

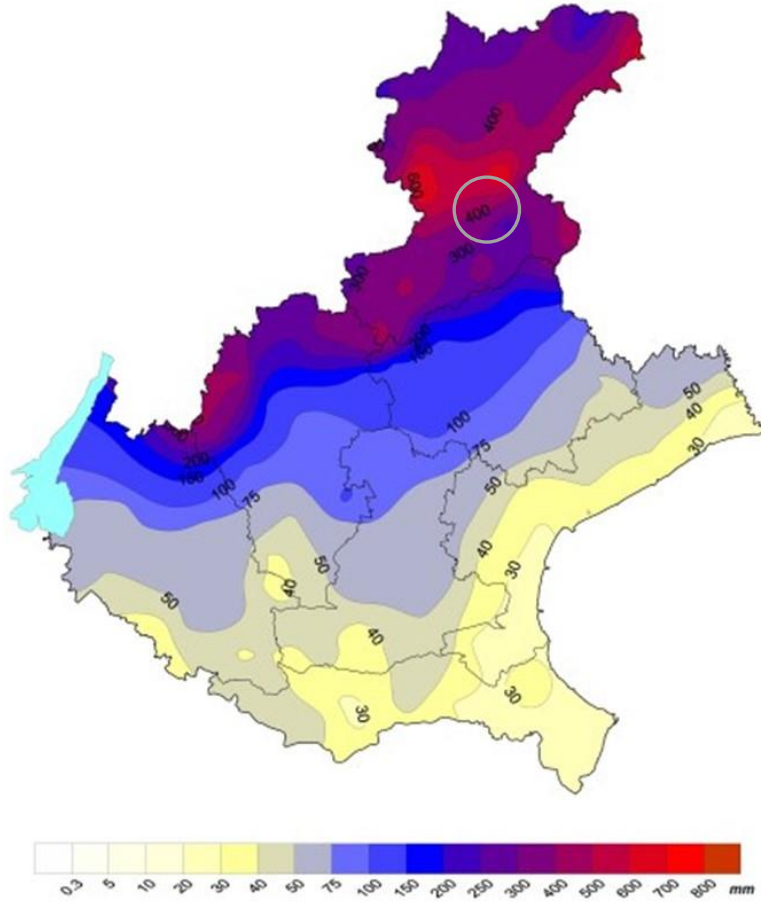


Morphodynamical 2D modeling to support the design of interventions for the mitigation of hydrogeological risk

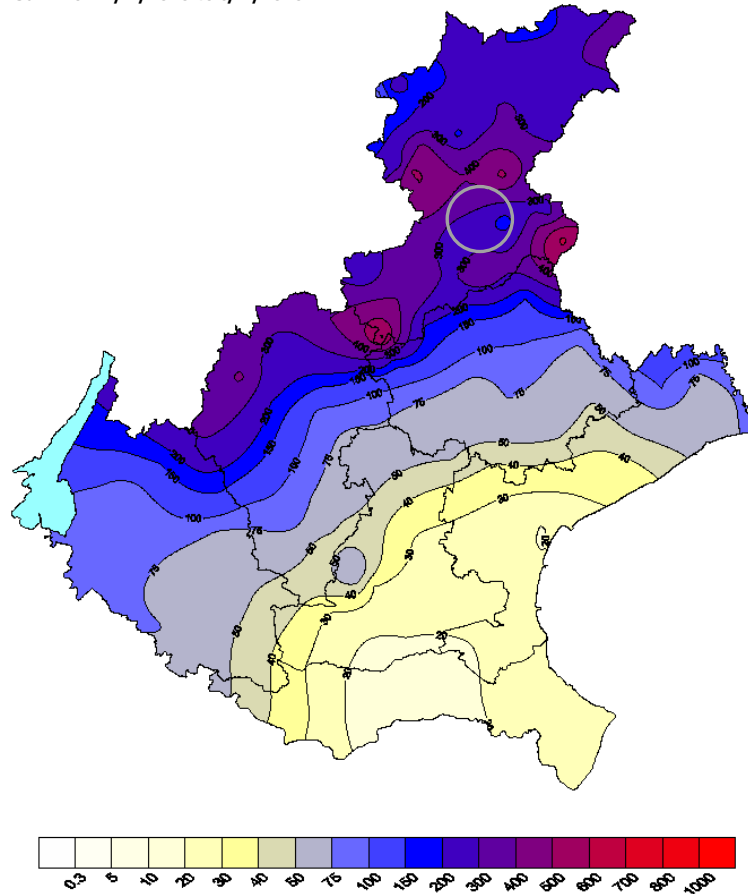
Cordevole River
Ponte Mas (BL-Italy)

Gaspare Andreella | Marika Righetto
BASEMENT users meeting 2021

DAILY PRECIPITATION
Sum from 4/12/2020 to 6/12/2020



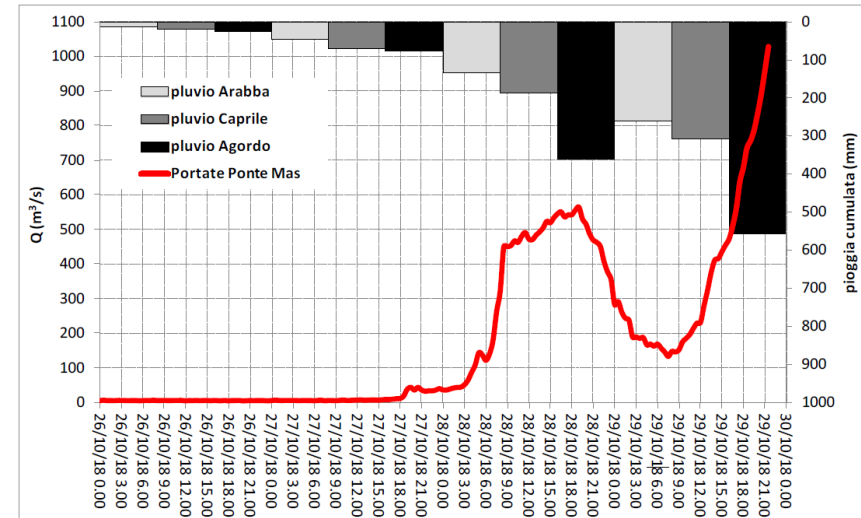
28-30 October 2018






4-6 December 2020

Spazializzazione con Kriging senza nessun aggiustamento per quota/esposizione.
Mappa elaborata il 10/12/2020 10:42 solari






BACKGROUND INFORMATION

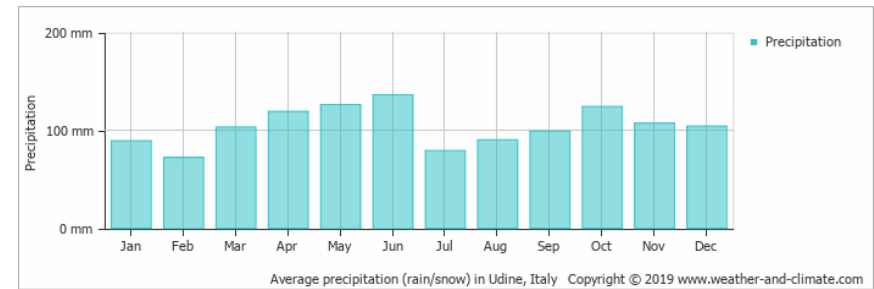
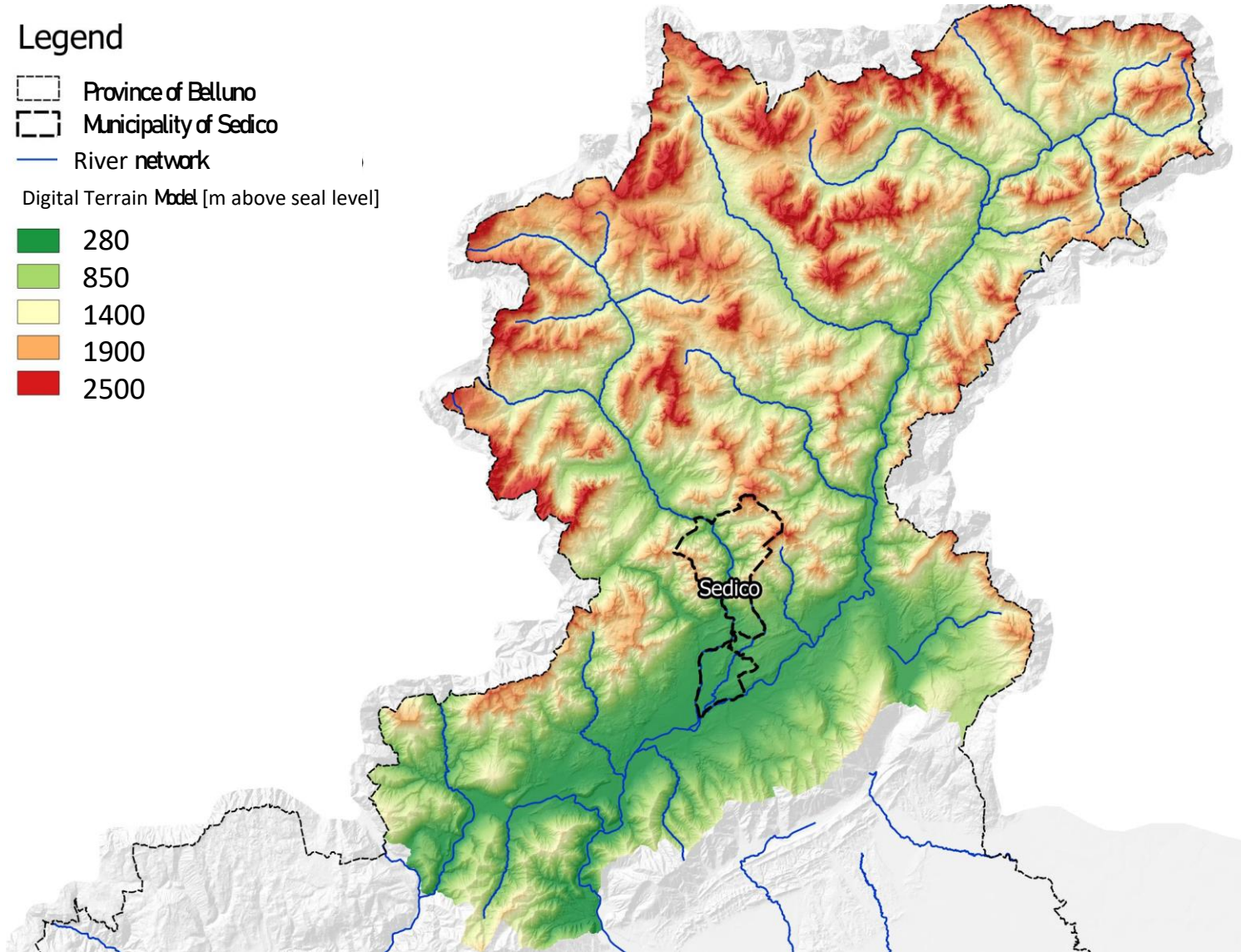


Legend

-  Province of Belluno
-  Municipality of Sedico
-  River network

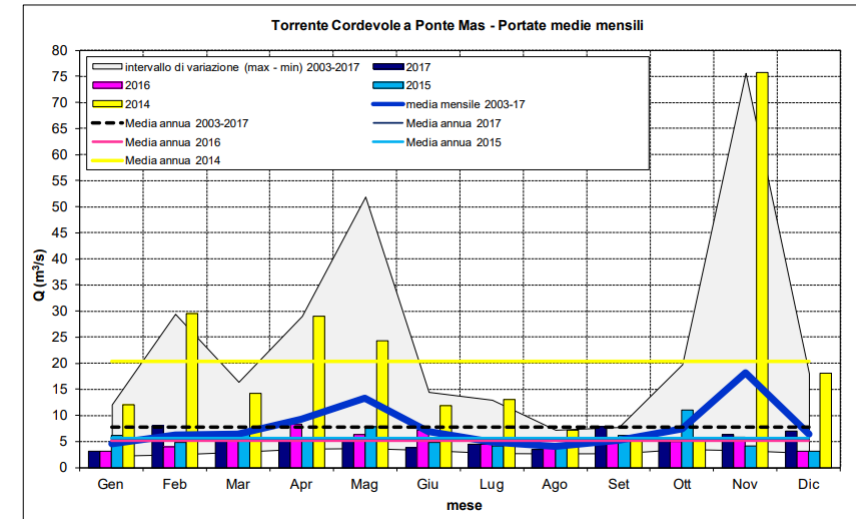
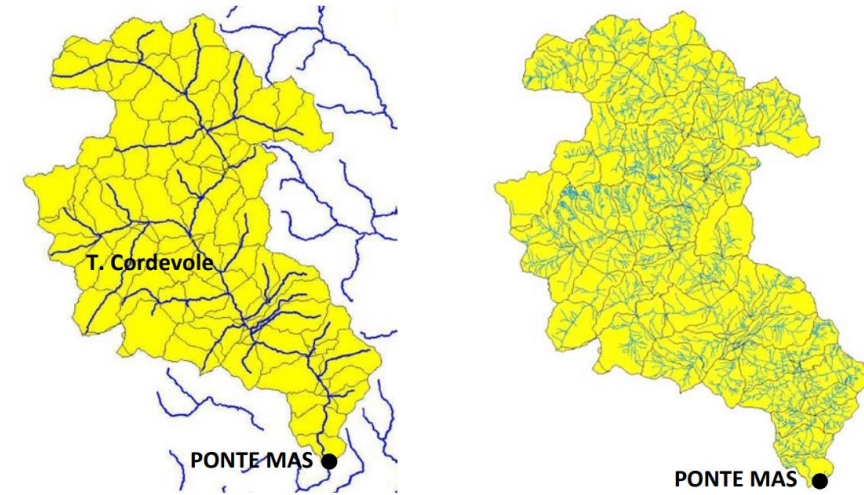
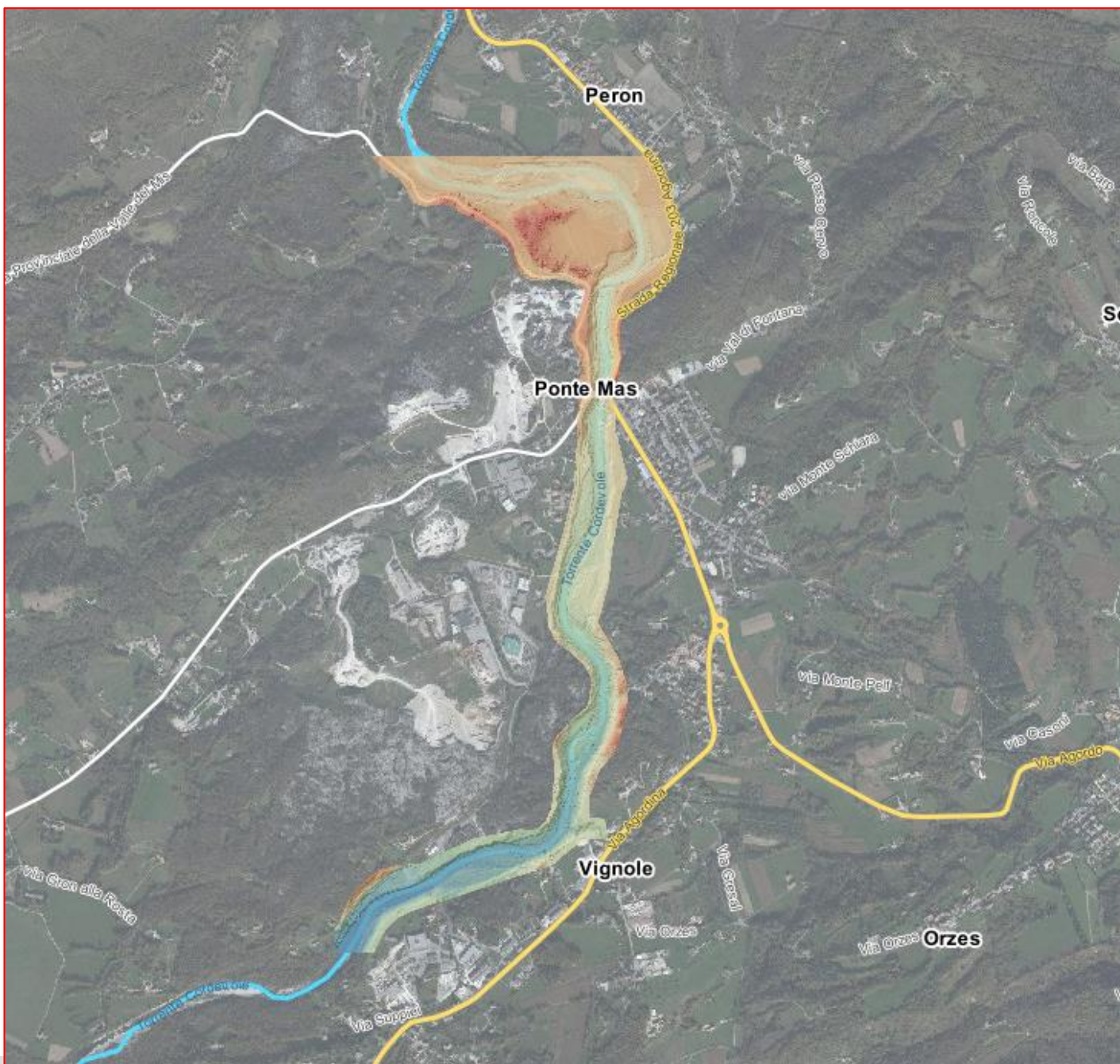
Digital Terrain Model [m above seal level]

