HydroBID-Flood: an integrated modeling approach for flooding risk assessment/mitigation in urban watersheds. Study case of Santa Fe city, Argentina.

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Highlights

- Integrated urban watershed management
- Climate change and urban risk mitigation

Introduction

Socio-economic losses, due to flooding by severe storms in urban areas, constitute a serious national problem for our country and several others in the world (Schomwandt et al., 2016; Etulain and López, 2017; Bertoni et al., 2004; González et al., 2015; Paoli, 2015). Santa Fe, the capital of the homonymous province in central-eastern Argentina, does not escape this problem (Figure 1). It stands out for its location on the confluence of the Salado River and the Setubal System (Parana River).

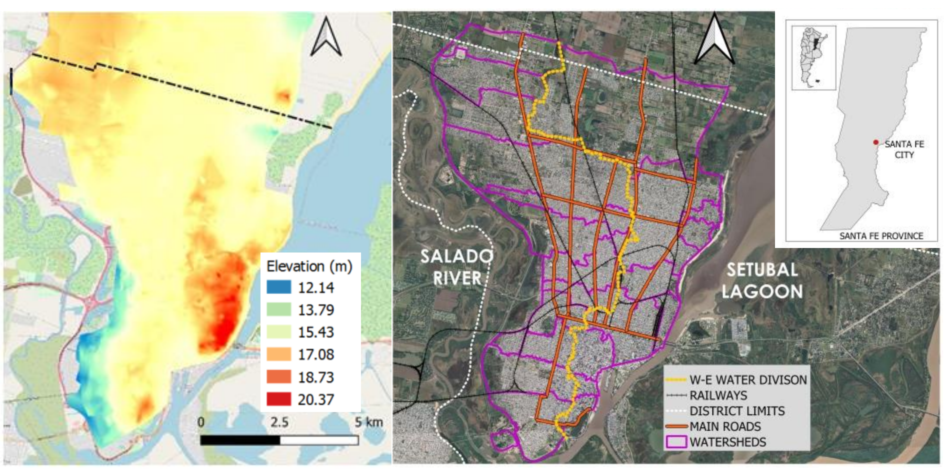

Figure 1. Location of the study area.

The advance of urbanization over green spaces, the consequent soil impermeabilization, and the limited discharge capacity of the drainage network have increased runoff volumes and flooding in significant areas. In addition, road and rail infrastructure constitutes barriers interfering with runoff. The almost flat topography also limits the efficient design of new hydraulic works (Figure 1). This scenario has worsened in recent years due to the increasing frequency of storms of high intensity. In response to the problem raised, this article presents the application of the Inter-American Development Bank (IDB)HydroBID-Flood tool (Hydronia, 2020) with its urban drainage module (Hydronia, 2021) to an urban watershed. The work aims at contributing to robust decision-making to mitigate the risk of disasters due to extreme rainfall in the Santa Fe Metropolitan Area.

Methodology

HydroBID-Flood is a 2D hydrologic-hydraulic model that integrates the storm drain routing capabilities of EPA-SWMM. The model shares the computational engine of RiverFlow2D and was developed by Hydronia and the University of Zaragoza with support from the IDB. In this project, HydroBID-Flood is applied to the State of Israel watershed to evaluate the surface water dynamics interacting with the hydraulics in conduits for two scenarios: a) Reference, representing the current situation of the drainage network; b) Intervention, including the design of a new drainage conduits system (Figure 2).

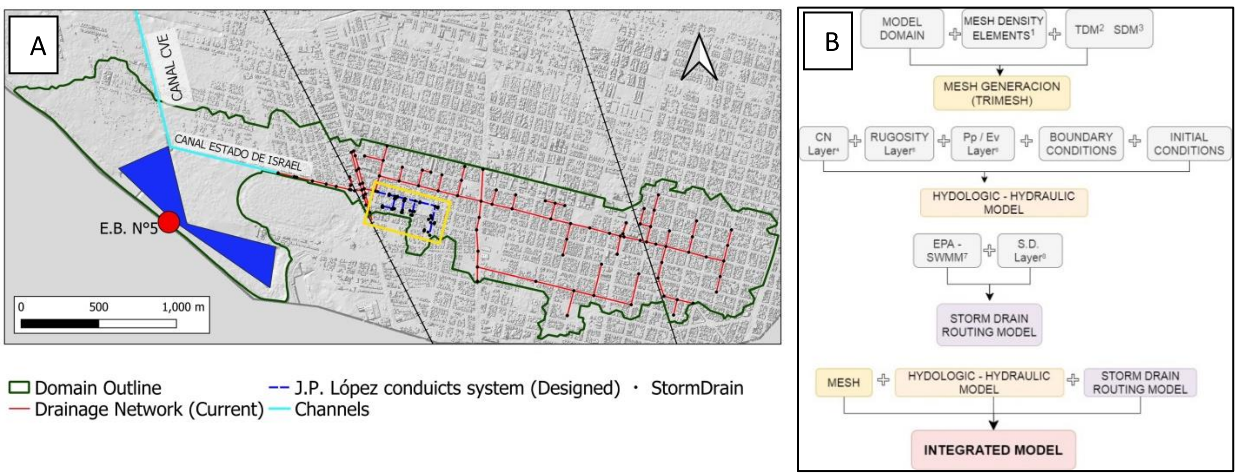

Figure 2. Representation of State of Israel watershed and drainage infrastructure. A: Watershed; B: methodological steps for model set up (1: mesh density line; mesh density polygons; mesh density break lines. 2: Terrain Digital Model. 3: Surface Digital Model. 4: Spatial distribution of Infiltration parameters – *CN*, SCS. 5: Spatial distribution of terrain rugosity parameter – Manning *n*. 6: spatial distribution of meteorologic variables – precipitation and evaporation. 7: Storm Water Management Model set up. 8: Storm drains location).

