Inundation Modeling Using HEC-RAS Software Farka Stream Case Study

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ABSTRACT

This study analysis how water flow corresponding to maximum discharge of Q=240m^3/s is distributed along Farka stream. To visualize flow dispersion, two modeling approaches 1-dimensional and 2-dimensional HEC-RAS models are implemented, and unsteady flow analysis is simulated. HEC-RAS models and hydraulic analysis are used to analyze water depth planimetry and flow hydrograph of each stream segment. The objective is to develop 1-dimensional and 2-dimensional models, representing possible stream rehabilitation scenario and performing unsteady flow analysis in order to make a comparison of results. In this study, it is concluded that flow distribution along stream was not the same for 1 and 2-dimensional models. These two modeling approaches, under the same conditions, produces different results and only engineering experience together with project aim can decide which one of them to use while performing flood modeling.

Keywords: *rehabilitation, unsteady flow, hydraulic analysis, flow hydrograph, simulation*

INTRODUCTION

Throughout history flooding has proved to be one of the most devastating natural hazards all over the world due to intense distribution of water streams. Based on available data Albania is considered to be as high-risk region related to flooding [1] [2] [3].

The high probability of flooding events has developed the necessity for flood protection. There has been a great, consistent effort to comprehend, rate and anticipate flooding events and their effect.

Several studies have been conducted related to flood modeling, their priorities and their deficiencies also. It is crucial to have a clear understanding of flood modeling approaches and to precisely distinguish them from one another. Only in this way the selection of the appropriate model will be easier [4] [5] [6] [7] [8].

Flood history of the study area

In year 2011 a government investment was made with the intention to rehabilitate the stream bed, by constructing a concrete covered trapezoidal cross section into the stream covered with concrete at a length of 140m, and by implementing a culvert with dimensions base b=5m, height h=3m and length l=90m to pass near the State Reserve Depots. Trapezoidal cross section has suffered numerous damages and water has found its path outside banks of stream.

The most critical discharge was registered in 30 November 2014, which based on the maximum water level measurements turns out to have been Q=240m^3/s. This unusual discharge caused considerable damage to the left concrete covered stream bank and to the bad of the stream.

The temporary interventions in Farka stream could neither provide an effective protection for the stream itself nor for the abovementioned structures located there

In order to, provide an effective and efficient evaluation of the Farka stream rehabilitation this project is based on 1-dimensional and 2-dimensional flood modeling.

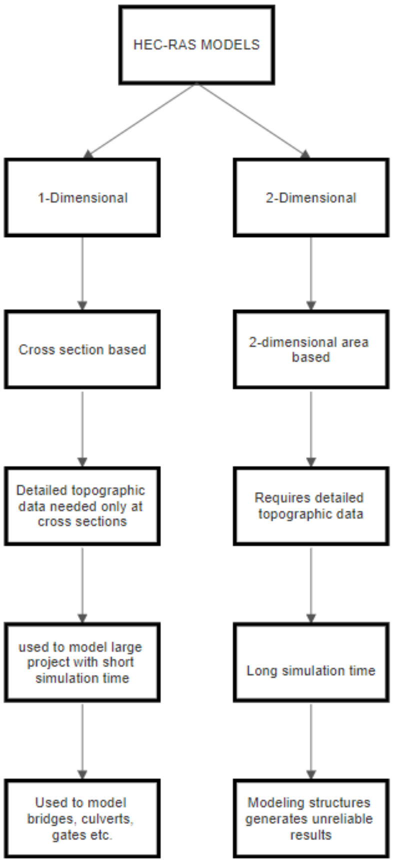


Figure 1. Flowchart of 1D and 2D HEC-RAS Models Potentials and Limitations.

RESEARCH DOMAIN

Figure 2 presents the location of Farka stream. In this study Farka stream is divided into three segments that are used as checking points to compare the results of unsteady flow simulation of each corresponding model. Topographic data required for modeling were obtained from topographic measurement of the area done by MANETCI Company and reference system used was WGS 1984/UTM zone 34. Besides HEC RAS software, ARC-GIS was used to generate 3-dimensional terrain model.

Furthermore, the same boundary conditions were used to perform 1D and 2D unsteady flow analysis. Flow Hydrograph and Normal Depth were used respectively as upstream and downstream boundary conditions. Also, the data from 1 in 100-year repetition flow hydrograph generated from hydrological analysis of the study area, performed by other researchers, was used as an input in HEC RAS hydraulic modeling, to perform unsteady flow analysis.