-  280
-  850
-  1400
-  1900
-  2500



Average annual precipitation = 900 - 1000mm per year

BACKGROUND INFORMATION



Annual average discharge = 20m³/s

ARPAV - 2019

November 1966: the left bank of the river eroded deeply causing the collapse of buildings and roads.

1970's Retaining wall constructed

1990's Basin authority and Universities - first studies and models

VAIA (October 2018): deep erosion on the left bank causing the failure of the above retaining wall and the consequent collapse of buildings and roads.

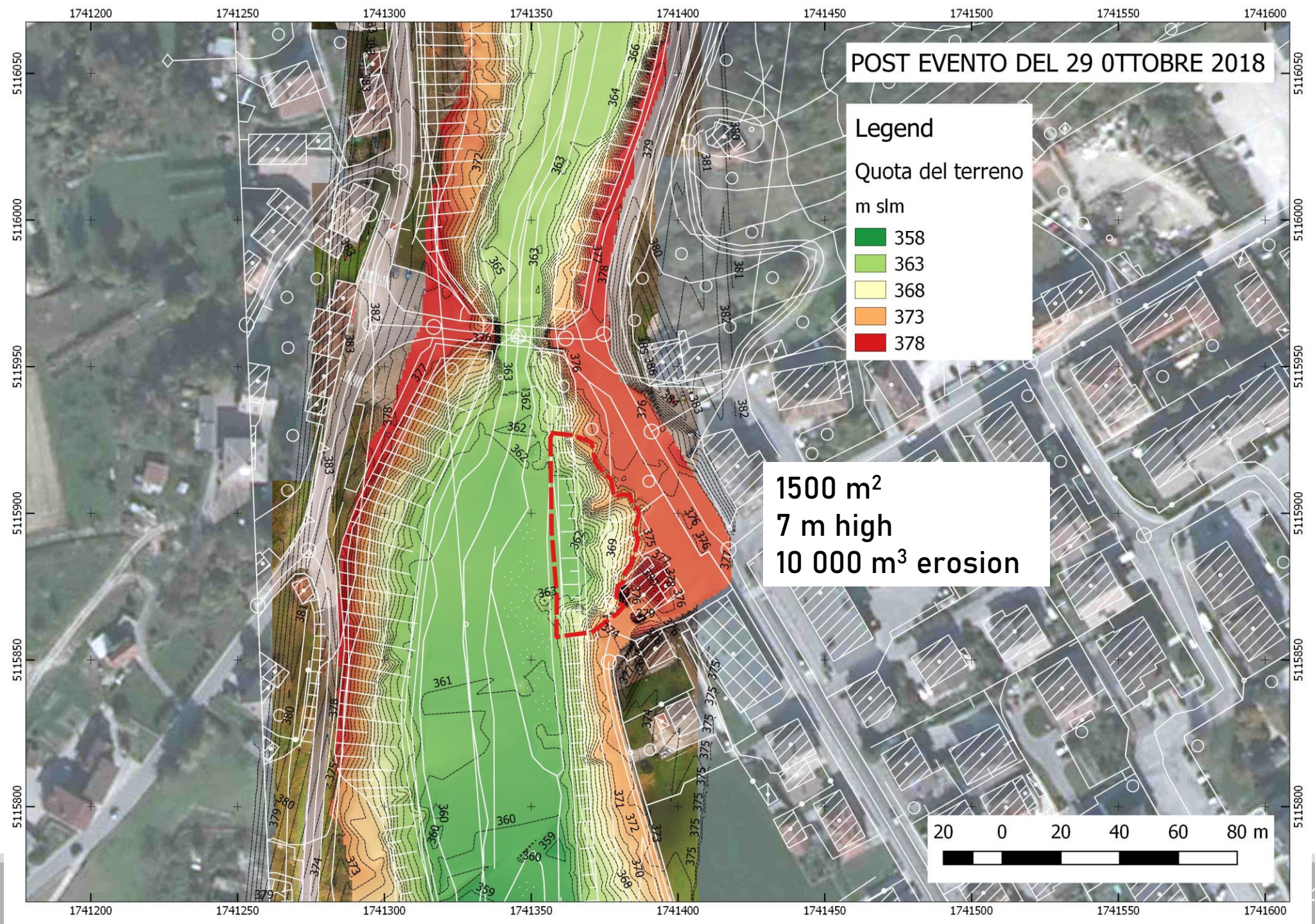
2019: Design and construction of flood protection

4-6 December 2020: partial collapse of the riprap

2021: New works began







POST EVENTO DEL 29 OTTOBRE 2018

Legend

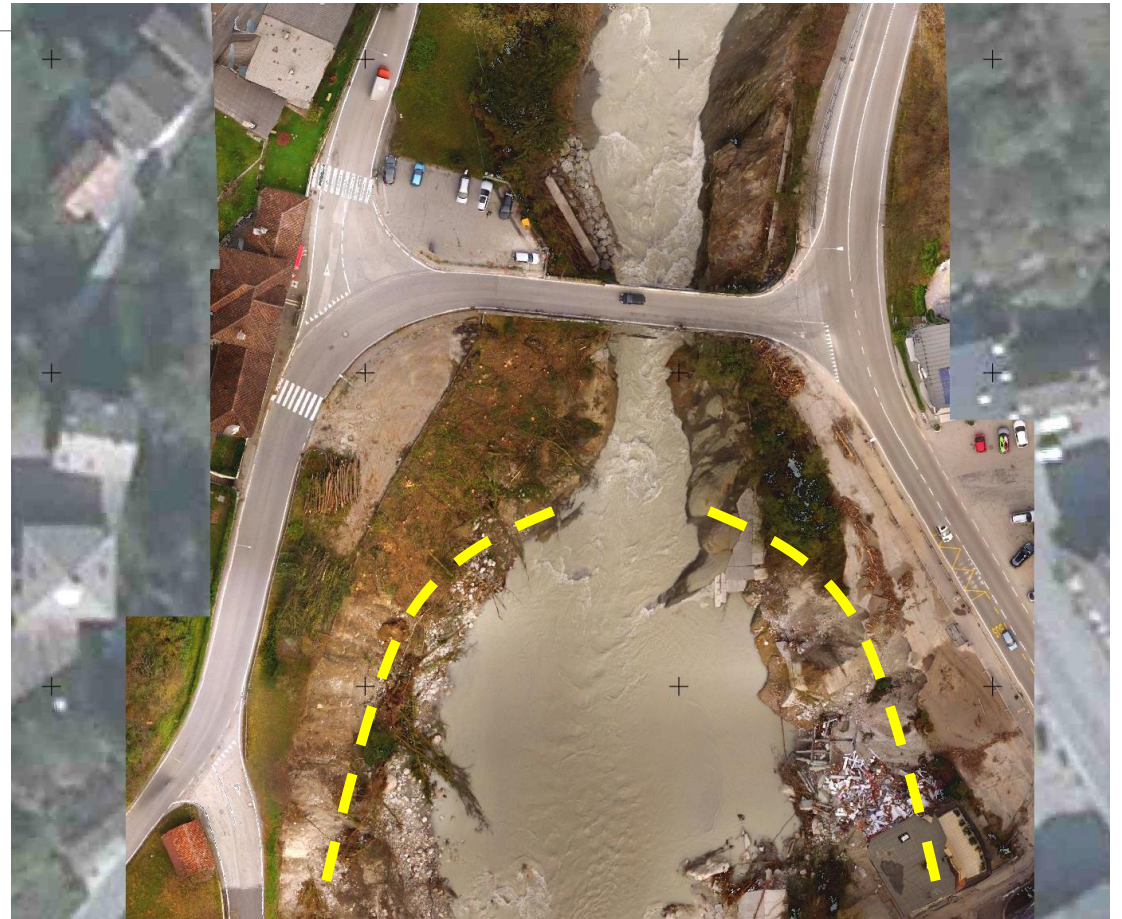
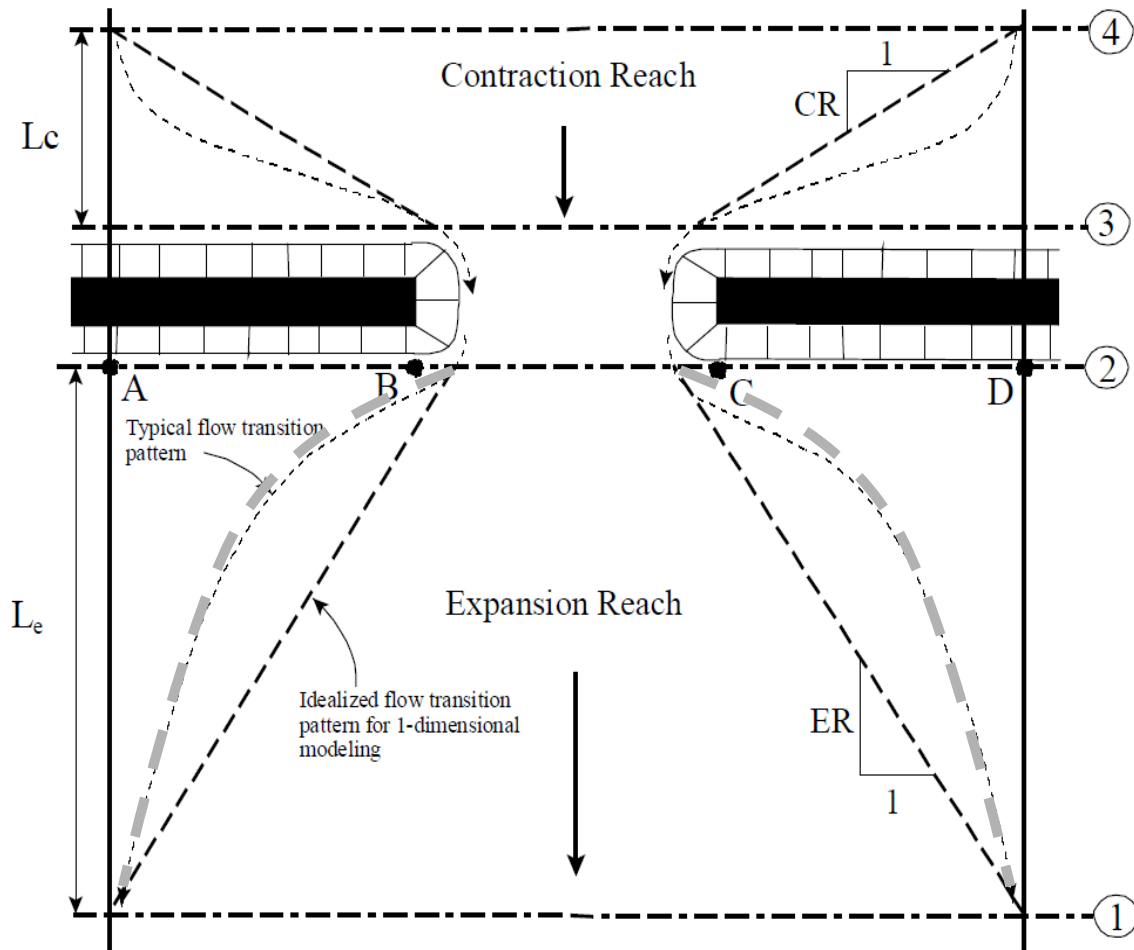
Quota del terreno
m slm

