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Team 02: Online Phase

HYDROEUROPE

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HydroEurope

WP2: Uncertainty in Advanced Hydrological and Hydraulic Modelling
WP3: Climate Change Impacts on Flash Floods
WP4: Accidental Water Pollution
Case Study: Tervuren-Belgium

Team02: Report Online Phase:
Modelling and Analysis of Tervuren Catchment

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1. Tervuren Catchment

1.1 Area

Tervuren, Belgium, is located approximately 11 km from the Royal Meteorological Institute (RMI) in Ukkel. The area covers approximately 8.7 km², with an elevation ranging from 52 to 121 m above sea level. The dominant land cover consists of grass and shrubs (36%), paved and built-up areas (32%), trees (20%), and crops (11%), while the prevailing soil type is loam. The region receives an average annual rainfall of 780 mm, with a potential evapotranspiration of 657 mm.

Figure 1. Location map of the study area (***https://hydroeurope.upc.edu/tervuren-catchment/*** ***)***

1.2 Meteorological Data

The climate is classified as temperate, with mean seasonal temperatures of 14°C in summer and 5°C in winter (Chormanski et al., 2008; Helmi et al., 2019). One of the recurring challenges in Tervuren is localized pluvial flooding, which affects residents. A potential mitigation strategy involves the implementation of Low Impact Development (LID) practices for stormwater management (Smitz, 2021).

1.3 Flood Event

One significant flood event in Tervuren occurred in 2005, when severe storms led to traffic disruptions and widespread issues across various streets. To mitigate and prevent such events, Nature-Based Solutions (NbS) can be implemented to improve water quality and reduce flood risk. Effective implementation requires the use of Hydrologic and Hydrodynamic (H&H) models, along with a LID locator tool to identify suitable locations for porous pavements and green roofs.

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2. Hydrological Model Development

The development of a hydrological model for the study area requires several key datasets and pre-processing steps. The Digital Elevation Model (DEM) is an important dataset but requires further processing to account for culverts and diversions, ensuring the accurate representation of river geometry. Land cover classification, based on ESA data, reflects variations in soil types within the catchment and necessitates reclassification for improved accuracy. The soil map provides information on hydrological soil groups, highlighting variations in runoff potential across the area. Hydrological parameters, including rainfall and discharge, are analysed using sub-flow filtering with WETSPRO, while the Peak-Over-Threshold (POT) method is employed for extreme value analysis. Additionally, Intensity-Duration-Frequency (IDF) curves are used to assess the statistical distribution of extreme rainfall events.