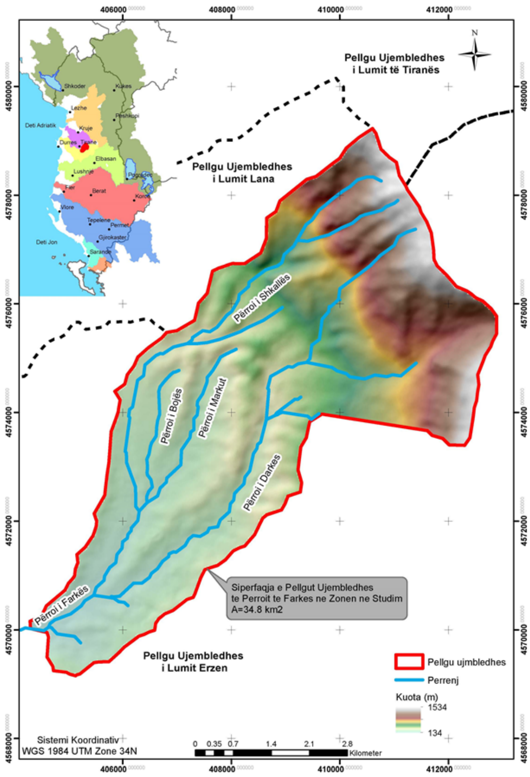
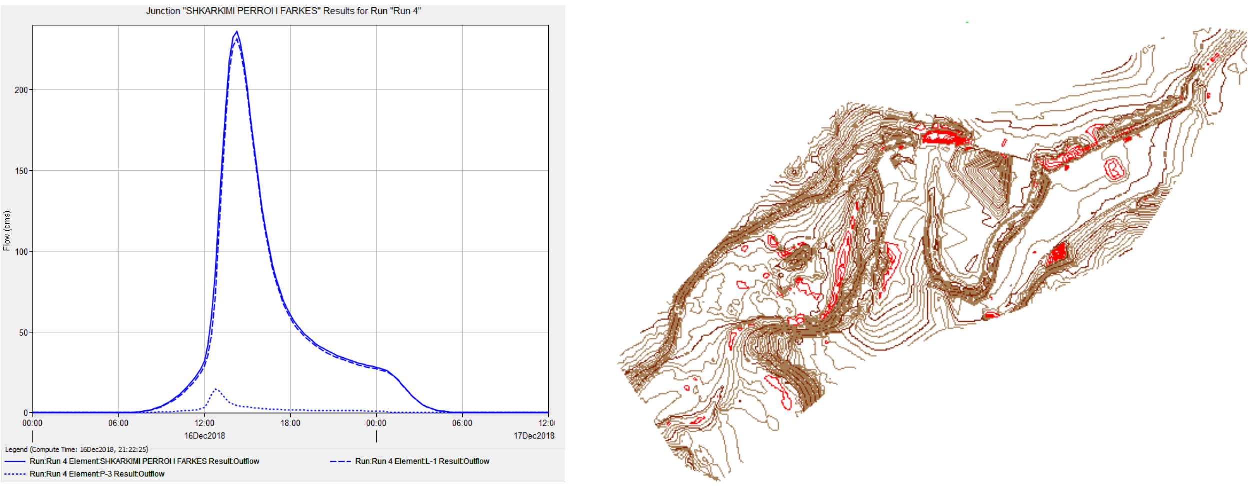


Figure 2. Location of the Case Study, Farka Stream



(a)

(b)

Figure 3. (a) Hydrograph of Farka Stream, 1 time in 100-year repetition, Q=236m^3/s, (b) Topographical Data of Area Under Study, Farka Stream

METHODOLOGY

Different procedures were followed do develop 1-dimensional and 2-dimensional models. As 1-dimensional model is more cross section-oriented modeling approach, attention was paid to cross section implementation also, junctions along the stream were carefully defined. Meanwhile, to set up 2-dimensional model, 2D flow are was developed. After specifying upstream, downstream boundary conditions the simulation of unsteady flow was performed and results related to water depth planimetry, flow hydrographs were obtained for both models. In this way the accuracy of each models and their capability could be rated.

