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## (Sub-)Catchment delineation with different levels of geographical data: which effects on combined sewer overflow modelling?

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### Keywords

Combined Sewer Overflow; Data scarcity; Hydraulic modelling; Sub-catchment.

### Introduction

Sustainable Urban Drainage Systems (SUDs) are increasingly used to alleviate the sewer system and thus contribute to reduce combined sewer overflows (CSO). However, this approach raises several questions about the minimal number of SUDs, their types, and optimal locations to achieve a significant decreasing of CSO at the catchment scale. Those questions are often appraised through modelling approaches and scenario analyses. However, hydrological and hydraulic (HH) models require a minimal description of the territory and its characteristics, notably the catchment and sub-catchment delineation, and the appropriate level of sewer network plan.

Several catchment delimitation methods already exist (Li et al., 2020). A first group of methods are generally applied to a single data source. Delimitation can be made with land use, mostly consisting of urban block divisions according to existing roads (Khurelbaatar et al., 2021); network sewer plans (Ghosh and Hellweger, 2012); or topography. For example, the “D8 algorithm” is used quite frequently, and is based on the Voronoï geometric division principle. A second group of methods, referred as “hybrid” partitioning methods, sequentially uses the different data sources to identify sub-catchments. The present study investigates the effect of different strategies for catchment and sub-catchment delineation – and when applicable, sewer network identification – based on different spatial data: topography and/or sewer network plans and/or land use data. Four scenarios of data availability are proposed and tested in two different sites, followed by HH modelling to compare the computed flow dynamics. The final objective is to test solutions for CSO mitigation.

### Methodology and results

**Methodology:** Available data were gathered through four scenarios: aerial images only (**Scenario 1**); aerial images and topography (**Scenario 2**); aerial images and actual network plans (**Scenario 3**); all above-mentioned data (**Scenario 4**). The overall delineation methodology is adapted accordingly. First, a preliminary catchment delimitation is made from aerial views, by excluding the external zones (forests, fields, parks), or by considering natural or artificial frontiers (river, highway). Whenever necessary, we propose to mimic the real sewer network by means of a fictive one following principal roads and driven by gravity. This follows the conclusions of Blumensaat et al. (2012) who showed that correlation between the network and roads goes up to 95% depending on the city, and emphasized that older infrastructures are more likely to follow this rule. When digital elevation models (DEM) data is not available (scenarios 1 and 3), each area is considered as contributor to the nearest network branch, so that boundaries between sub-catchments are defined by the equidistance between two pipes. When DEM data is available (scenarios 2 and 4), the extent of this area is determined considering the natural path flow direction (D8 method).

The delineation methodology was applied in two study sites: Ecully (245 ha) and Vernaison (360 ha), France. For those two sites, DEM data with a resolution of 5m x 5m grid is available (RGE ALTI©; IGN, National Geographic Institute). The network plans were provided by local authorities.

The outputs of the above-mentioned method were used in a semi-distributed HH model based on (i) the rational method for rainfall-runoff transformation, (ii) a linear reservoir as a transfer function, and (iii) a spilled flow equation for CSO simulation. In each delineated sub-catchment, the percentage of impervious area was derived from land use maps (high-resolution Map Tiler Satellite imagery©).

**Key results:** Approaches in which topography is unknown tend to include contributing areas on the catchment edges whose slope does not converge towards the sewer network inlets: therefore, they may overestimate the total catchment area. For instance, scenarios 1 and 3 lead to a total catchment area up to 30% higher than scenarios 2 and 4 (Figure 1), and consequently a runoff volume increased by a factor of ~2. On the other hand, knowledge of the actual sewer network plan (scenarios 3 and 4) may lead to the identification of additional contributing urban areas outside the pre-identified catchment boundaries, as exemplified by the case of Vernaison with a south-western zone connected to the sewer system.

Also, it was confirmed that mimicking the network following the main roads provides a good approximation of the main branches of the network. In Ecully, the fictitious network in scenarios 1 and 2 tends to be more detailed than the available information on the actual one (which only includes the downstream branches). However, when comparing results from topography-based inputs (scenarios 2 and 4), the simulated hydrographs show quite similar flow dynamics during rainfall events (Figure 1), and thus similar CSO characteristics (total volume and frequency).

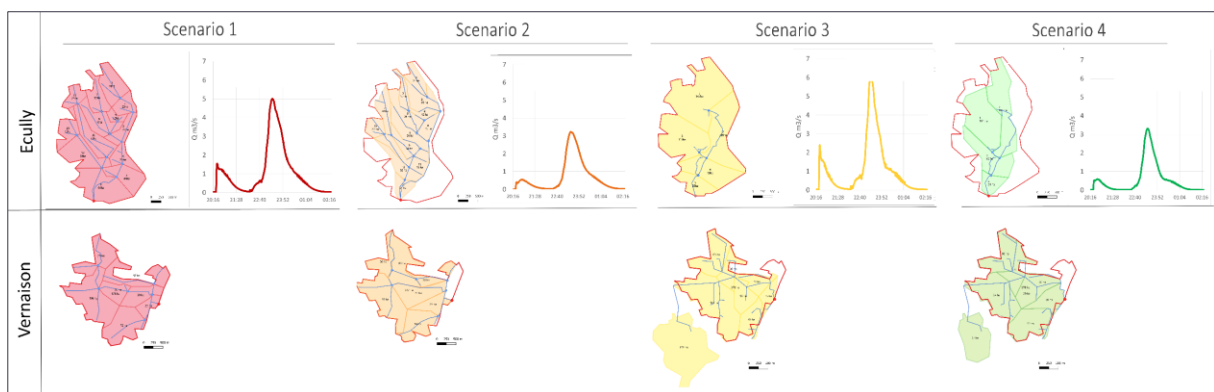


Figure 1: Catchment and sub-catchment delimitation for scenarios 1, 2, 3, 4. Red delimitation represents delimitation made with minimal data, colour polygons correspond to sub-catchments, blue lines represent the fictitious or real network and red points correspond to catchment outlet. Ecully case study show the preliminary HH simulation for a 19 mm rainfall event.

**Conclusion and perspectives:** This study explores different strategies to collect the required input data for HH models, depending on the available geographical information. Current results show a better estimation of total runoff volume when topography is available, even if the actual plans of the sewer network are unknown. Further research will include one more case study with different land characteristics, and will consider different data resolutions: DEM with a 5m x 5m grid vs. DEM with a 30m x 30m grid (assumed to be more easily accessible). Ongoing simulations are based on long-term rainfall series and will be compared to sewer flow monitoring data. The final objective will be to model the effects of SUDS dissemination on CSO.

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