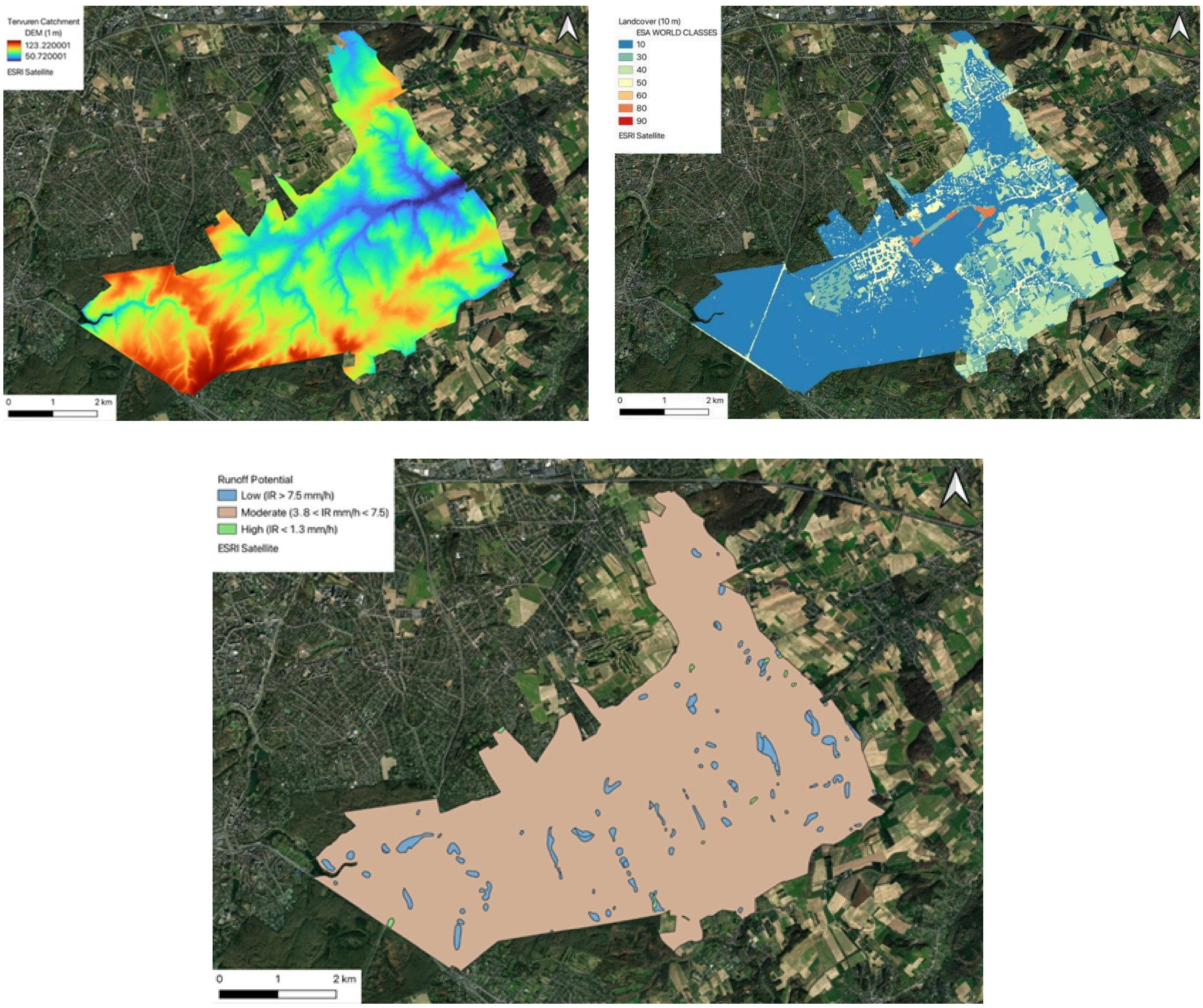

Figure 2,3 and 4. Maps representing DEM, Land cover and soil type, respectively.

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The hydrodynamic model was developed using HEC-RAS, incorporating a hydrograph input to define the variation of flow rates over time at the upstream boundary. The normal depth condition was applied at the downstream boundary, where the riverbed's longitudinal profile was analysed to determine the slope. The extracted slope was then incorporated into the model as the assumed energy slope to ensure accurate flow simulations.

The hydrological parameters considered in the analysis include rainfall and discharge. Sub-flow components were filtered using WETSPRO to refine the dataset for further evaluation. The Peak-Over-Threshold (POT) method was employed to identify significant discharge events, facilitating extreme value analysis. Additionally, IDF curves were used to assess the statistical distribution of extreme rainfall events and their potential impact on the hydrological system.

3. Building the model and Results with analysis

3.1 Model Calibration

Model calibration involved refining the riverbed elevation to improve accuracy in hydrodynamic simulations. The initial assumption set the bed elevation equal to the water surface derived from the elevation model. Calibration was based on a two-year return period storm, corresponding to the bankfull discharge and stage. If the riverbed elevation was over- or underestimated, adjustments were made accordingly. Validation was conducted to assess discrepancies, with initial results indicating an overestimation. To address this, a correction factor of 8.5 meters was applied to accurately adjust the elevation and improve model performance.