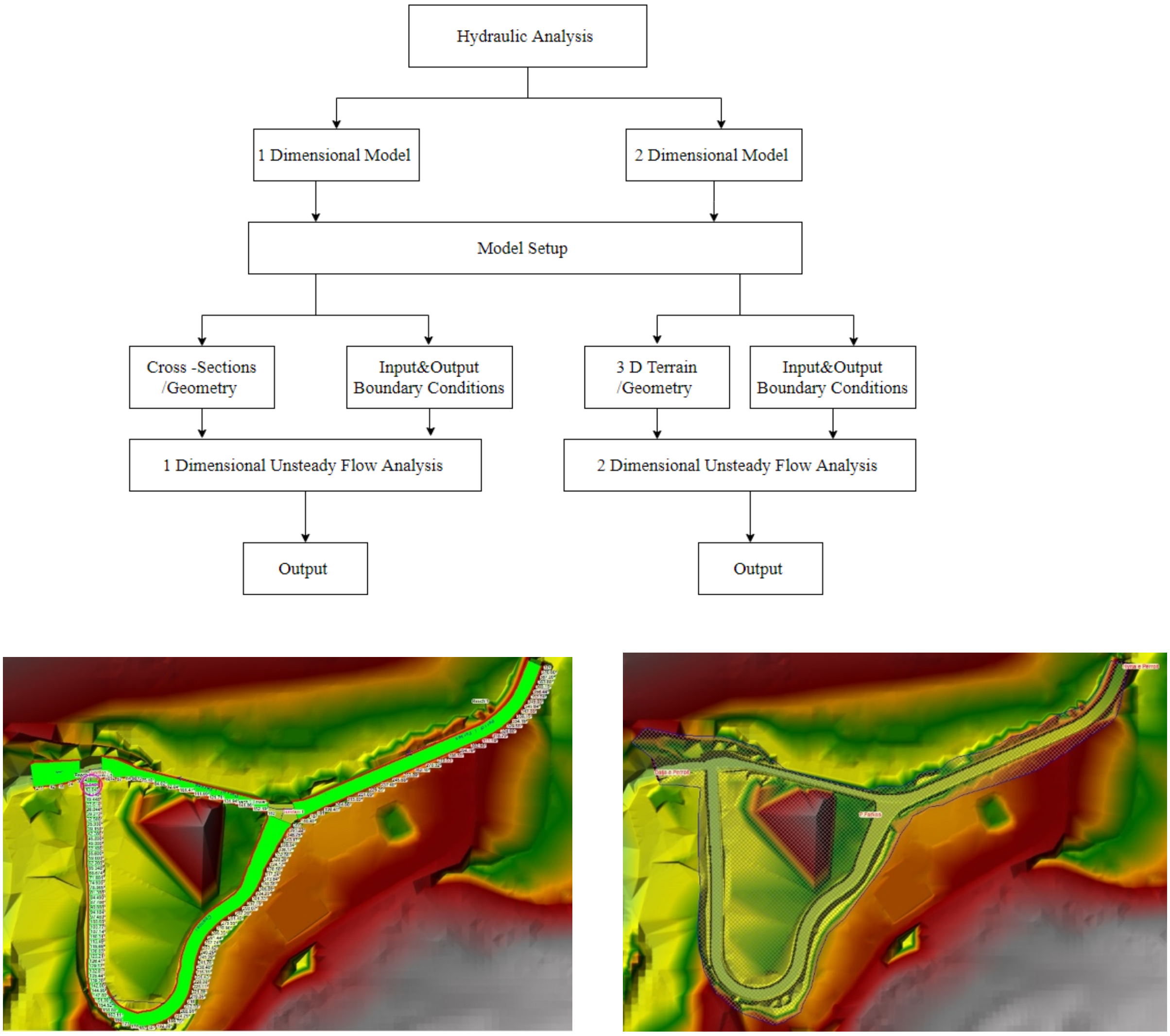


Figure 4. (a) Flowchart of Hydraulic Analysis of Modeling Approach Using HEC-RAS 5.0.7, (b) 1D Model Setup, Cross Sections, Junctions, (c) 2D Model

RESULTS AND ANALYSIS

In order to study whether the flow inundated the rehabilitated channel for both models and also to interpret flow distribution on junctions for 1-dimensional model and flow distribution along stream for 2-dimensional model, it was important to carefully interpret the results obtained from the simulations. Water depth planimetry represented the distribution of water into the channel and the areas nearby it and visualizes if the water inundated the area or not.