- 358
- 363
- 368
- 373
- 378

1500 m²
7 m high
10 000 m³ erosion

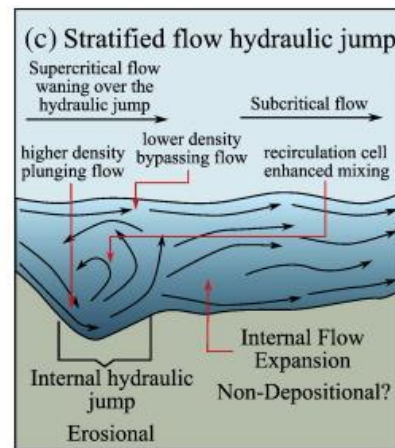
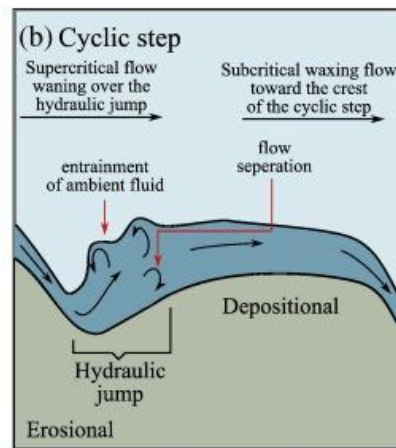
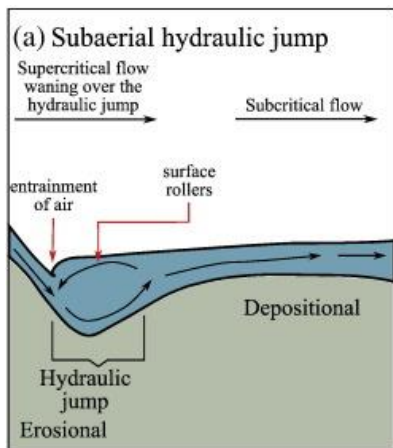
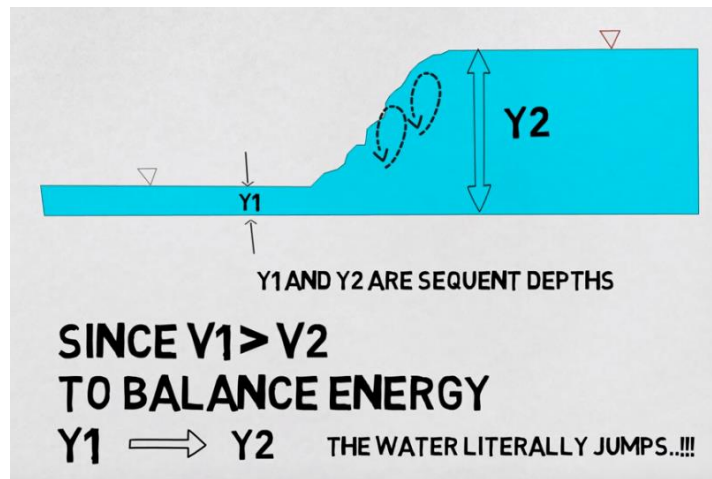


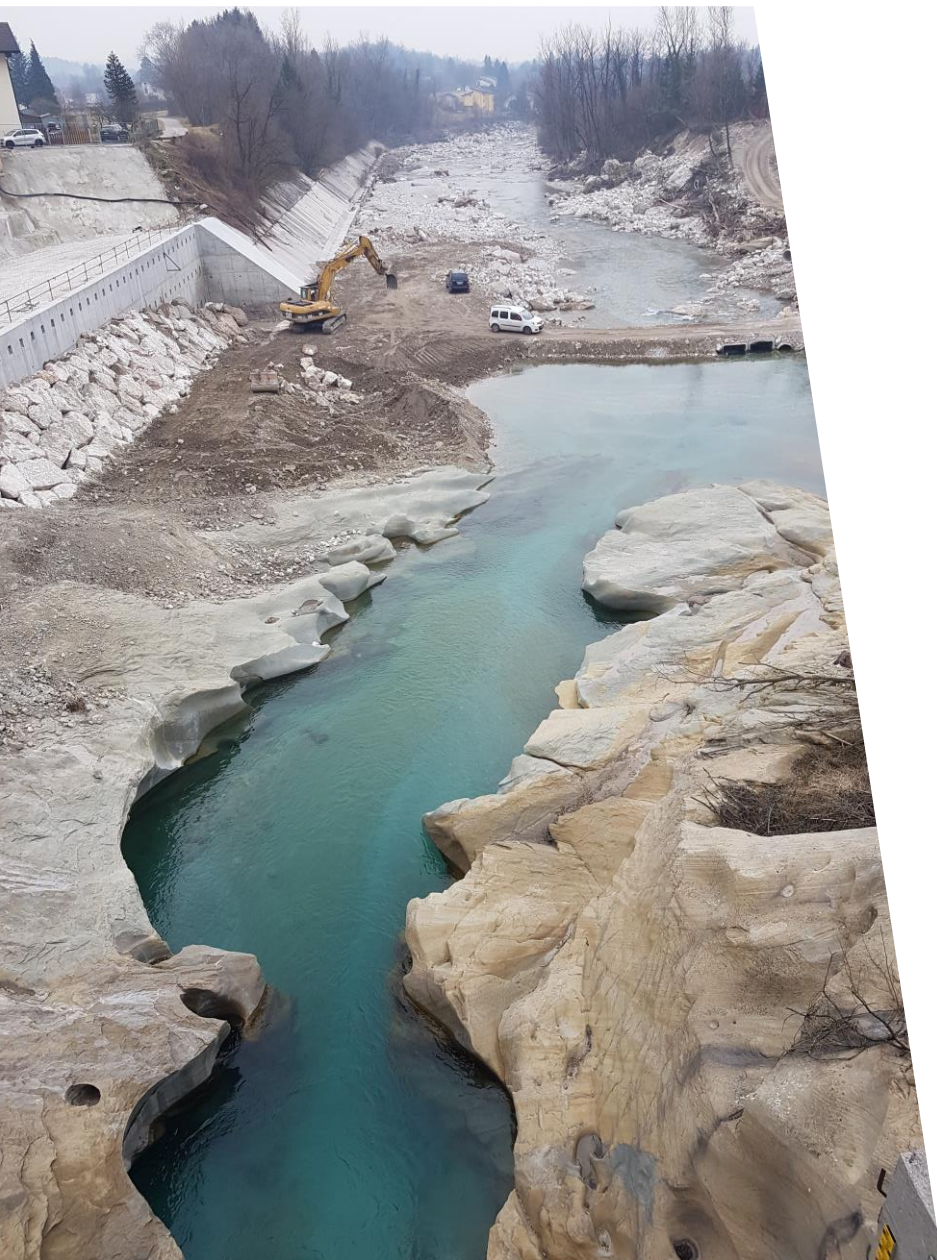
1. Expansion of the reach downstream to the bridge



2. The hydraulic jump between upstream and downstream of the bridge determines a rather abrupt rise in the water surface, establishing an area of strong erosion followed by a deposition area.

DYNAMICS OBSERVED





To reproduce what happened during both the VAIA storm and the December 2020 event in order to better understand the dynamics that led to the bank collapse

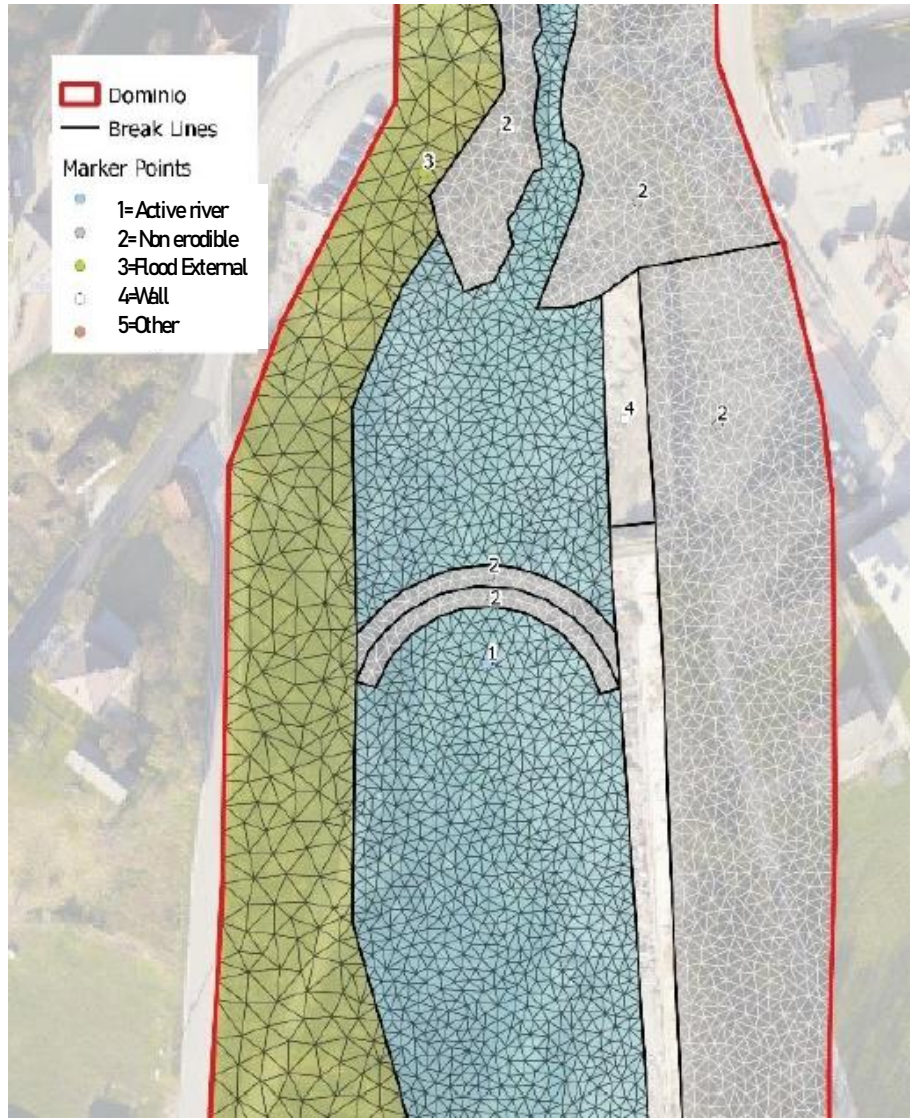
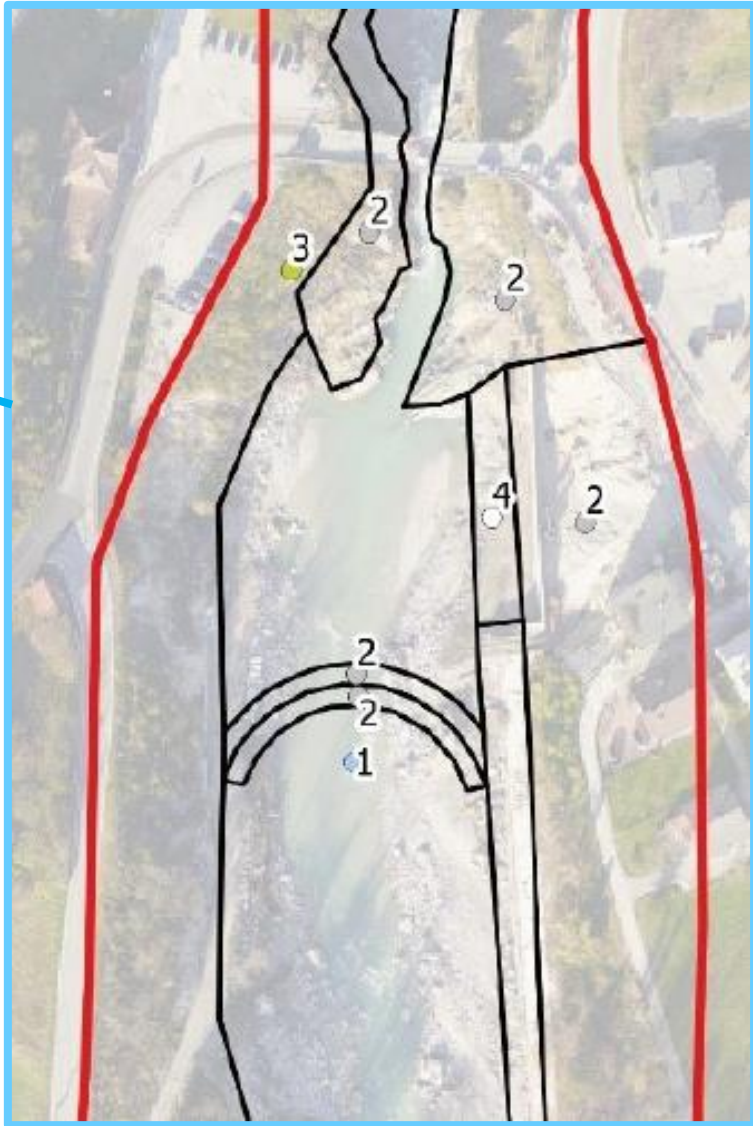
To give useful indications to the design of hydraulic and structural countermeasures. Specifically, the model should facilitate the assessment of the excavation behind the retaining wall, supporting the design of the new works

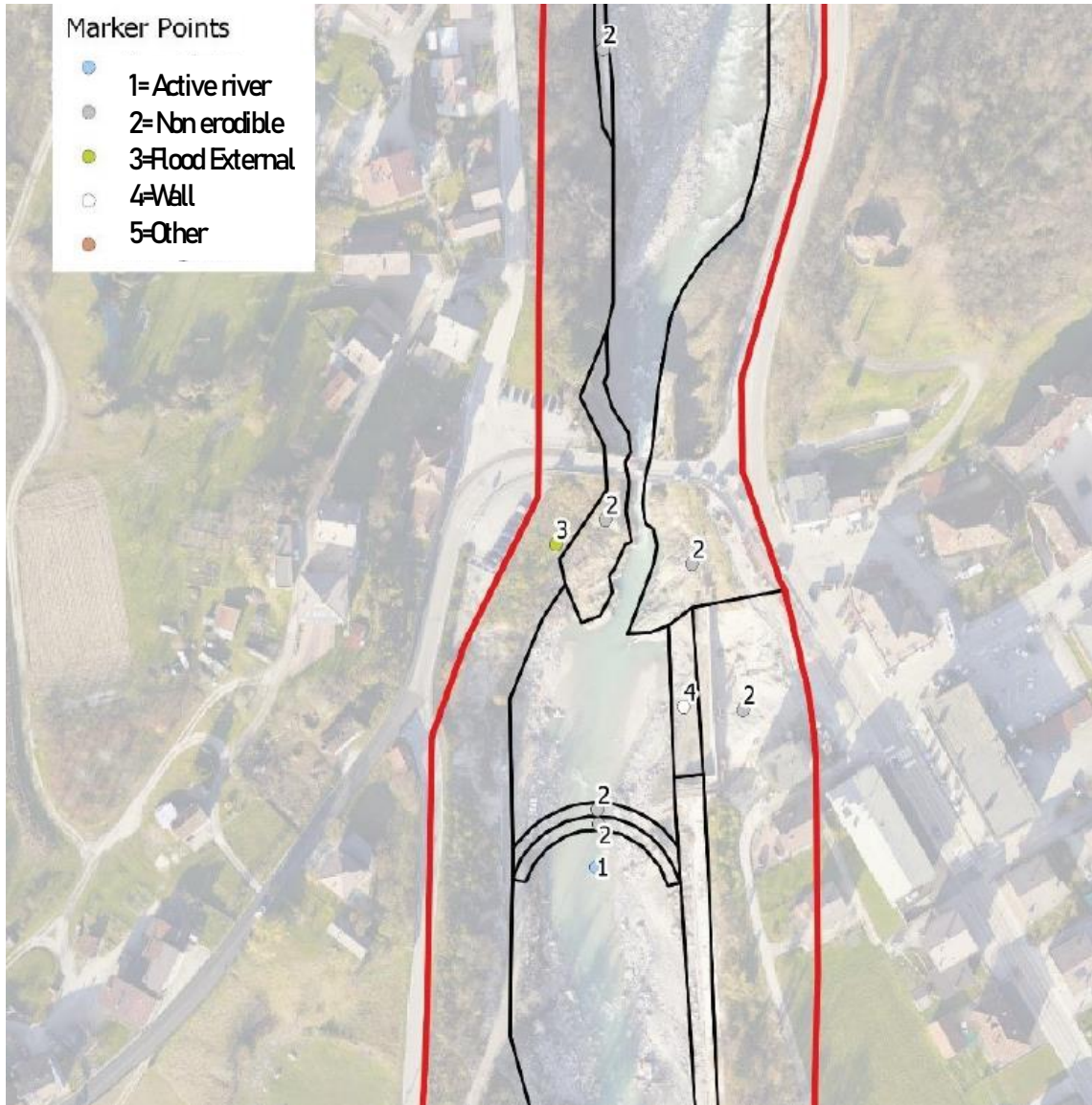


A 2D - Model is necessary in order to reproduce the planimetric variation of flow streams and the establishment of helicoidal velocities