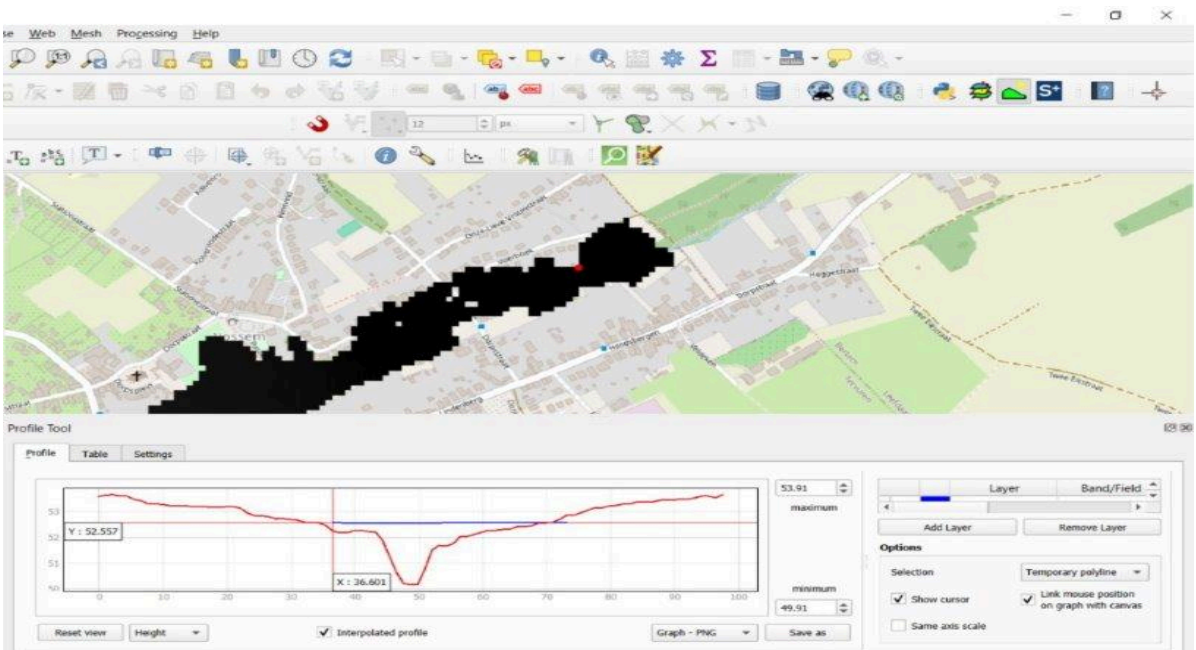

Figure 5 : Overestimated bankfull elevation

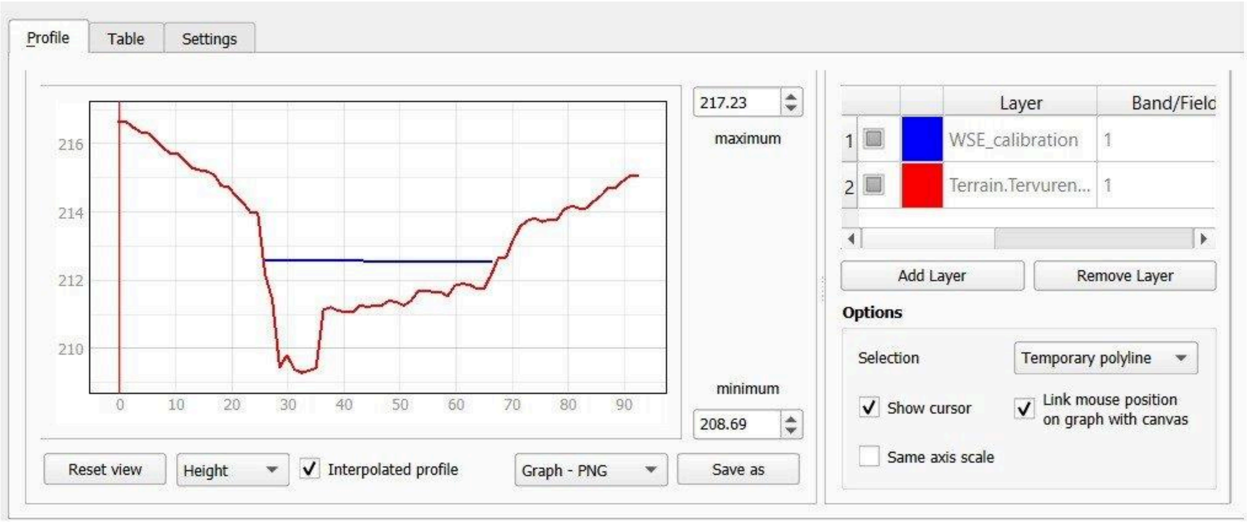

Figure 6: Overestimated bankfull elevation

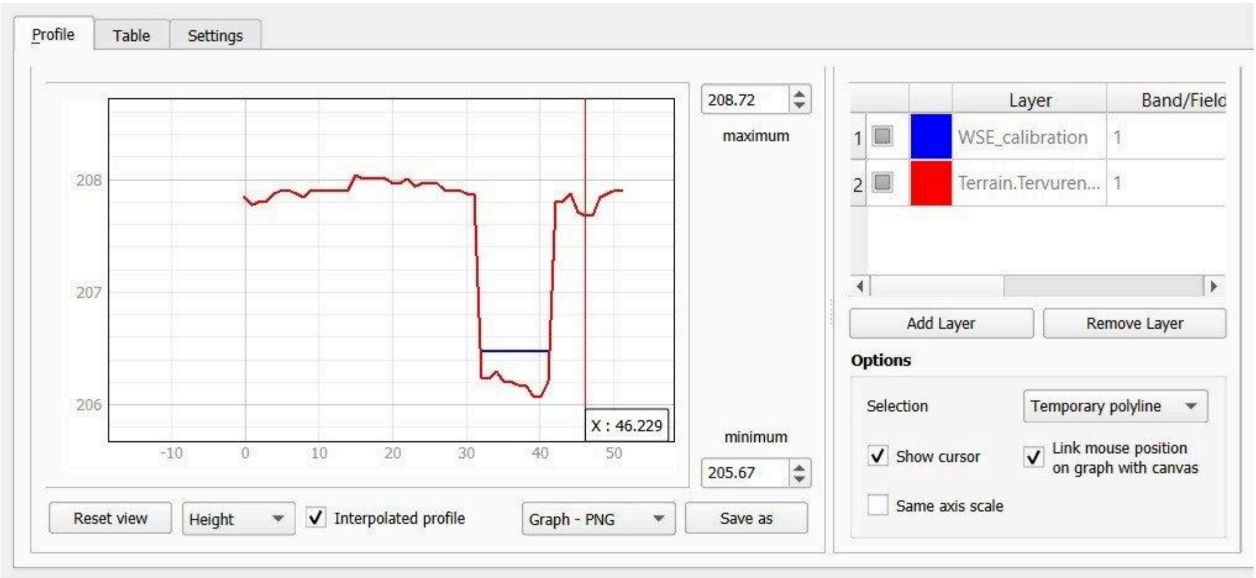

Figure 7 : Underestimated bankfull elevation

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Figure 8 : Corrected bankfull elevation

Figure 5 illustrates the overestimated bankfull elevation within the catchment. Figures 6 and 7 depict river cross-sections from the initial two-year return period simulation before calibration. The results indicate that, in Figure 6, the water elevation exceeded the bankfull elevation, suggesting an overestimation of the riverbed level. Figure 8 presents the corrected bankfull elevation after calibration, demonstrating the adjustments made to improve the model's accuracy.

3.2 Building HEC-RAS Model

The HEC-RAS model was developed with a hydrograph input to define the variation in flow rates over time at the upstream boundary, ensuring an accurate representation of hydrological conditions. At the downstream boundary, the normal depth condition was applied, with the riverbed's longitudinal profile used to determine the slope. The extracted slope was then incorporated as the energy slope assumption in the model, contributing to a more precise simulation of flow dynamics.

