# Calibration of SWMM Model with Continuous Simulation at Riacho Fundo I, Federal District, Brazil

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## Highlights

- The SWMM model obtained results more similar to reality after its calibration;
- An accurate rating curve is essential to provide consistent data to build hydrology and hydraulics model.

## Introduction

Tools such as hydrological and hydraulic modeling have brought advances in the management of urban drainage systems. One model widely used is the Storm Water Management Model – SWMM, which can be applied from the planning to the analysis phases of existing systems, as well as in the sizing of new structures, including the application of Low Impact Development (LIDs) measures (Zhang et al., 2020; Broekhuizen et al., 2019; Xu et al., 2018; Barros et al., 2016).

SWMM is characterized as a dynamic rainfall-runoff model used to simulate the runoff and pollutant loads generated by precipitation data from isolated rainfall events or long time series in continuous simulation. The model operates according to the equations of conservation of mass and momentum for non-permanent flow, which is governed by the Saint-Venant equations (Rossman, 2009). Thus, the calibration process is essential to obtain a model with good accuracy that represents the hydraulic and hydrological phenomena studied as realistically as possible.

The objective of this work was to analyse the calibration of the rainfall-runoff model in order to validate the use of the tool in urban drainage management. Thus, continuous simulation was performed in SWMM for the urban drainage system installed in the Administrative Region of Riacho Fundo I (RF I), which discharges stormwater into Riacho Fundo, the main tributary of Lake Paranoá. Rainfall monitoring data was used as input, and water level monitoring at the system's outlet and the rating curve used for model calibration and validation. In total, 21 rainfall events were identified in the simulated period. This catchment was chosen because it is located in a region with no evidence of illegal sewage disposal into the stormwater system, which characterizes a separate sewer system, with exclusive conduits for stormwater.

## Methodology

The PCSWMM software developed by CHIWater in version 7.2 was used, which couples the SWMM model engine to a Geographic Information System – GIS – and is freely available to academic institutions, being commonly used in urban drainage studies in the Federal District, Brazil.

For the continuous simulation it was necessary to consider the evaporation parcel, computed by the Hargreaves method. This method requires daily data of minimum and maximum temperatures, obtained by the climatic station, in addition to the solar irradiance and latent heat of vaporization, the latter two being automatically computed by the model (Rossman and Huber, 2016).

For calibration and validation of the SWMM model, the automatic method provided by PCSWMM was used through the SRTC (Sensitivity-based Radio Tuning Calibration) tool, in which the calibration is based on the uncertainty analysis of the parameters user-defined. The calibrated response is generated by linear interpolation of the parameter values, based on 8 sensitivity points and the uncertainty range. The calibrated result needs to be evaluated, and validation of the results is required to determine the optimal

parameter values.
The objective functions selected were: ISE rating and ISE (Integral Square Error), NSE (Nash-Sutcliffe coefficient), $R^2$ (coefficient of determination), SEE (Standard Error of Estimate), LSE (Simple Least Square Regression) and RMSE (Root Mean Square Error).

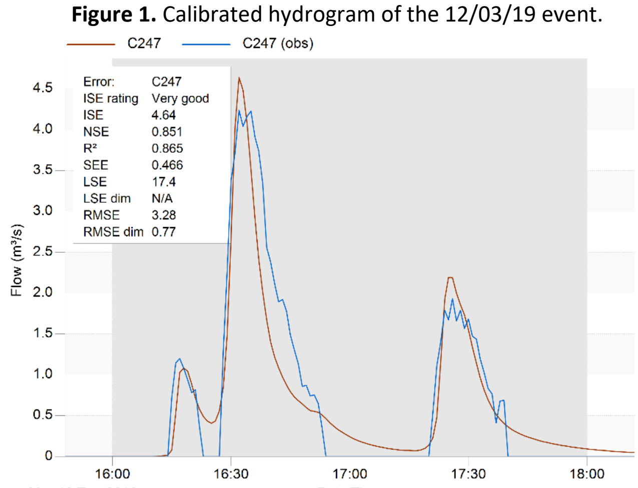
## Results and discussion

The event that obtained the best results for the objective functions corresponded to the one on March 12, 2019 (Table 1 and Figure 1). The calibrated runoff generation for the event presented the behaviour closest to the observed in the monitoring data, being also the event that presented the best results for model validation.
The calibrated model result presented in Figure 1 was considered satisfactory, given that it obtained NSE = 0.851, $R^2$ = 0.865, ISE = 4.64, among the other objective functions with good results, representing small divergences between the observed and simulated values. For this solution, it was necessary a 62% increase in the CN parameter, that the area was adjusted in 8.5%. In addition, the junctions invert elevations needed to be adjusted in 8.3%, while there was a 100% reduction of Manning's coefficient n, being the calibrated value equal to 0.010, and also 100% decrease in the Perv Dstore (depression storage for permeable areas) wtih the final value ranging between 0.099 - 1.35 depending on the subcatchment.

**Table 1.** Comparison of the calibration of the 03/12/19 event in the SWMM model.

| Parameters | Without calibration | Calibrated |
|---|---|---|
| ISE rating | Fair | Very Good |
| ISE | 16.1 | 4.64 |
| NSE | -0.747 | 0.851 |
| $R^2$ | 0.0005 | 0.865 |
| SEE | 1.6 | 0.466 |
| LSE | 206 | 17.4 |
| RMSE | 9.74 | 3.28 |
| RMSE dim | 0.000418 | 0.77 |

**Figure 1.** Calibrated hydrogram of the 12/03/19 event.




In only three events, it was not possible to obtain results considered "GOOD" and with positive NSE values. These are the events in which the model generated very high flows, with Qmax higher than 8 m³/s, which can be associated to problems in the monitored data, due to the difficulty of measuring large flows and its reflect in the rating curve. In the other events, the ISE values are "GOOD", but NSE<0 is still observed in 40% of the events, where Qmax is greatly overestimated, situations in which the flow increase in the model is greatly exaggerated, causing the objective functions to have values outside the range considered adequate.

## Conclusions and future work

From the rainfall and flow monitoring data in the RF I catchment, it is possible to conclude that the SWMM model used for the urban drainage system of the RF I obtained results more similar to reality after its calibration, showing that this step being fundamental for the use of hydrological and hydraulic models in the best management of stormwater.

The SWMM model needed adjustments in parameters such as area, junctions' depth, and mainly in the Manning coefficient n, which refers to the roughness of the conduits, in the Dstore Perv that refers to the storage in permeable areas and in the CN parameter, that is indicates the impermeability of the subcatchments.

More than one objective function should be used for validation, because despite the fact that in 40% of the validated events there were negative NSE values found, the model was still proved satisfactory considering other statistical metrics. The problem in NSE occurs due to the overestimating of Qmax by the model, which can be attributed to problems in the rating curve construction, which needs to be improved, evidencing the relevance of monitoring data for the quality of modeling results.

## References

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