A morphological model is necessary in order to consider the presence of minor or major erosion areas

Need to examine the phenomenon dynamically over time to identify the maximum potential excavation at the critical instant

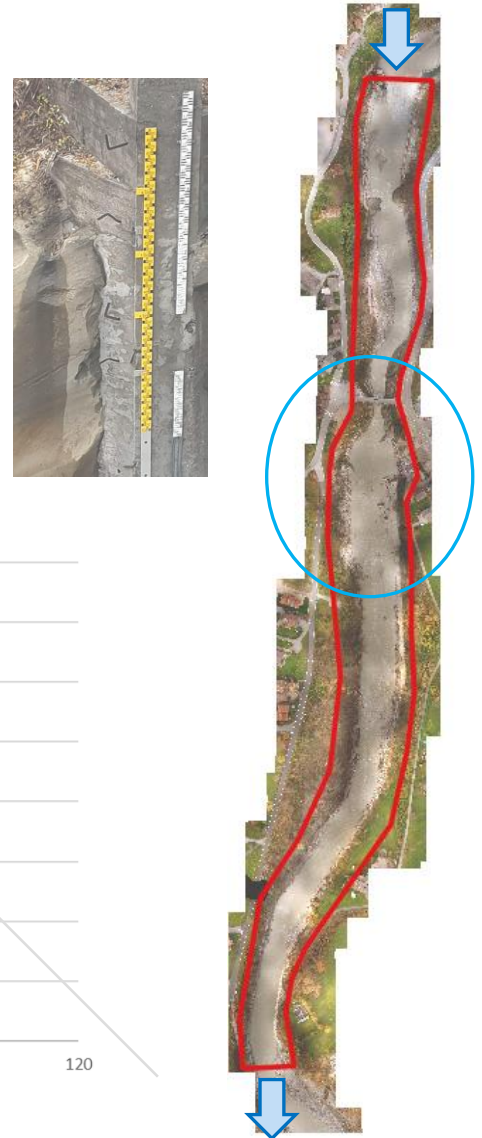
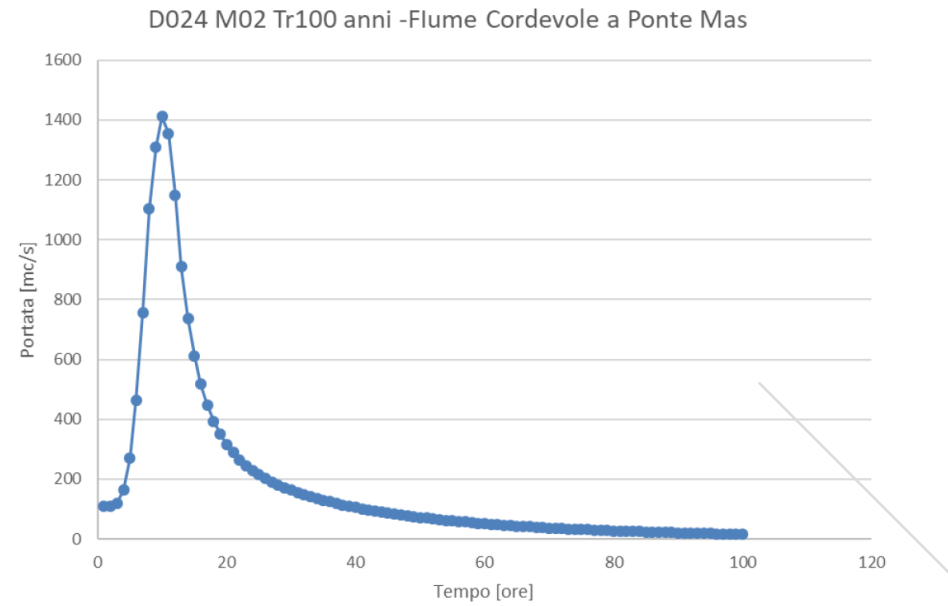
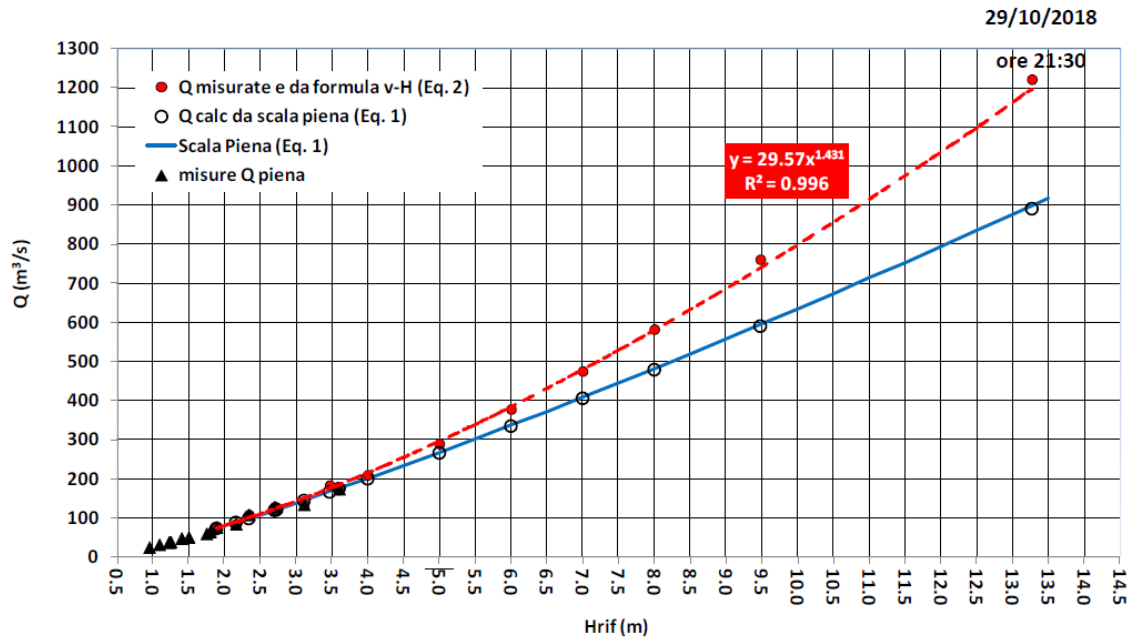




- MAT ID=1: Active river bed - $K_s = 15 \text{ m}^{1/3}/\text{s}$ ($n=0.066$ Manning)
- MAT ID=2: non erodible areas - $K_s = 20 \text{ m}^{1/3}/\text{s}$ ($n=0.05$ Manning)
- MAT ID=3: Flood external areas - $K_s = 10 \text{ m}^{1/3}/\text{s}$ ($n=0.10$ Manning)
- MAT ID=4: Retaining wall (object "HOLE" in the design simulations)

BOUNDARY CONDITIONS

- **Hydraulics**: Input hydrograph and output average slope, friction Ks
- **Bed Load**: Mayer Peter Muller equation, boundary equilibrium conditions (IOUp, IODown)

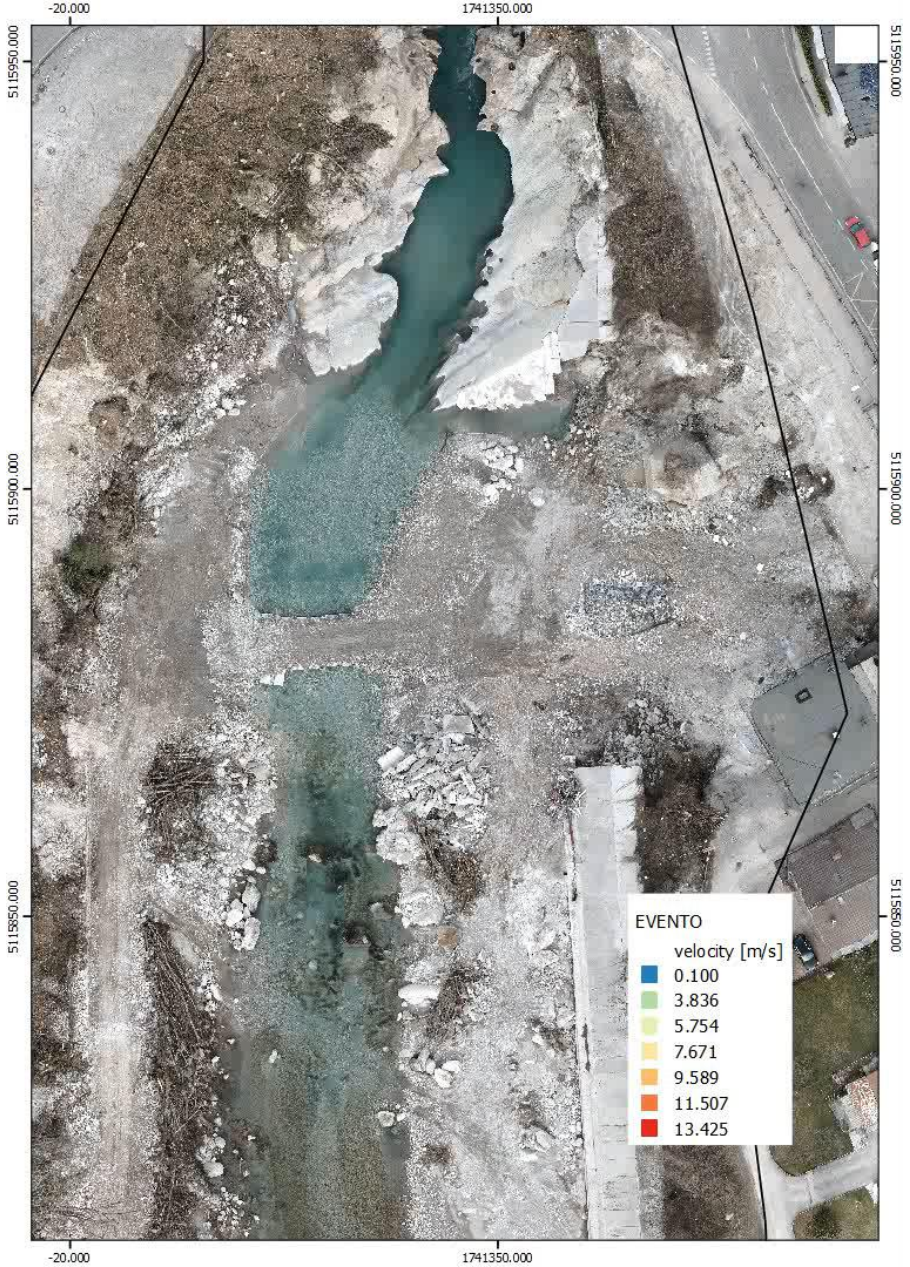


SCENARIO 1: SIMULATION OF THE OCT. 2018 EVENT	Existing (Lidar 2018)	VAIA Event Hydrograph
SCENARIO 2: SIMULATION OF THE INTERVENTION RI=100	Design (various options)	100 Years Hydrograph
SCENARIO 3: SIMULATION OF THE DEC. 2020 EVENT	Design	Dec. 2020 Event Hydrograph
SCENARIO 4: UPGRADE OF WORKS	Upgraded Design	100 Years Hydrograph



SCENARIO 1 : SIMULATION OF THE OCT. 2018 EVENT

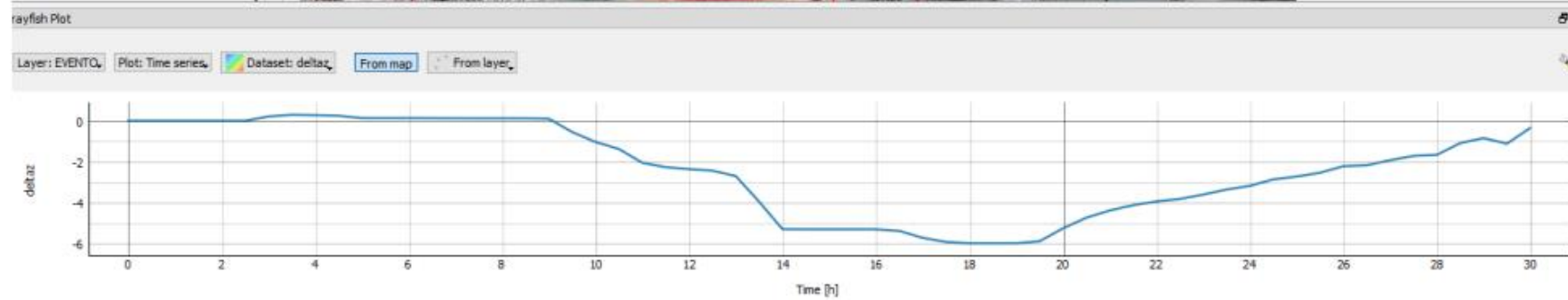
SCENARIO 1: SIMULATION OF THE OCT. 2018 EVENT