3.3 Scenarios

3.3.1 First scenario

The initial simulation of flooding for a two-year return period rainfall event indicated no instances of overbank flooding. However, results varied when analysing different return periods, highlighting the influence of rainfall intensity on flood dynamics. The simulation was conducted with a time step of 30 seconds to ensure accurate representation of hydrological and hydraulic processes.

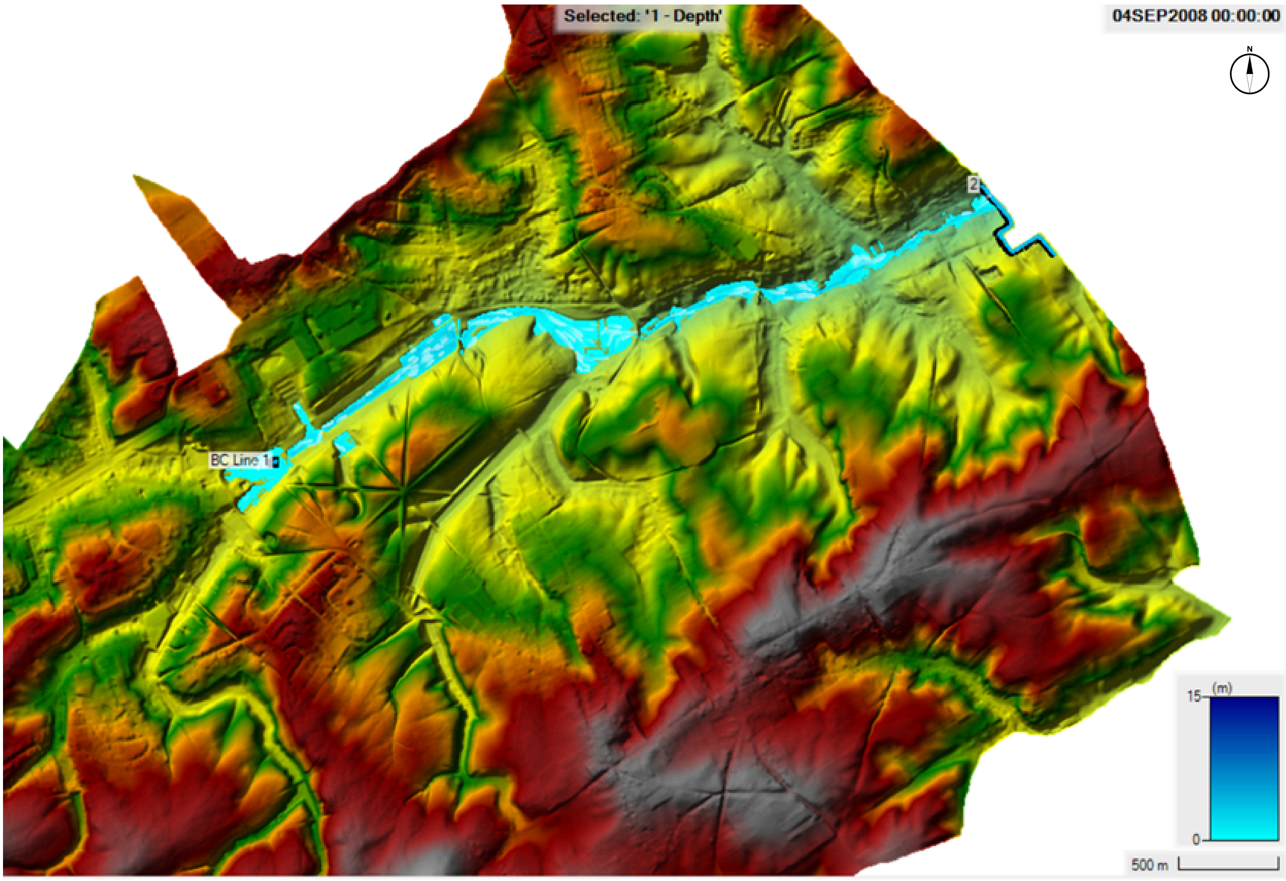

Figure 9. Resulted map for the first scenario

3.3.2 Second Scenario