Moreover, three segments were defined on each corresponding part of the stream and for each segment there were obtained results corresponding to flow capacity.

The simulation is developed based on maximum water flow 240m^3/s which occurs 1 in 100 years, generated from the hydrological study.

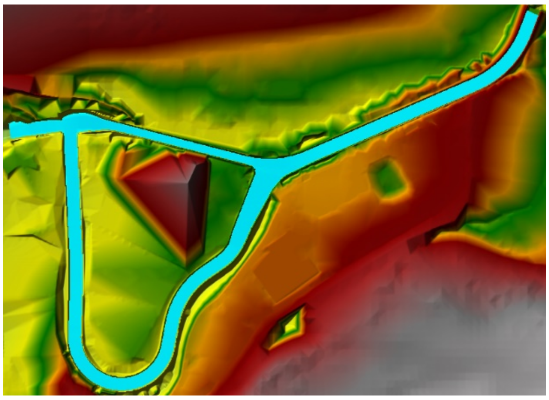


Figure 5. Water Depth Planimetry, 1-Dimensional Model

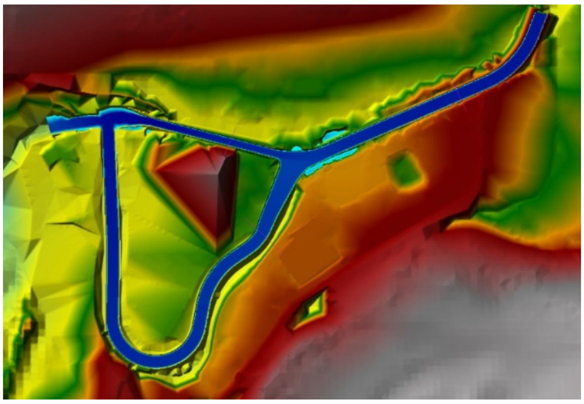


Figure 6. Water Depth Planimetry, 2-Dimensional Model

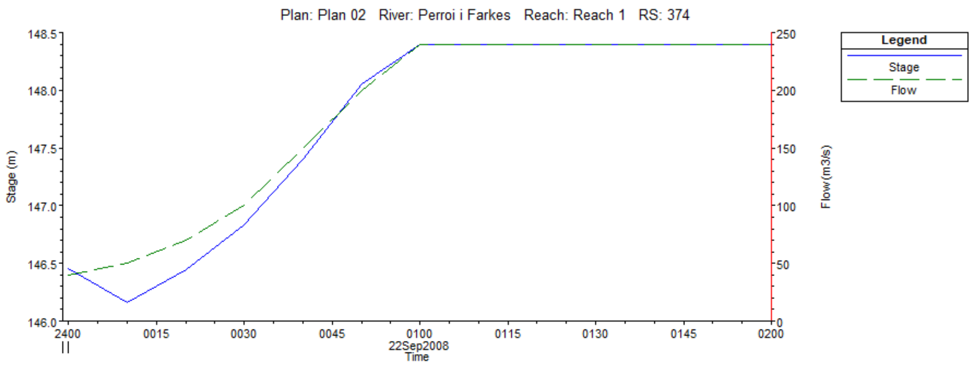


Figure 7. Stage & Flow Hydrograph, Q=240m^3/s, Section 1, 1-Dimensional Model

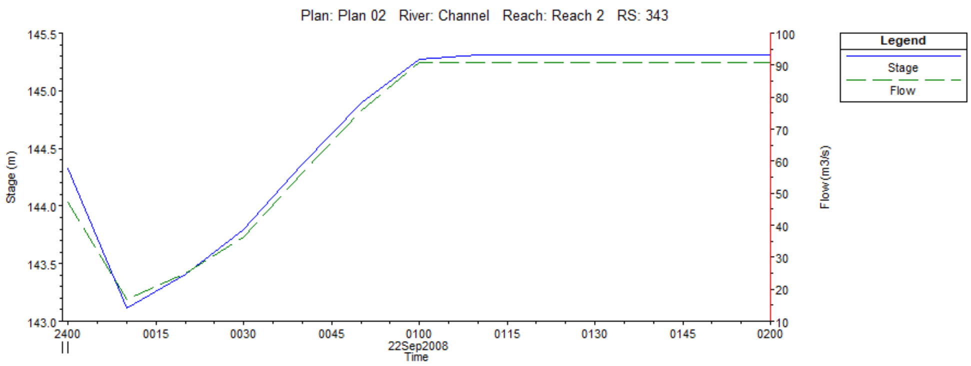


Figure 8. Stage & Flow Hydrograph, Q=90.91m^3/s, Section 2, 1-Dimensional Model

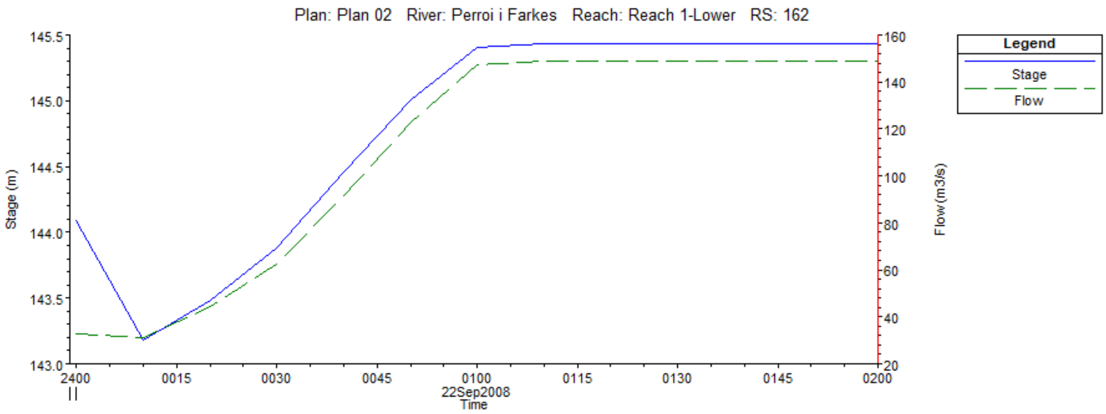


Figure 9. Stage & Flow Hydrograph, Q=149.09m³/s, Section 3, 1-Dimensional Model

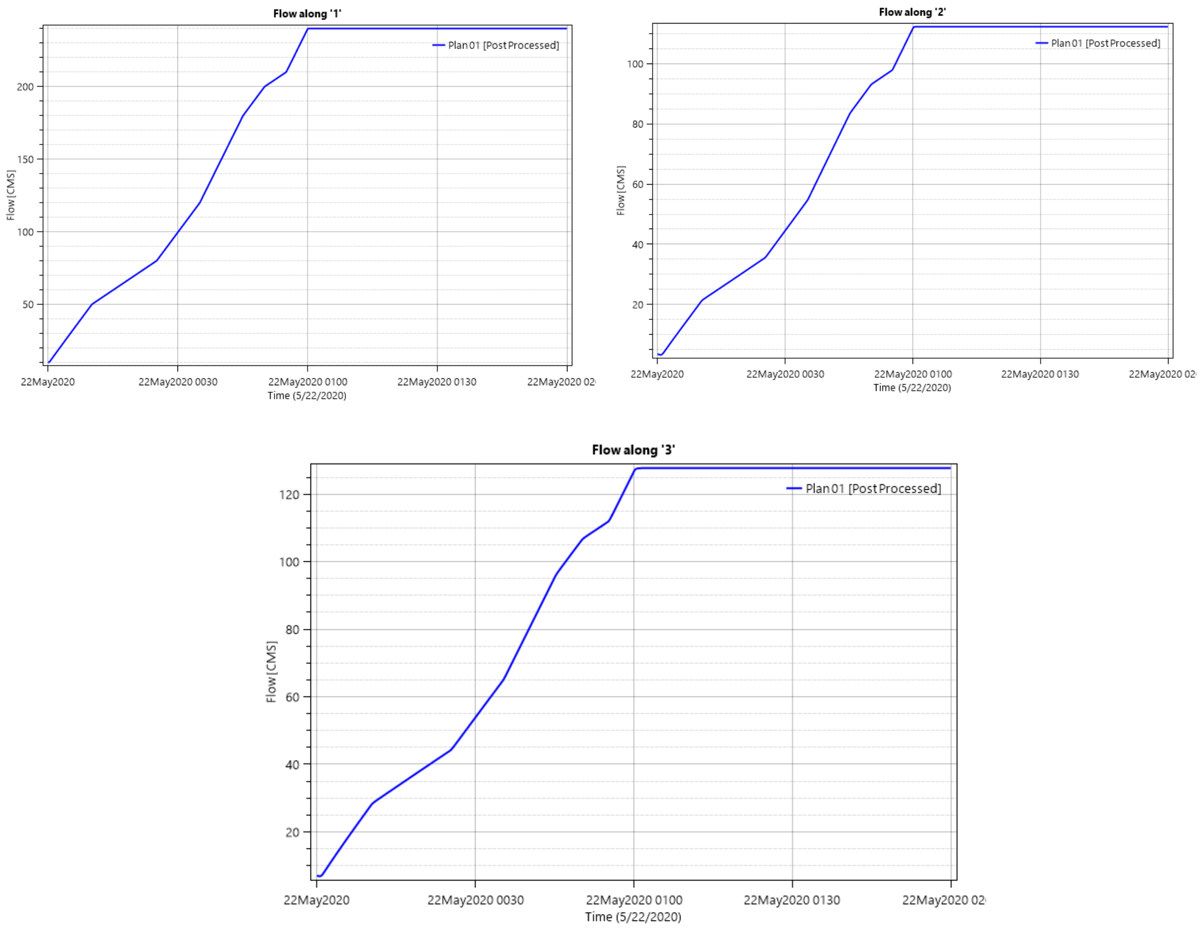


Figure 10. Flow Along Section 1 Q=240 m³/s, Section 2 Q=112.3 m³/s, Section 3 Q=127.7 m³/s, Variant 1

The result generated from 1-dimensional model, (Figure 5), is similar to water depth planimetry received from 2-dimensional model, (Figure 6). In both cases, the area, under the specified conditions is not inundated.