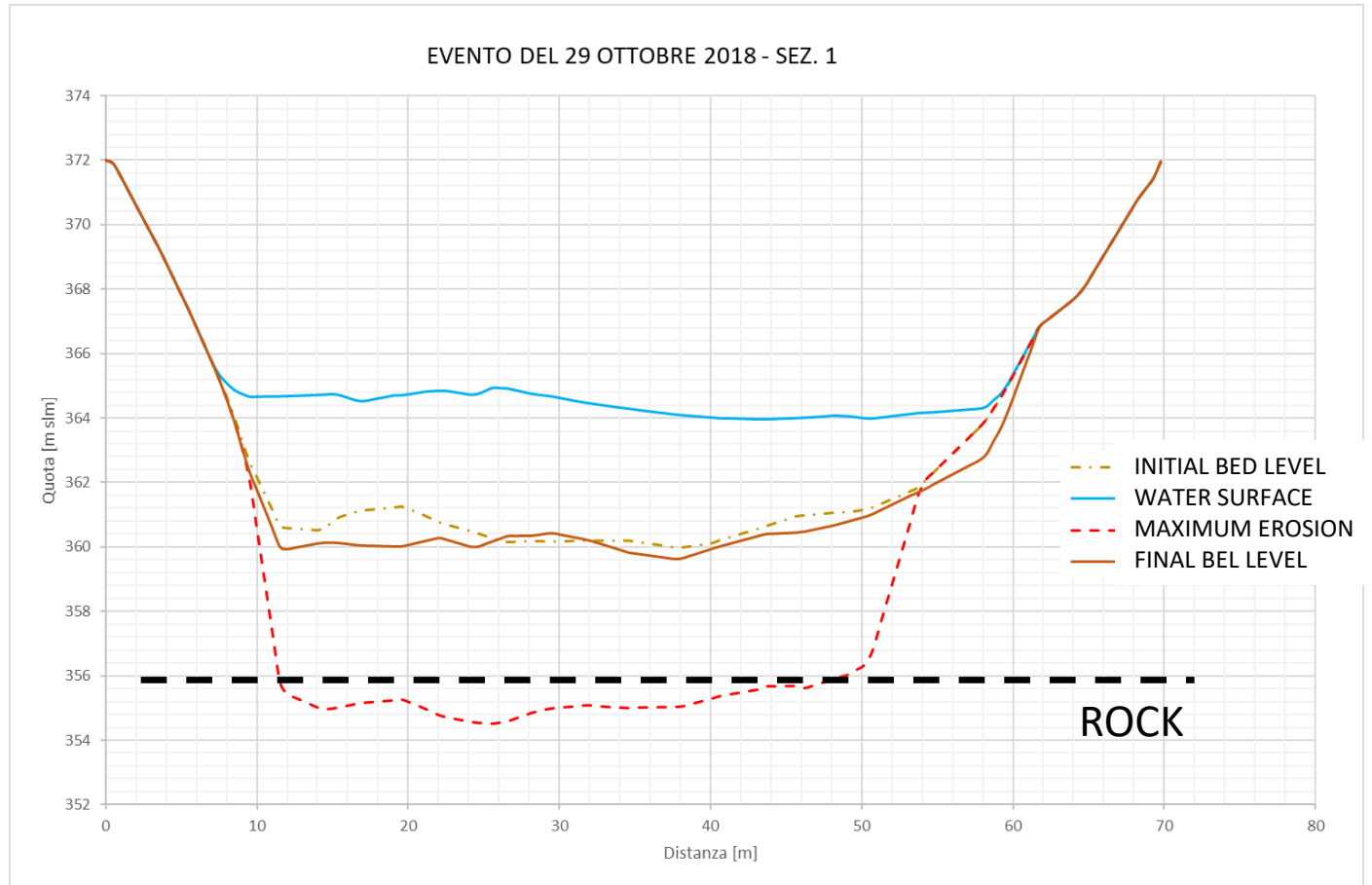
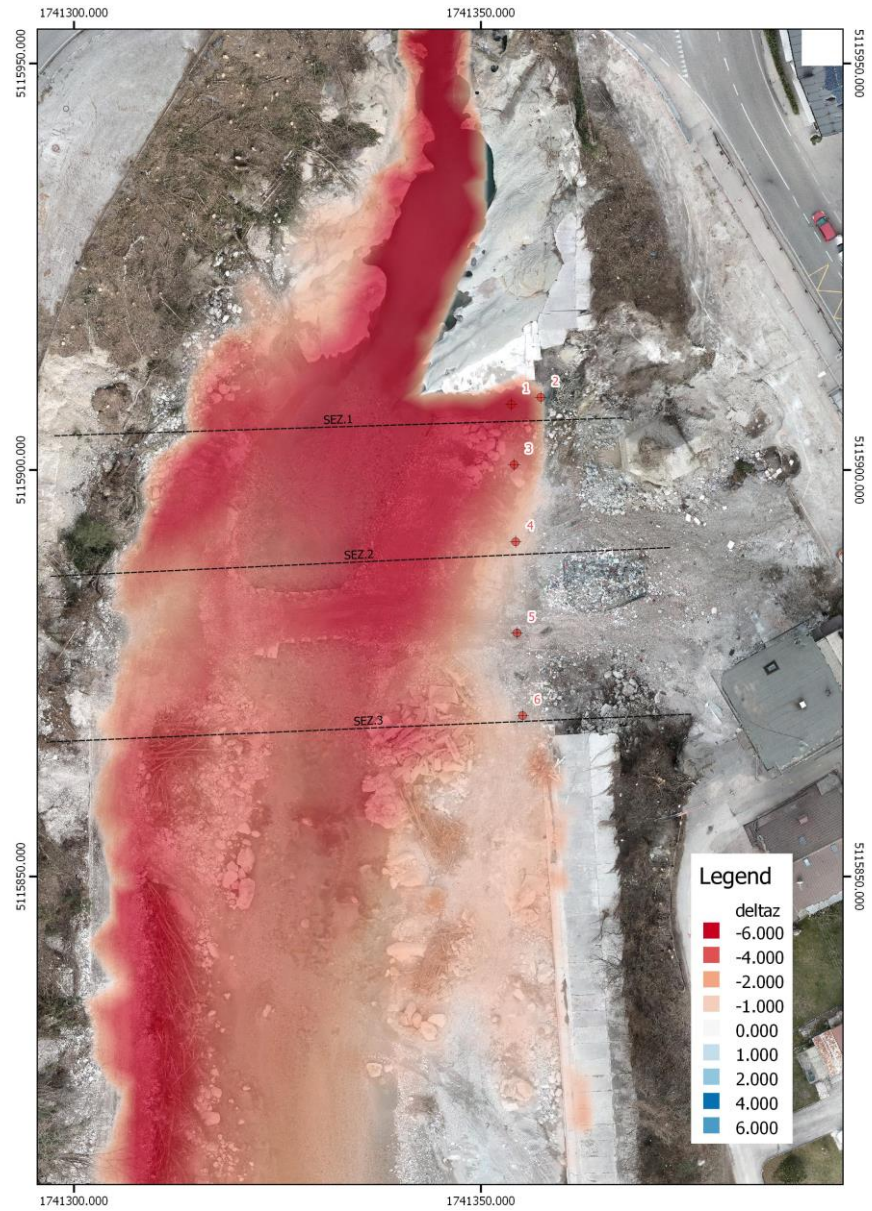
RED = erosion
BLUE = deposit

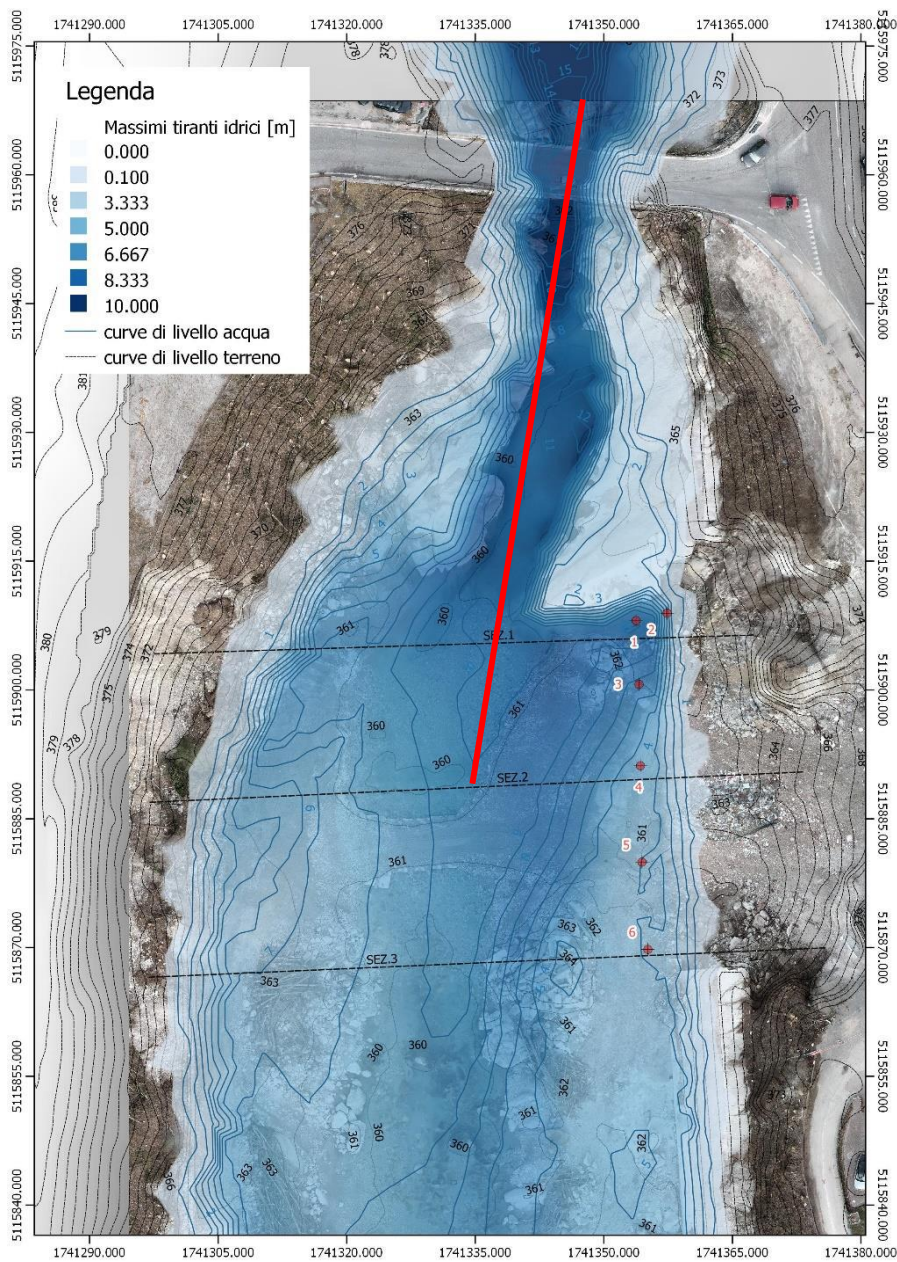
EVENTO 28-30 OTTOBRE - PUNTO DI CONTROLLO N.1

SCENARIO 1: SIMULATION OF THE OCT. 2018 EVENT

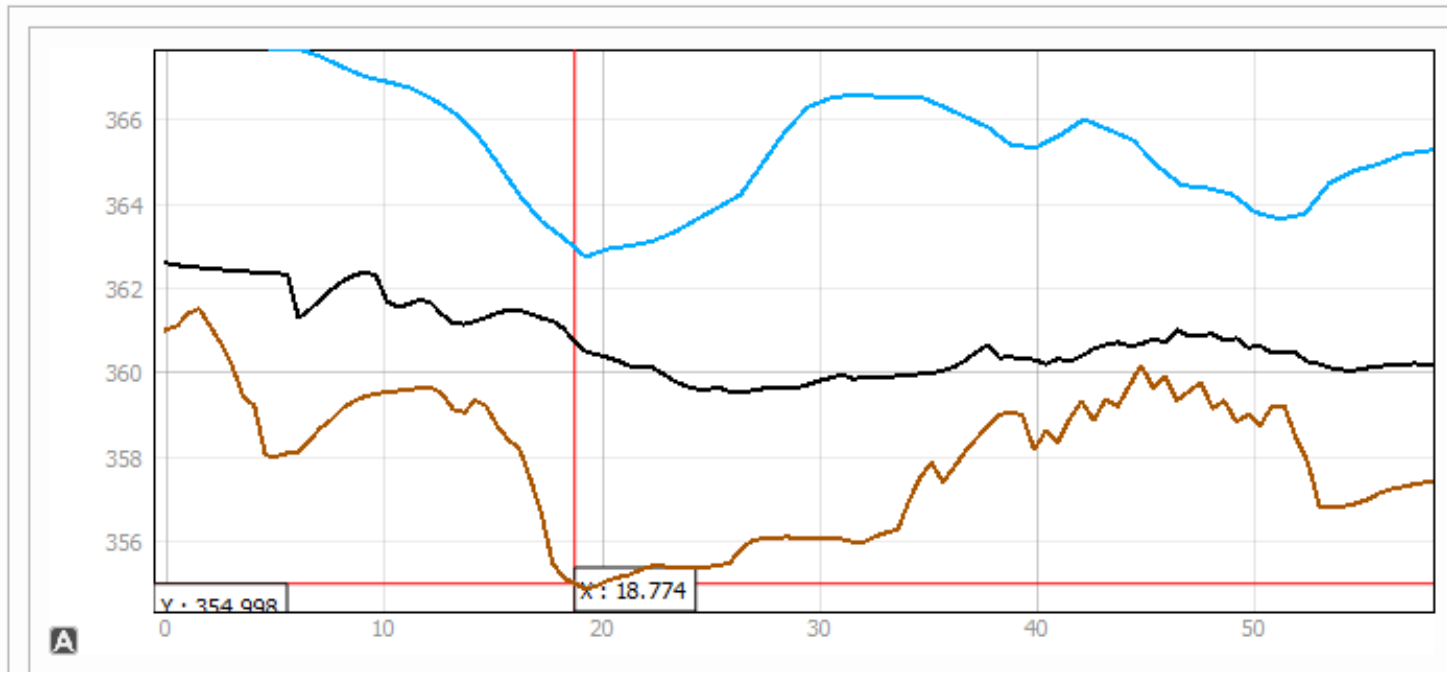
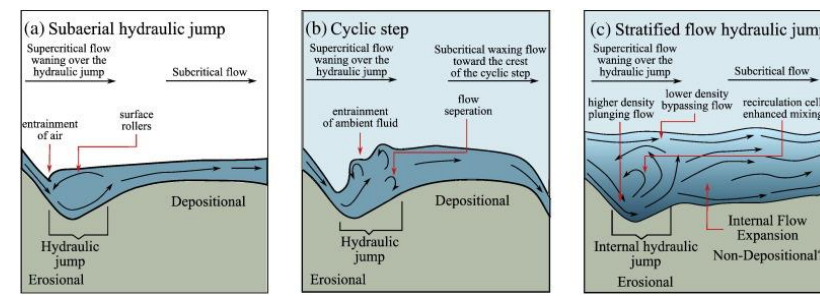


