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The Urban Flooding case study of Ribeira da Agualva

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The village of **Agualva**, located in Terceira Island, **Azores, Portugal**, experienced severe flooding on the early morning of **15th of December 2010**. The flooding was caused by a short-duration and extreme intensity rainfall event. In less than four hours a total of **70mm of rain** rushed down the catchment, flooding several streets and causing the main water course to transport a mix of mud, rocks and debris.

Agualva (meaning "*clear water*") is located in the North coast of Terceira Island. The historical economical importance of the village in Terceira as a centre of water-mill houses from the 16th to the 19th century led to an urban development that closely follows the main water stream.

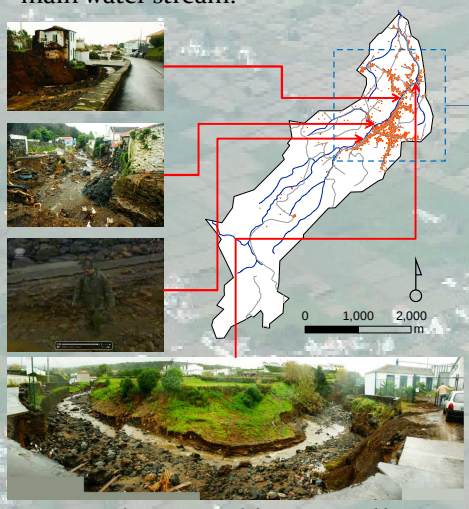

Figure 1. Agualva stream and damage caused by the December 15th rainfall event

The **ribeira da Agualva** stream is the longest water stream in Terceira with approximately 8km long. It starts at *Pico Alto* which is the highest point at 797m and ends at the ocean. The slope varies between 30% and 6% with an average of 10%. The hydrologic **basin** (Fig. 2) has approximately 9km² with a concentration time of about 1,5h. The soil is characterized by an average SCS (Soil Conservation Service) curve number of 93.

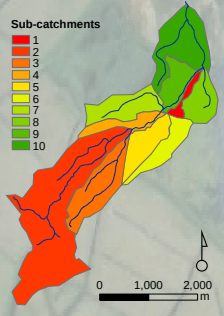

Figure 2. Agualva basin and its sub-catchments

The **Agualva basin** is characterised by a low level of impervious areas (average of 4%). The impervious areas are mostly located (approx. 20%) at the downstream part of the basin, as can be seen in Fig. 1. In addition, the majority of buildings and roads are located in the stream floodplain. The water stream cross-section varies between five (upstream) and 10m (downstream) wide. In the downstream part, there are a few road bridges that strangle the stream cross-section, creating conditions prone to flooding (Fig 3).

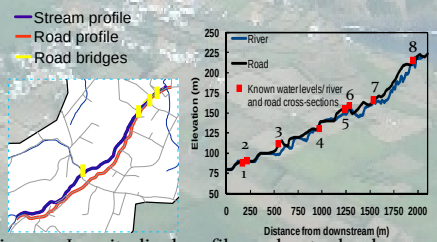

Figure 3. Longitudinal profiles and water level survey

The rainfall event of December 15th 2010 was recorded by the meteorological station of the American Air-base 4. A low-pressure system and the topographic characteristics of the basin were responsible for the high intensity of this rainfall event (see Figs. 4 and 5).

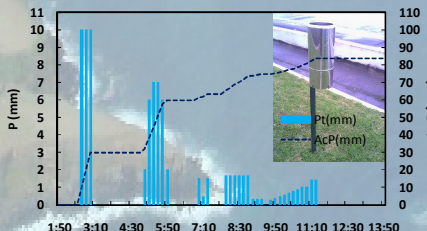

Figure 4. 15 Precipitation hyetograph of the event

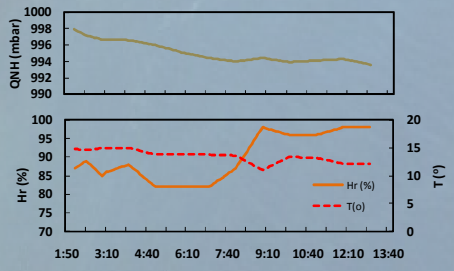

Figure 5. Temperature, pressure and humidity recorded During the December 15th 2010 rainfall event

The basin hydrograph was obtained using the SCS synthetic unit hydrograph (U_{n-m+1}), and considering a total of nine sub-catchments in order to reflect the different soil occupations within the whole basin. The direct runoff (Q_n) was computed using the discrete convolution equation (1) given the excess rainfall (Pe_m) and the unit hydrograph.

$$Q_n = \sum_{m=1}^{n \le M} Pe_m U_{n-m+1} \qquad (1)$$

where *m* and *n* are the input (rainfall hyetograph) and output (flow hydrograph) pulses of 10 min duration (equal to the rainfall temporal resolution), respectively. *M* is the total number of input pulses.

The hydrograph (Fig. 6) shows four consecutive peaks. The highest peak at 6a.m. comes after a large one that occurred at 3a.m. These results are in agreement with local reports.

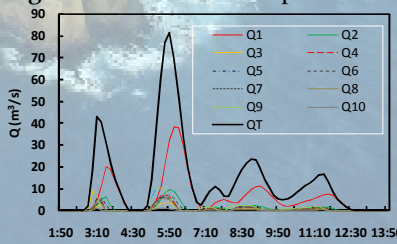

Figure 6. Hydrographs - uncertainty evaluation 1

Uncertainty was included by recognizing that some of the parameters used for estimating the flood hydrograph are non-deterministic. Figure 7 shows the preliminary results of the uncertainty evaluation. Further investigations are being carried out.

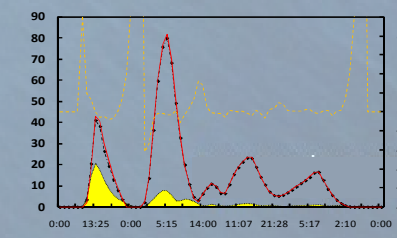

Figure 7. Hydrographs - uncertainty evaluation 2