In our second scenario, the flood model was applied and tested under a five year return period rainfall event. Compared to the two-year return period, the results indicate a noticeable increase in water spread and flood depth, suggesting that higher rainfall intensities contribute to greater flood risks. While certain areas remain unaffected, low-lying regions near the riverbanks experience more overbank flooding, highlighting the system's vulnerability to extreme weather conditions. The simulation was again conducted with a 30 second step, ensuring consistency in hydrological and hydraulic process representation.

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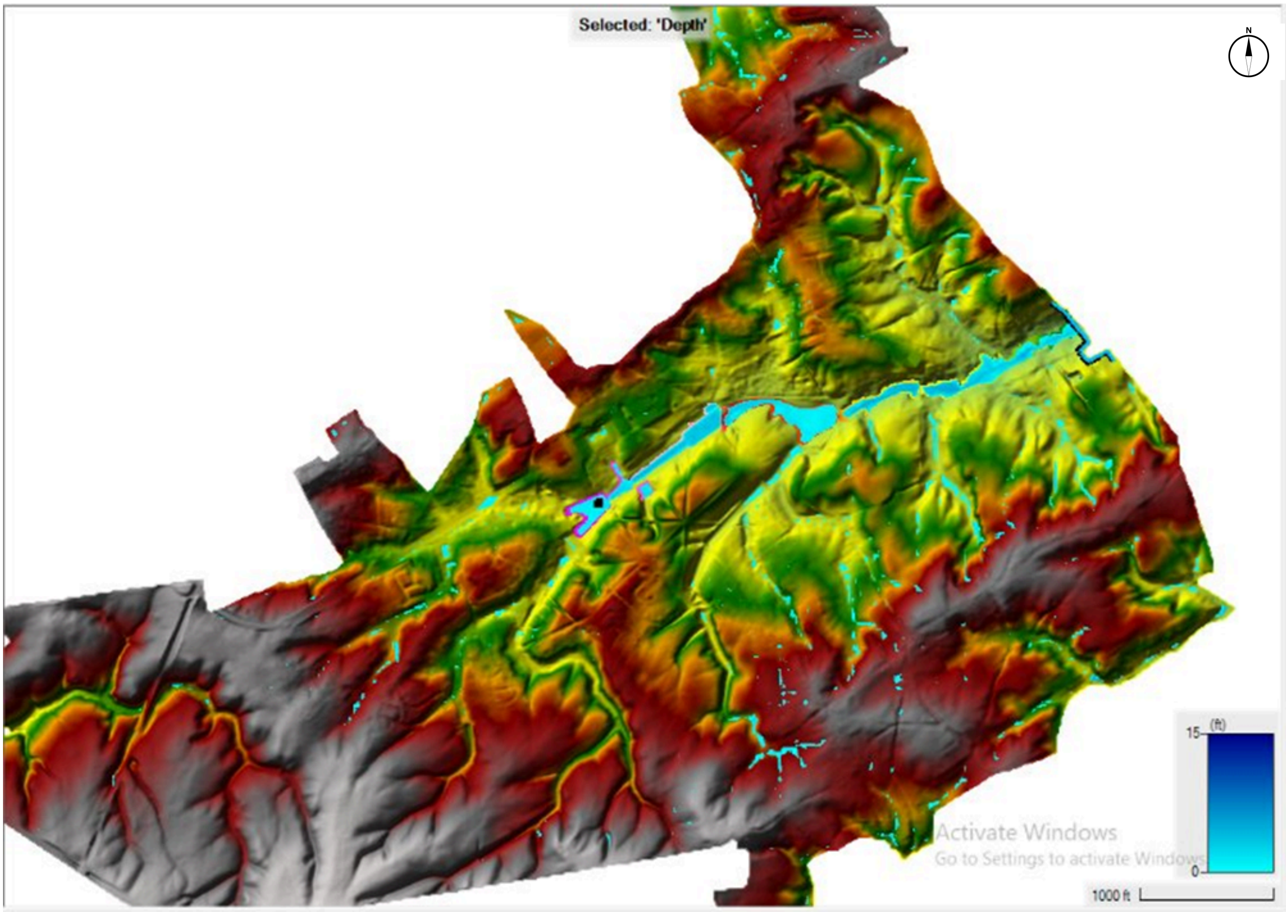