SCENARIO 1: SIMULATION OF THE OCT. 2018 EVENT





SCENARIO 01: SIMULATION OF THE OCT. 2018 EVENT



SCENARIO 2: SIMULATION OF INTERVENTION RP 100 YEARS

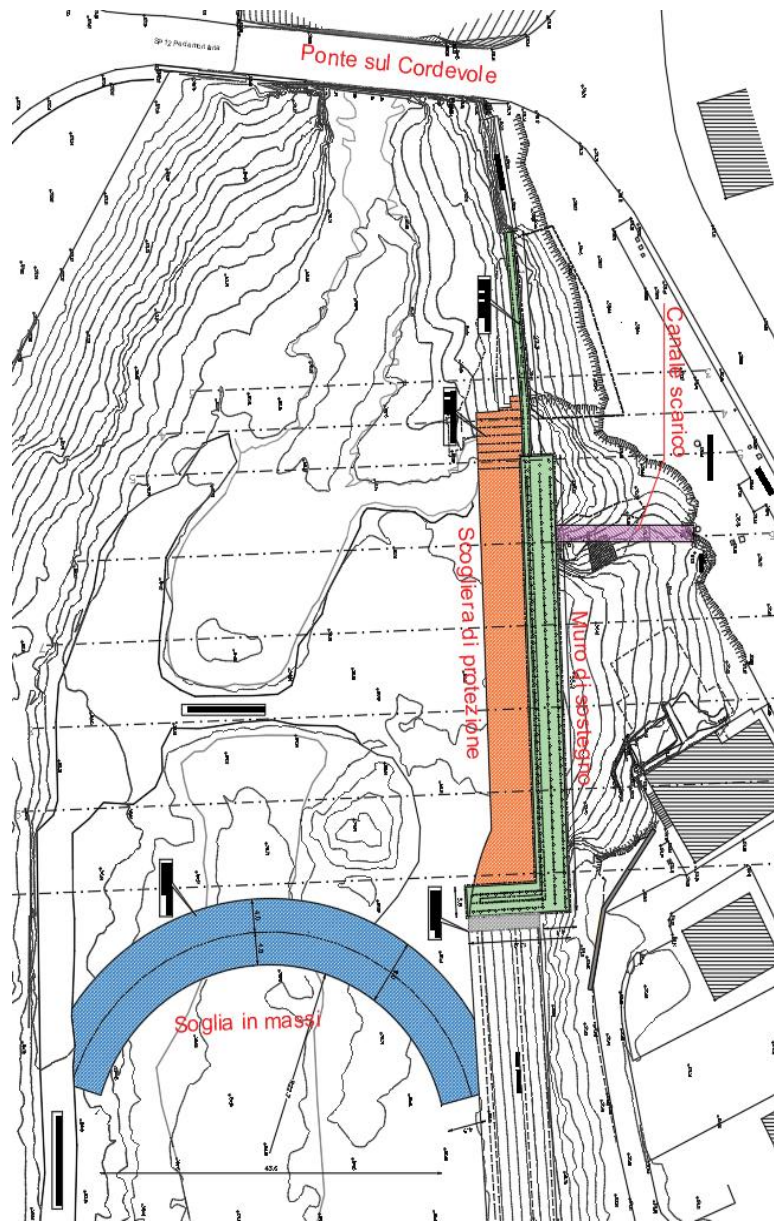


SCENARIO 2: SIMULATION OF INTERVENTION RP 100 YEARS



SCENARIO 2: SIMULATION OF INTERVENTION RP 100 YEARS





1) RETAINING WALL WITH TIEBACKS AND FOUNDATION PILES

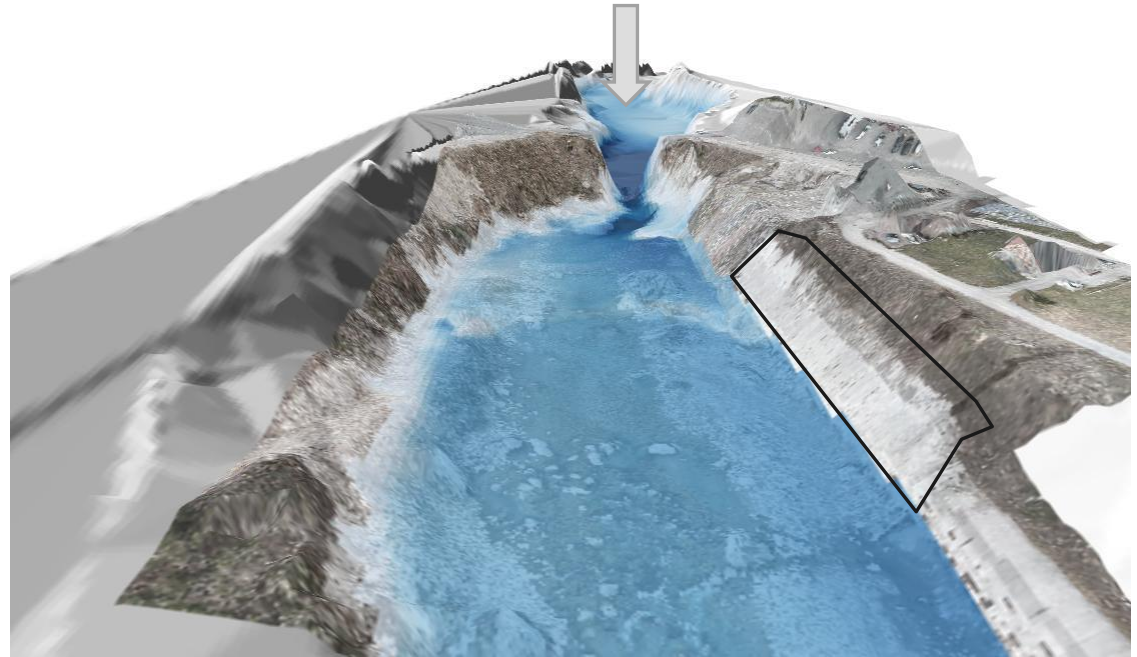
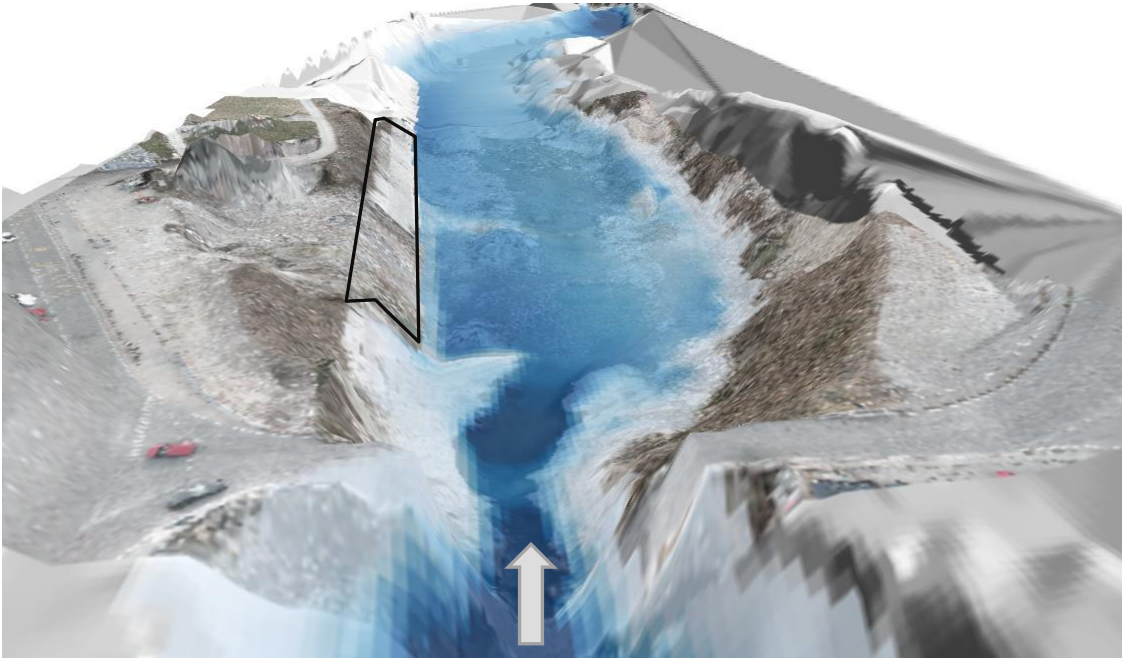
2) RIPRAP BANK PROTECTION

3) CURVED STEP WEIR

SCENARIO 2: SIMULATION OF INTERVENTION RP 100 YEARS



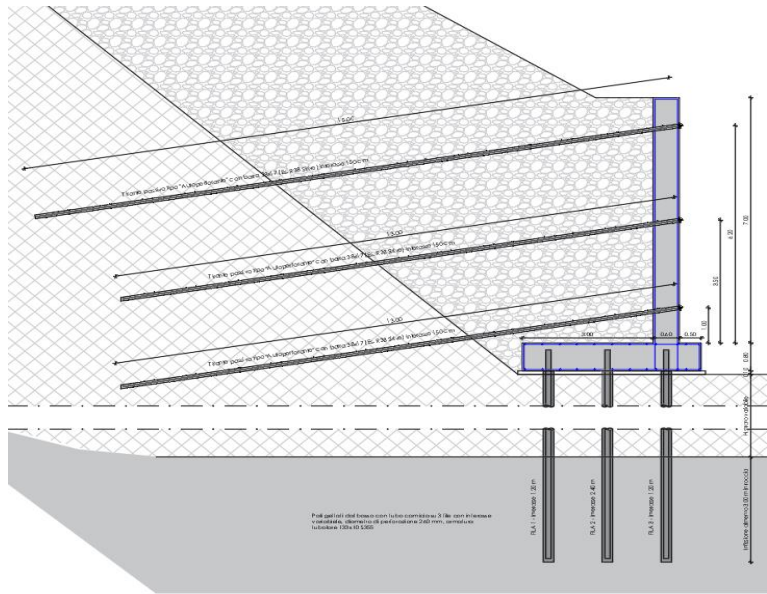
SCENARIO 2: SIMULATION OF INTERVENTION RP 100 YEARS



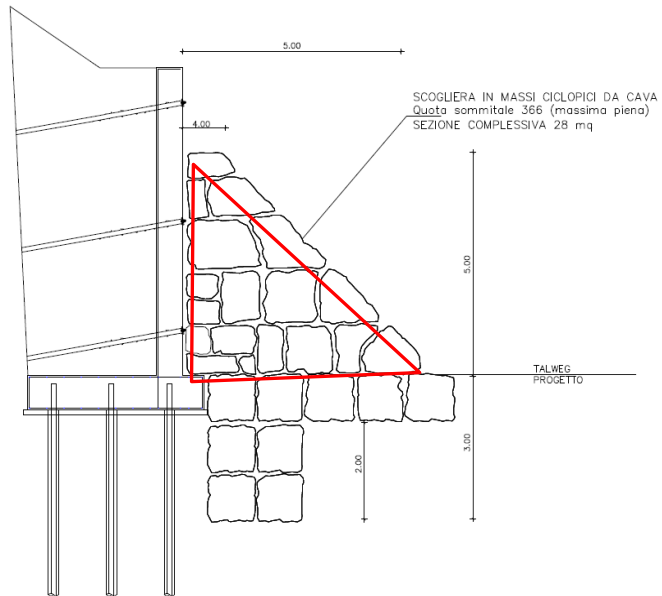
SCENARIO 2: SIMULATION OF INTERVENTION RP 100 YEARS



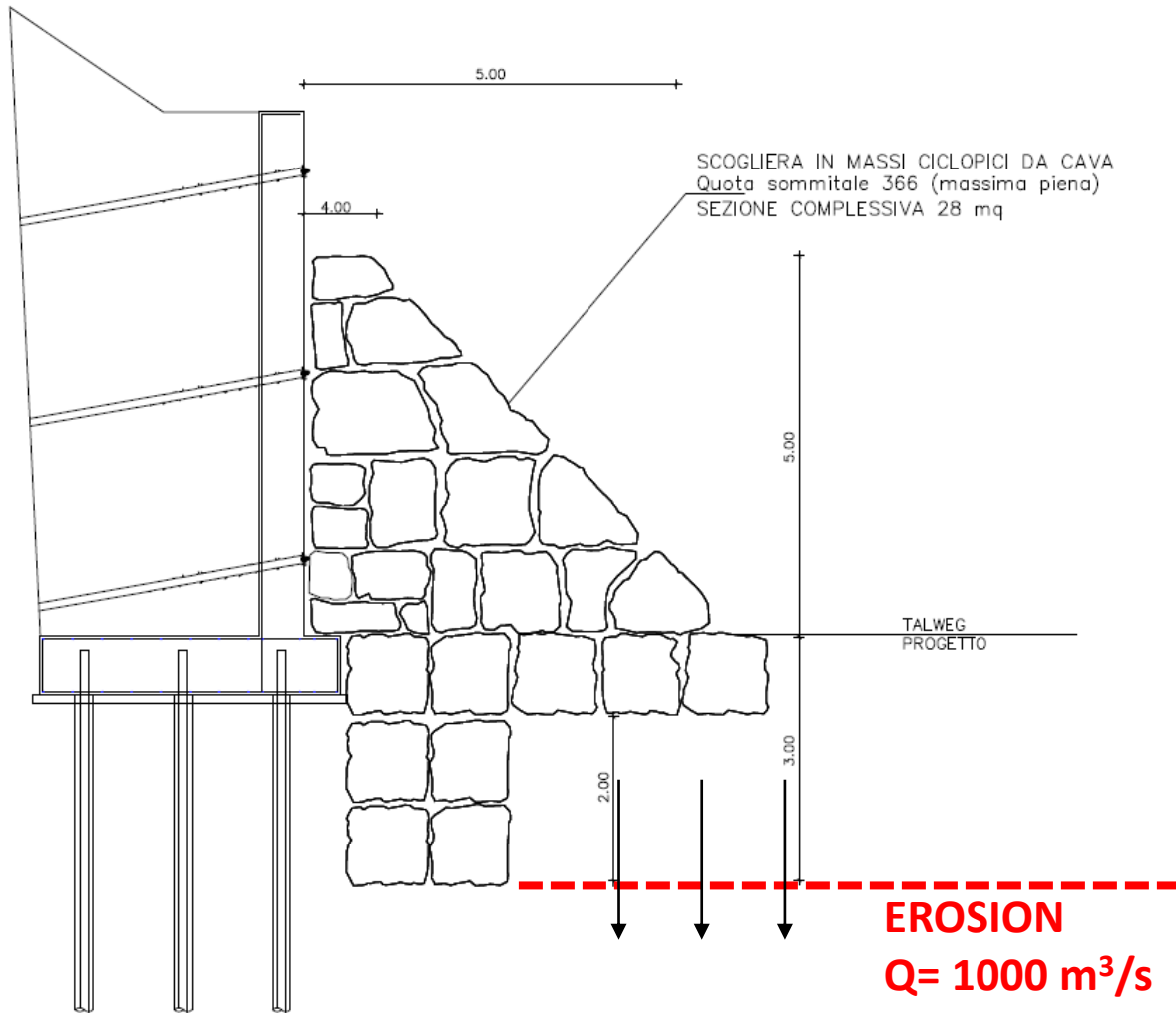
SCENARIO 2: SIMULATION OF INTERVENTION RP 100 YEARS



