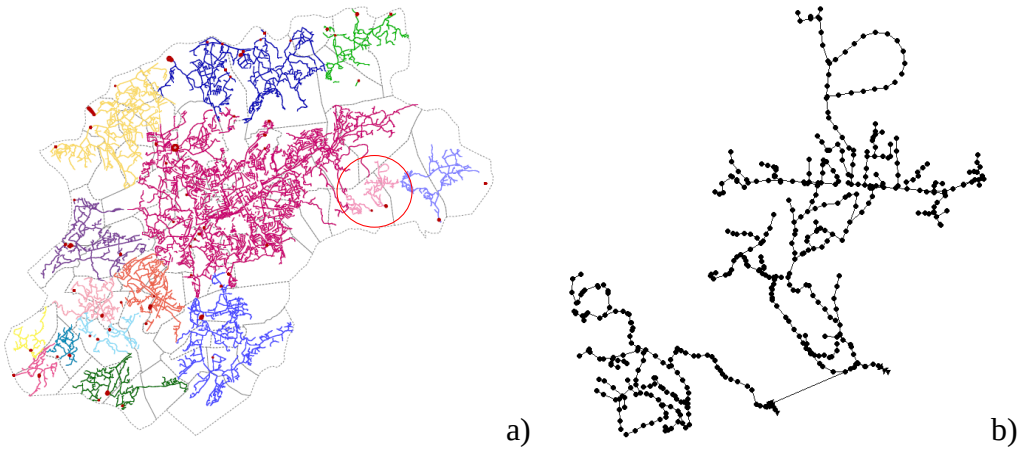
Management difficulties in separate drainage networks seldom occur when unexpected groundwater inflow, stormwater infiltration, and flows from improper connections enter into the dedicated sanitary sewer systems. These difficulties negatively affect the managerial conditions of the network and the downstream wastewater treatment plant efficiency often leading to the increase of operation and maintenance costs. Although the consequences that undue flows may have on wastewater systems are known, the problem is difficult to locate and quantify. The use of modelling tools is of special relevance to the planning, management and rehabilitation of these types of systems, which can be very useful for: (i) evaluating the capacity of existing systems in real time; (ii) testing alternative solutions to solve problems detected; or testing different procedures to operate the systems in extreme events scenarios.

The implementation of mathematical models for determining the hydrodynamics behaviour of dry weather and wet weather flows in sewers was applied in a small urban wastewater network of the city of Braga (Portugal). The free user program USEPA SWMM (Rossman, 2015) was applied with the integration of GIS information related to the wastewater collection system. Figure 1 depicts the conceptual layout of the wastewater network (Espinho network) obtained after exporting the cadastral information contained in GIS (InterAqua).

Figure 2 presents the hydraulic model exported to the SWMM environment, generated from the topological file. In this way, it was then possible to automatically obtain the characteristics necessary for modelling the network components, such as the manholes, culverts and catchments.

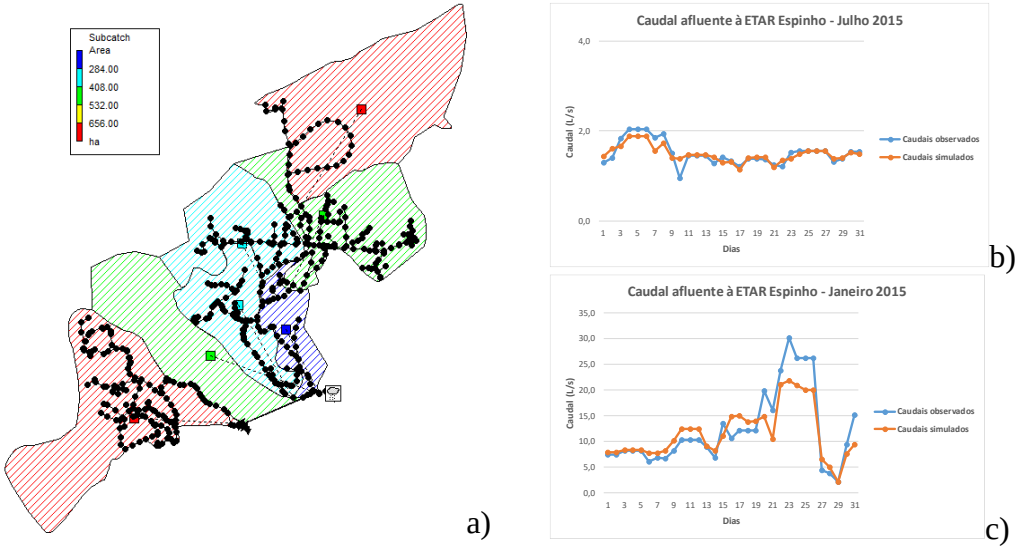
Model construction adopted the standard procedures (Walski et al., 2007), considering the flow rates arriving at Espinho wastewater treatment plant, and the estimations of inflow and infiltration rates. Through the calibration and verification processes, it was observed that the adopted mathematical model successfully described the hydraulic behaviour of the wastewater drainage system. For flow rate calculations a typical daily pattern was adopted for each month to simulate the variability in rain distribution and in drinking water demands (Figure 2).

Although in global terms the model had good results with errors within the recommended limits, it was found that they were more consistent and accurate for dry weather flow rates than for wet weather flow rates. This fact can be justified by uncertainty associated to input data, namely: (i) use of average values of daily flows affluent to the WWTP; (ii) inaccuracy of some flow values recorded at the WWTP, with emphasis on weekend values; (iii) consideration of a uniform precipitation in the catchment area.



a) b)

Figure 1 Braga wastewater system representation: a) Network subsystems highlighting the Espinho subsystem; b) Conceptual SWMM hydraulic model representation of Espinho subsystem.



a) b) c)

Figure 2 Modelling results: a) hydrologic model for 7 catchment areas; b) WWWT affluent flow in dry weather conditions; c) WWWT affluent flow in wet weather conditions.

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