Figure 10. Resulted map for the second scenario

3.3.3 Third scenario

In this third scenario, the flood model was simulated for a 50 year return period rainfall event, representing a much more extreme rainfall intensity. Compared to the 2-year and 5-year return periods, the results show a significant increase in flood extent and depth, with wider overbank flooding and greater water spread into surrounding areas. The results showed that areas that remained dry in previous scenarios are now partially or fully covered by water, demonstrating the increased sensitivity of the region under extreme climate conditions. The simulation was conducted with the same 30 second time step, ensuring consistency in model accuracy.

By comparing those scenarios, we can notice the importance of flood risk assessment and the need for proper mitigation strategies to manage extreme flood events caused by climate change and this is one of the tasks we are planning to do here during our stay in Barcelona.

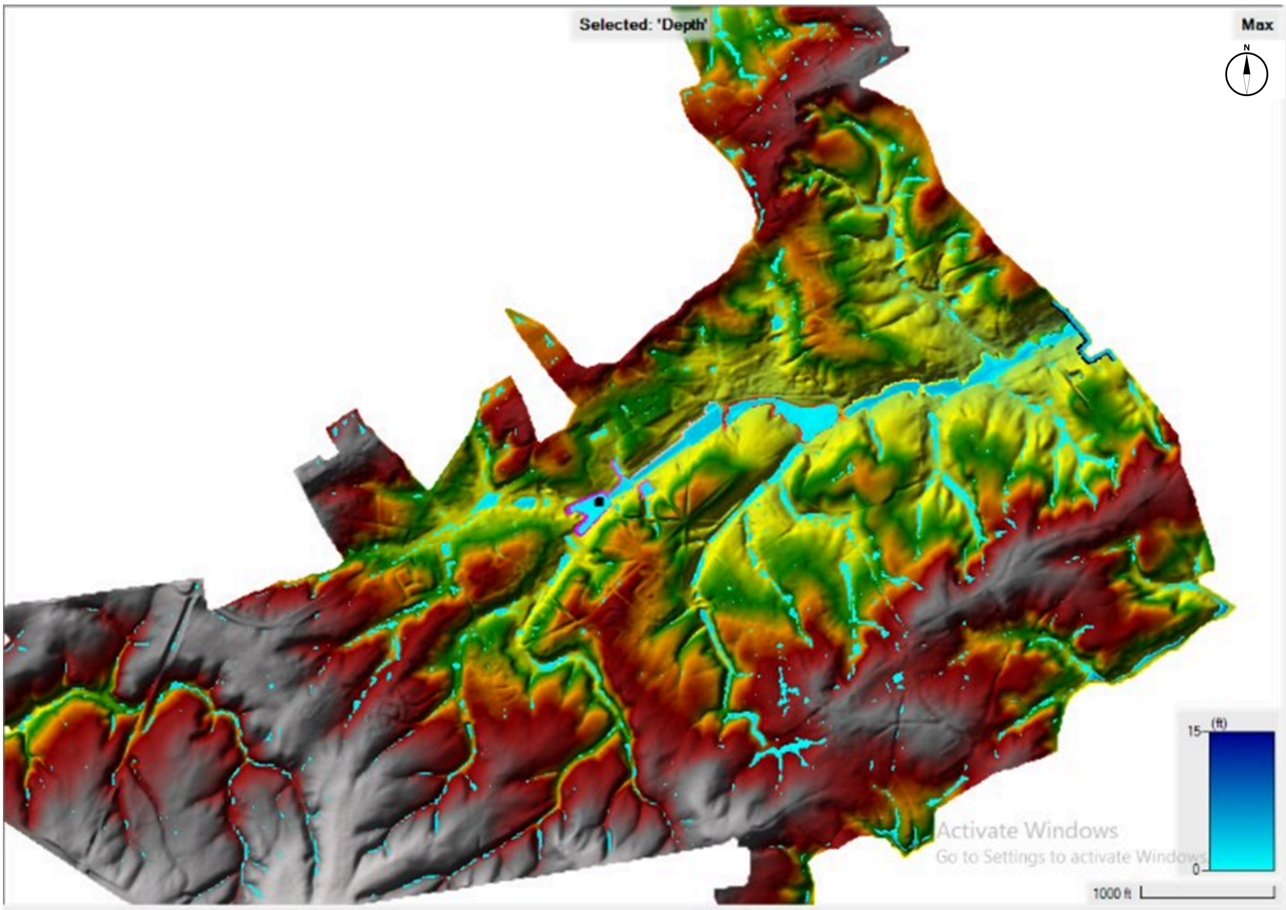

Figure 11. Resulted map for the third scenario

4. The Challenges and Difficulties

Throughout the building and execution of our flood simulation model, we faced multiple challenges that required problem-solving and adaptation. Each team member encountered technical difficulties related to data quality, model calibration, and computational constraints. Some of these issues were due to inconsistencies in data, while others stemmed from software compatibility and the complexity of the simulation itself. Addressing these challenges was crucial to ensuring accurate and reliable results. Below are some of the key obstacles we encountered:

- **Data Limitations:** One of the primary challenges was the incomplete or inconsistent meteorological and hydrological data, which affected the accuracy of the input parameters for the model.
- **Digital Elevation Model (DEM) Issues:** The DEM required preprocessing and modifications due to the absence of culverts and diversions, which are essential for accurate floodplain modeling.
- **Soil Type Variability:** The variation in soil types across the study area necessitated reclassification and adjustments to improve the accuracy of infiltration and runoff calculations.