SCOGLIERA IN MASSI CICLOPICI

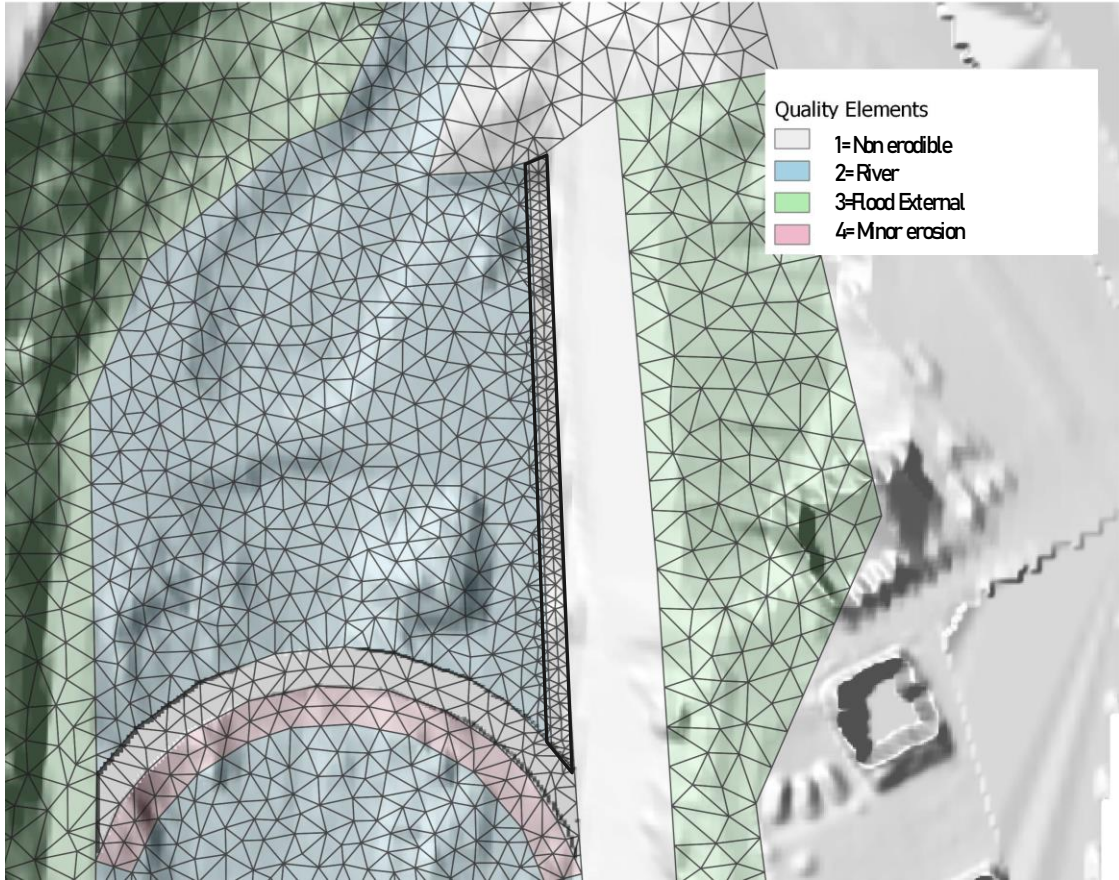


BOULDERS RIPRAP

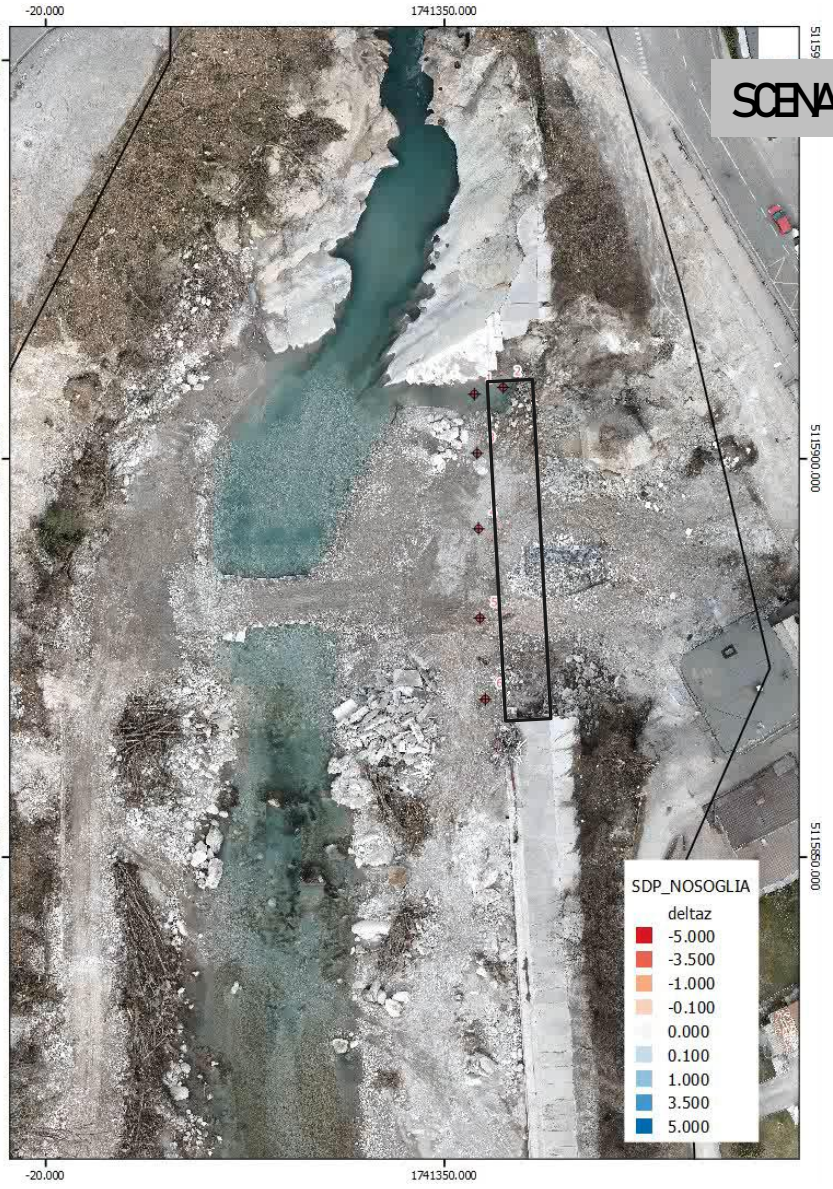
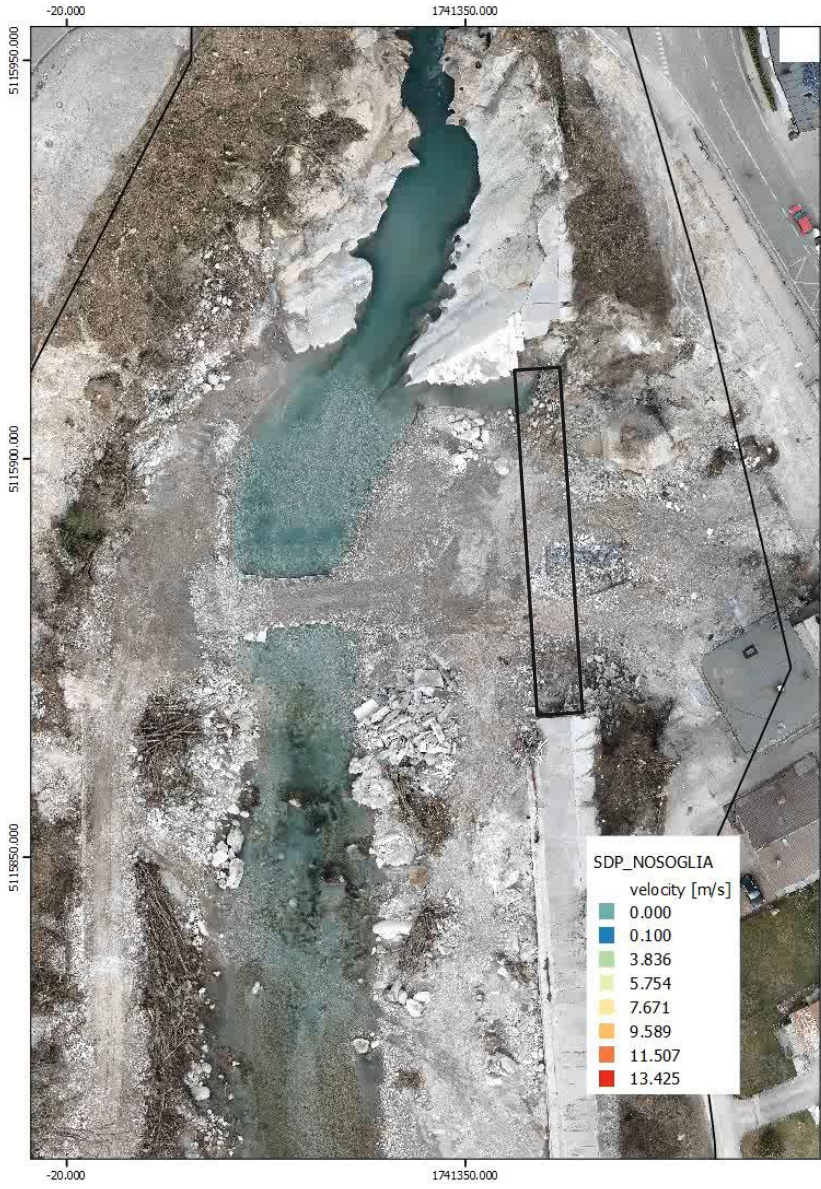


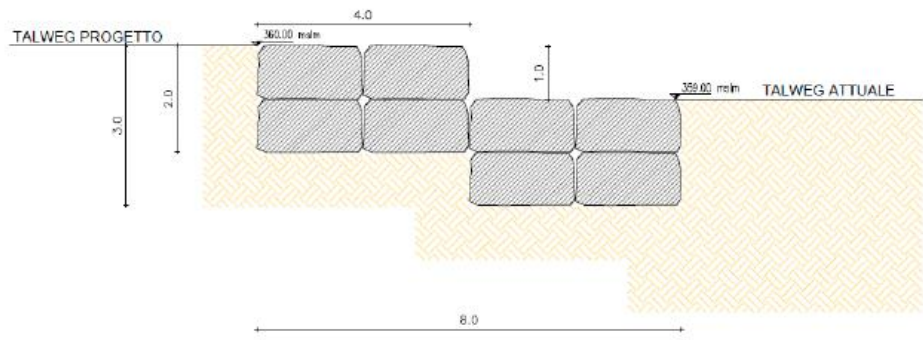
The riprap is designed to be flexible. Rocks fill the area eroded by the flood, protecting the foundations of the wall, even if the erosion is deeper than expected

SCENARIO 2: SIMULATION OF INTERVENTION RP 100 YEARS



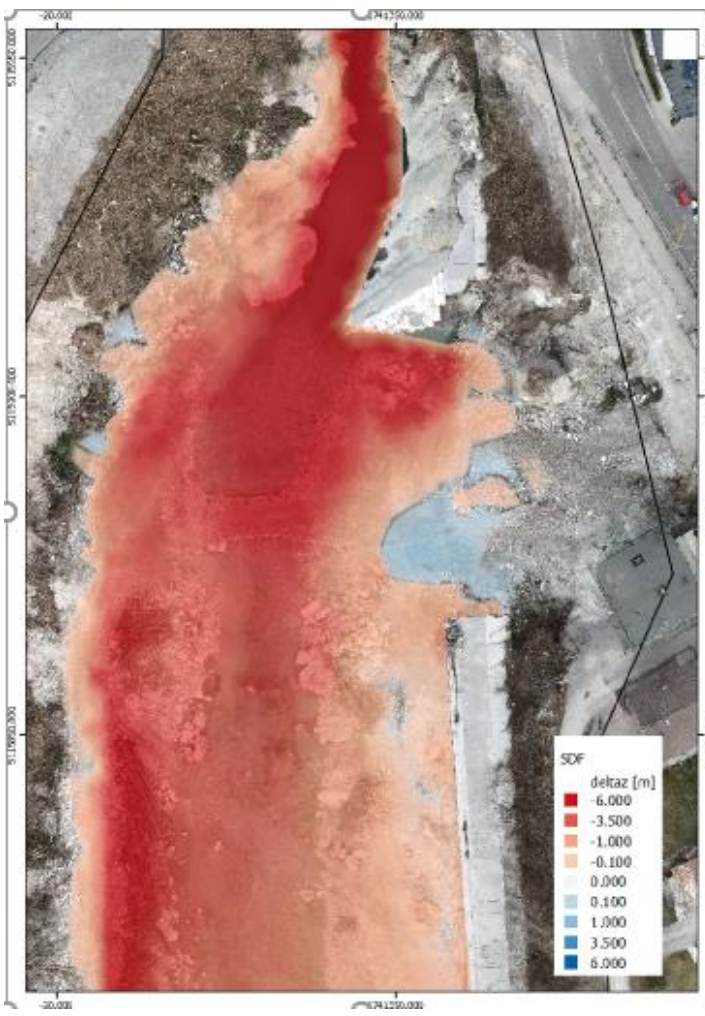
SCENARIO 2: SIMULATION OF INTERVENTION RP 100 YEARS