Continuing with, Flow Hydrograph, (Figure 7), (Figure 8), and Figure 9 (Figure 9), the primary water stream known as 'Reach1', (Figure 7), corresponding to segment 1 has a discharge of Q=240 m³/s, maximum discharge. This segment is reconstructed with a rectangular cross section BXH=8x3m. This segment ends into a split junction that reorganizes water flow into, 'Reach 2' corresponding to segment 2,

(Figure 8), and 'Reach 1-Lower'corresponding to segment 3, (Figure 9), where the flow distribution is Q=90.91m^3/s and Q=149.09m^3/s respectively. Even thought, segment 2 has the same cross section as segment 1 the flow will not be the same in both of them. Segment 3, where a culvert of dimensions BxH=5x3m, will provide a stream with optimal conditions for the water to flow there.

Considering flow hydrograph of 2D model, (Figure 10), the primary water stream corresponding to segment 1 has a discharge of Q=240 m^3/s, maximum discharge, segment 2 and segment 3 the flow distribution is Q=127.7m^3/s and Q=112.3m^3/s respectively. Even thought, segment 2 has the same cross section as segment 1 the flow will not be the same in both of them. Segment 3, where a culvert of dimensions BxH=5x3m, will provide a stream with optimal conditions for the water to flow there. In all three segments water flow does not overcome the limits of each segment.

Water flow distribution, in both models (Figure 7-10) is not as consistent. Comparing both models, segment 2 and 3 differs with ± 21.39 m^3/s flow capacity.

CONCLUSION

In the presented thesis, hydraulic analysis was provided to perform a comparison of 1-dimensional and 2-dimensional flood models. Unsteady flow analysis was simulated under the same boundary conditions for both 1-dimensional and 2-dimensional models. These two models were compared to each other, in terms of water distribution along stream in order to define their capability and accuracy.

Moreover, results obtained from 1-dimensional model, did not align with results obtained from 2-dimensional model. Two modeling approaches showed that, under the same boundary conditions, the proposed rehabilitation case offered valid conditions to prevent flooding of the area around, Farka stream. But, on the other hand, the flow distribution along streams changed for both models.

1-Dimensoional and 2-dimensional HEC-RAS models, can both be efficiently used for flood mitigation. However, selection of appropriate model strongly depends on project aim. Further studies are required to be conducted in order to clearly define project characteristic linking it to the most realistic modeling approach.

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