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- **Model Calibration Difficulties:** Initially, the model **overestimated water surface elevations**, requiring adjustments to properly define the **bankfull elevation**. Additionally, integrating correction files into the DEM posed technical difficulties.
- **Technical and Computational Constraints:** The **high-resolution input data** led to increased processing times and computational limitations, making simulations **long and resource-intensive**. This was especially challenging when dealing with extreme weather event simulations, which required more complex processing and longer runtimes.

With all these challenges, the team worked collaboratively to troubleshoot issues, refine the model, and improve its accuracy, ensuring that the final results provided meaningful insights into flood behavior under different rainfall scenarios.

5. Next Steps in our Project During our Stay

As we continue our work here in Barcelona, our focus will be on deepening our analysis and refining our flood simulation model. The next steps in our project will involve:

1. **Analyzing the Impact of Climate Change on Increased Flooding**: We will evaluate how climate change is influencing flood patterns by assessing variations in rainfall intensity, frequency, and distribution.
2. **Assessing the Effectiveness of Climate Adaptation Solutions in Mitigating Flooding.**
    - We will explore different flood adaptation strategies, such as nature-based solutions.
    - The effectiveness of these measures will be tested using our hydrological model to determine their impact on reducing flood risks under various climate scenarios.

3. Also, in the next phase of our project we will try to focus on refining the flood simulation model to enhance accuracy and reliability. This includes fixing technical errors encountered in the first phase, improving the DEM by integrating more precise elevation corrections, further calibrating the model to reduce overestimation and underestimation errors, and optimizing riverbed slope assumptions for better downstream flood modeling. These improvements will ensure a more accurate assessment of flood risks and the effectiveness of climate adaptation solutions.Bottom of FormTop of Form

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