The design rainfall used in both scenarios has a recurrence of two years. Figure 2 summarizes the steps carried out for the model set up.

Results and discussion

For the Reference Scenario, the model represents the hydrological-hydraulic behavior, satisfactorily (Figure 3). Simulated waterlogging is close to the photographic records and neighbor's claims during rain events of the same recurrence. The results indicate that surface storage is the most relevant hydrological process. The runoff is laminar, being trapped in terrain depressions or discharging in gutters or conduits at a slow rate. The extension and depths of ponding are consistent with those observed during storm events of similar intensity and duration, with depths between 0.05 m and 0.6 m (Figure 3). In general, flooding features (areal extension, depth, and permanence) respond to the combination of flat topography with depressions and the lack of efficient connections to main collectors. Regarding the hydraulics in conduits, the urban drainage network works under gravity forces throughout the simulation, with the exception of some small secondary pipes. For the intervention scenario, the representation of the new J.P. López conduits system in the model leads to a significant decrease of waterlogging in the surroundings of its trace (Figure 4).

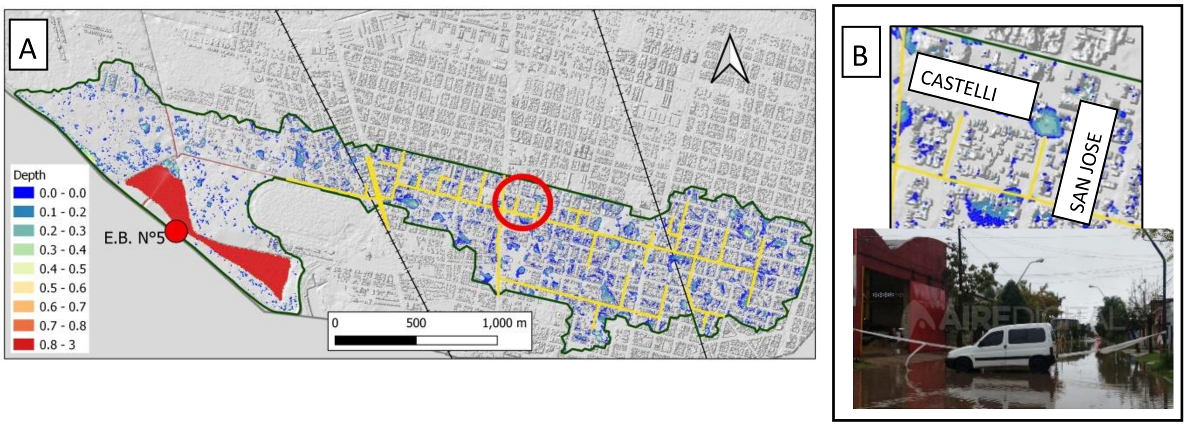

Figure 3. A: Waterlogging after 12 hours simulation for the Reference Scenario. B: simulated waterlogging vs. observed waterlogging for April 10th 2021 storm event. Castelli Street - San José Street intersection.

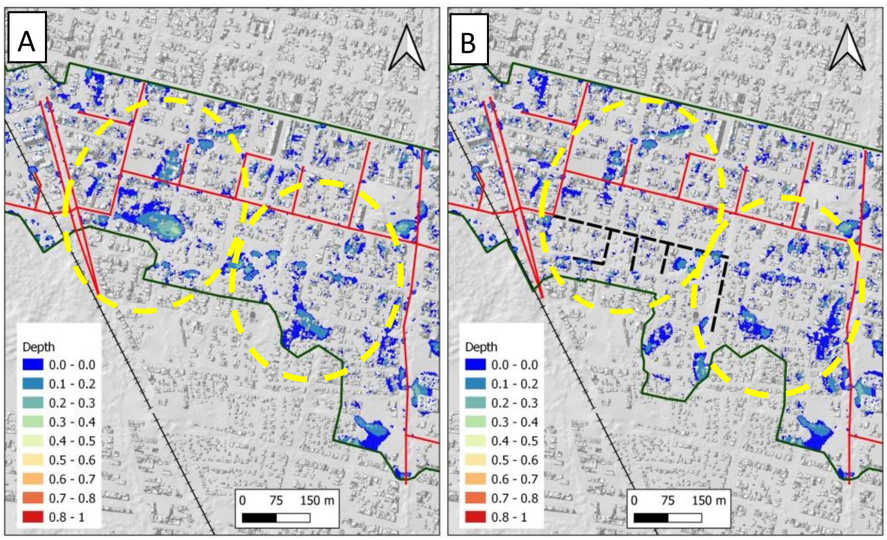

Figure 4.Effect of the designed J.P. López conduits system on the runoff pattern. A: Reference Scenario; B: Intervention Scenario.

Conclusions and future work

Results of the simulations demonstrate the capacity of HydroBID-Flood to identify critical sectors affected by flooding, design economically feasible hydraulic works, and evaluate the performance of new infrastructure to mitigate flooding risk.

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