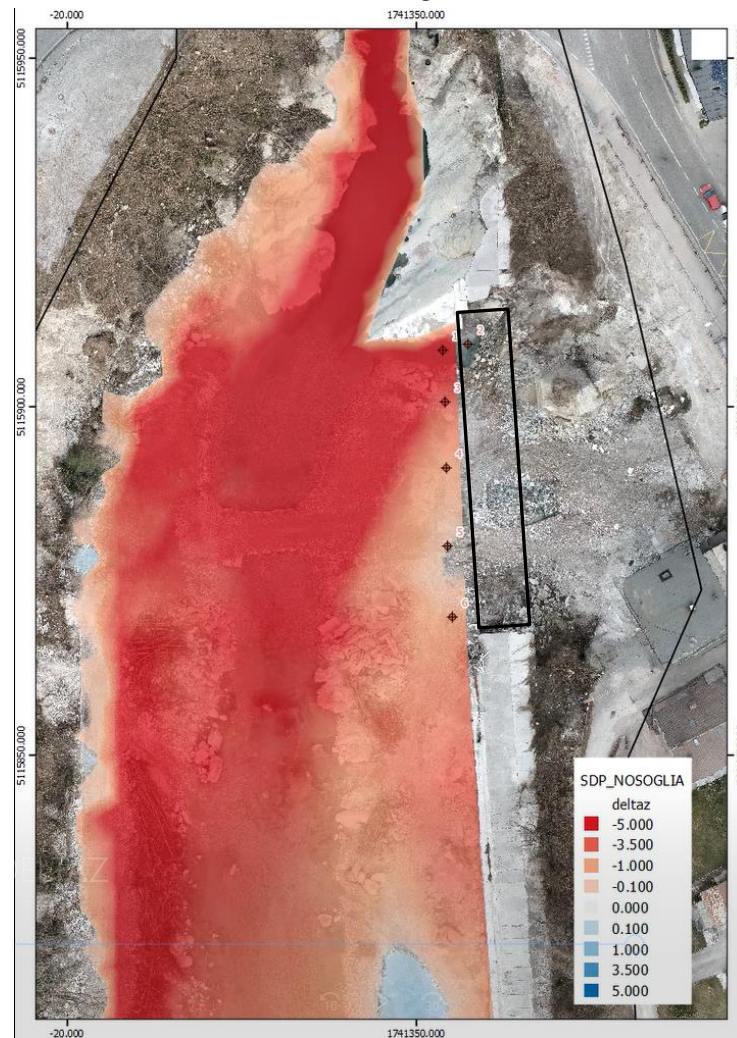


SCENARIO 2: SIMULATION OF INTERVENTION RP 100 YEARS

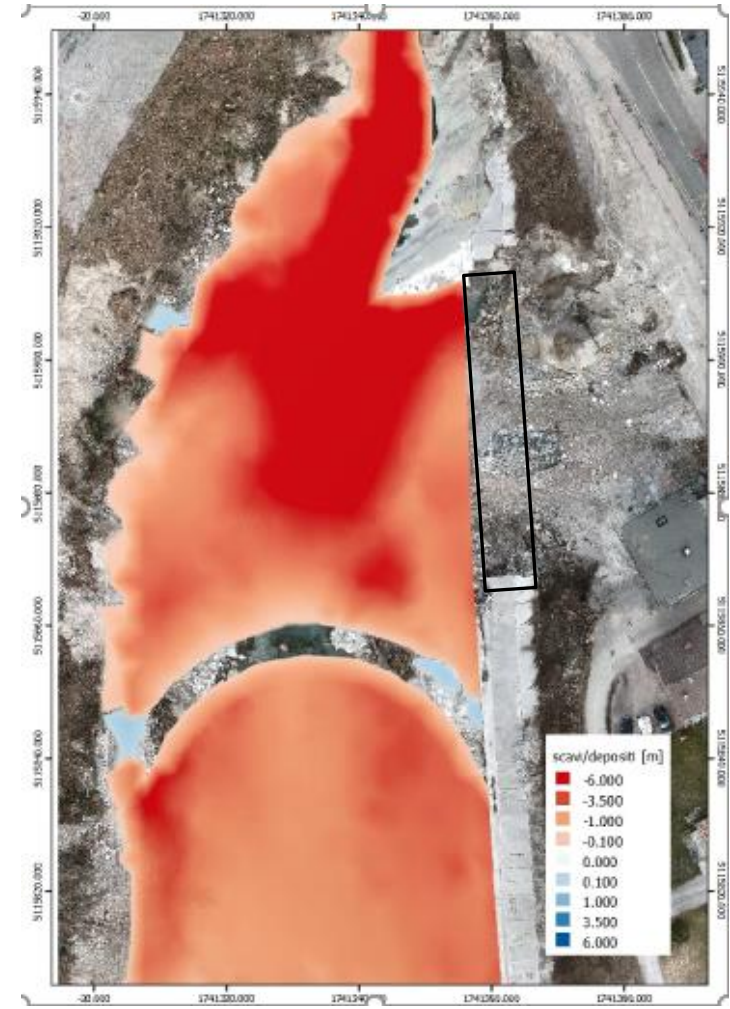
Before Works



Retaining Wall



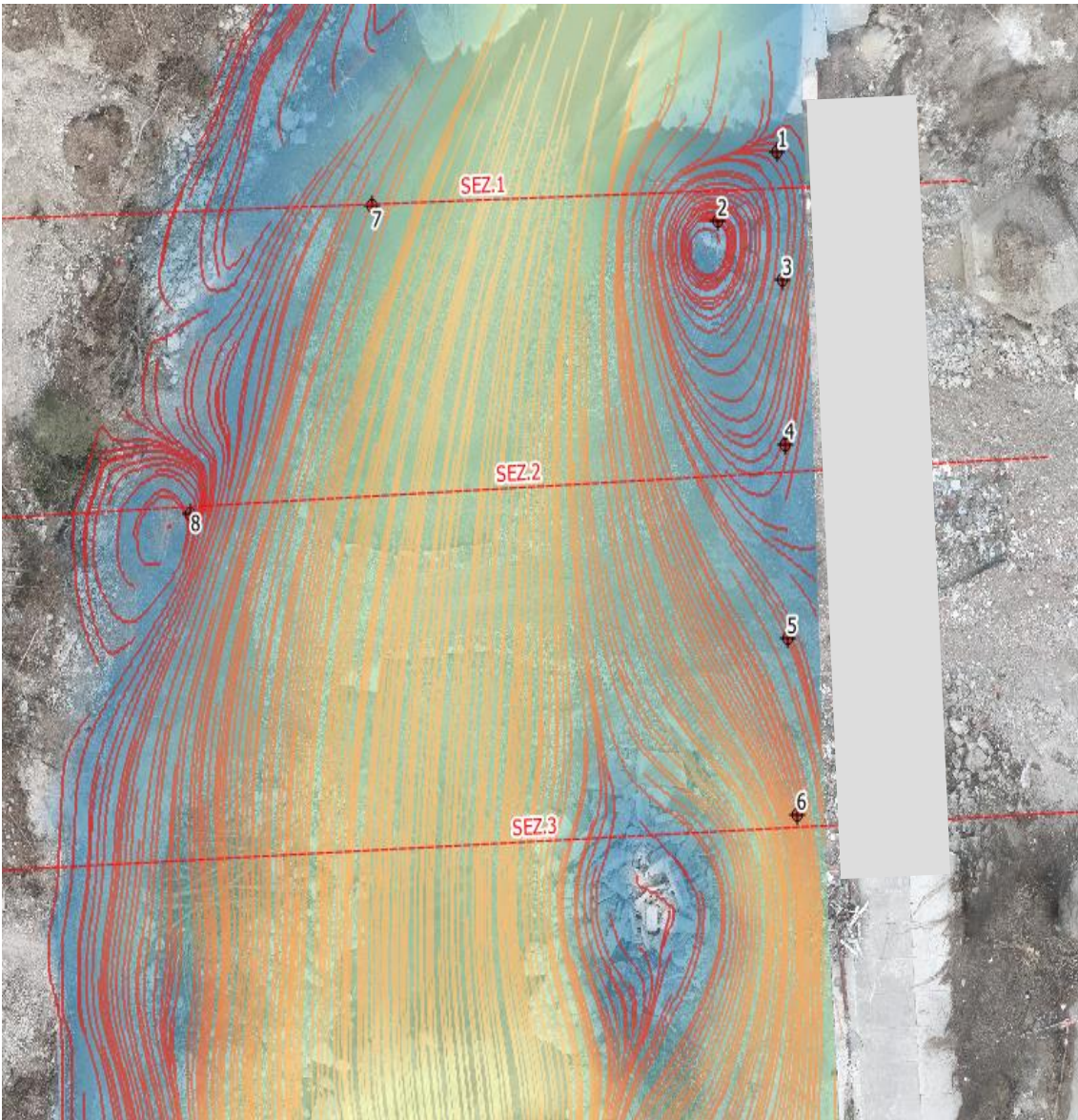
Retaining Wall and curved weir



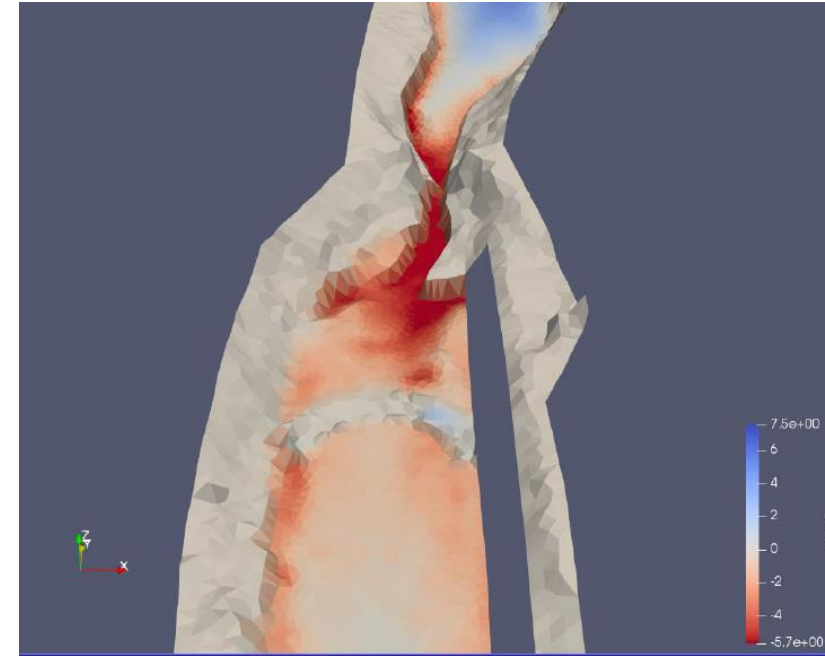
Instant of maximum erosion

SCENARIO 3: SIMULATION OF THE DEC. 2020 EVENT





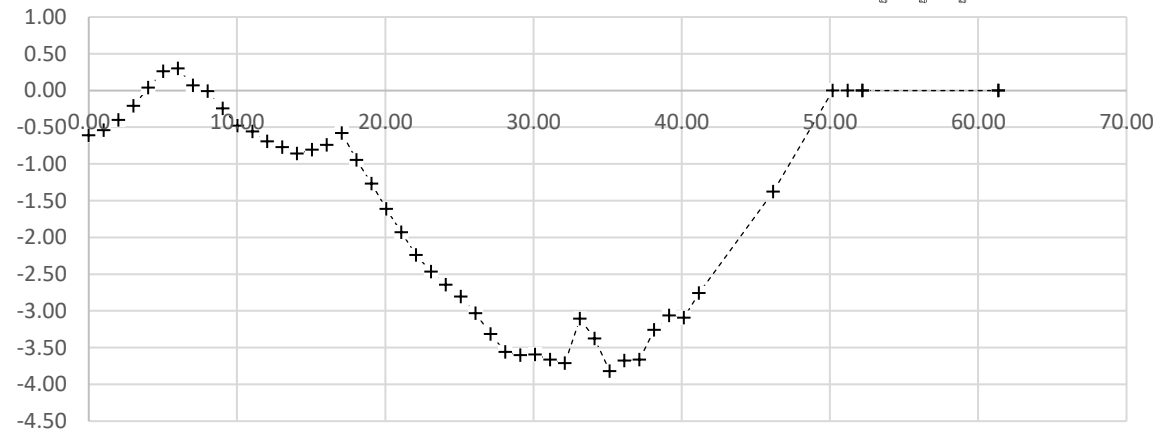
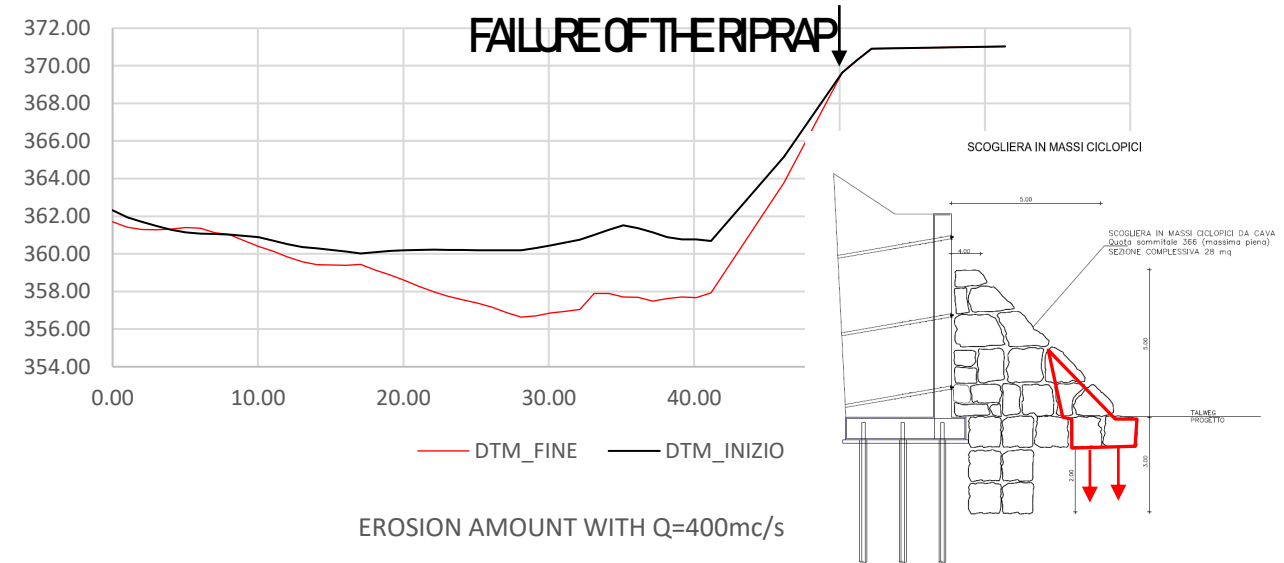
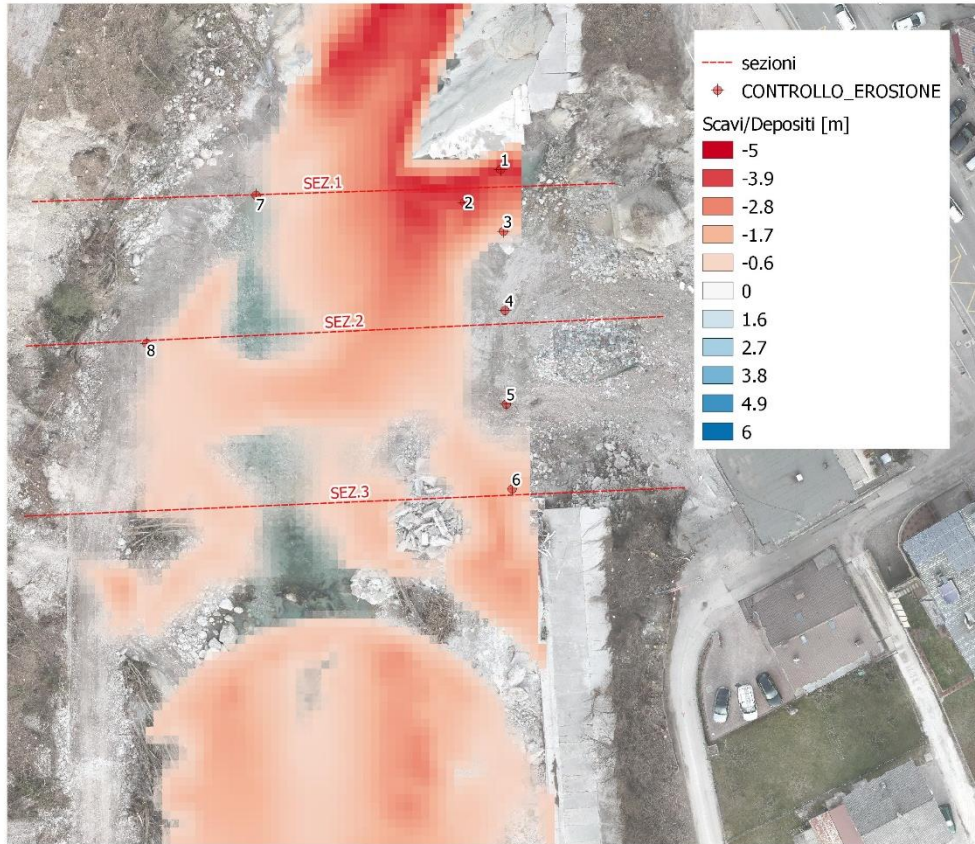
SCENARIO 3: SIMULATION OF THE DEC. 2020 EVENT



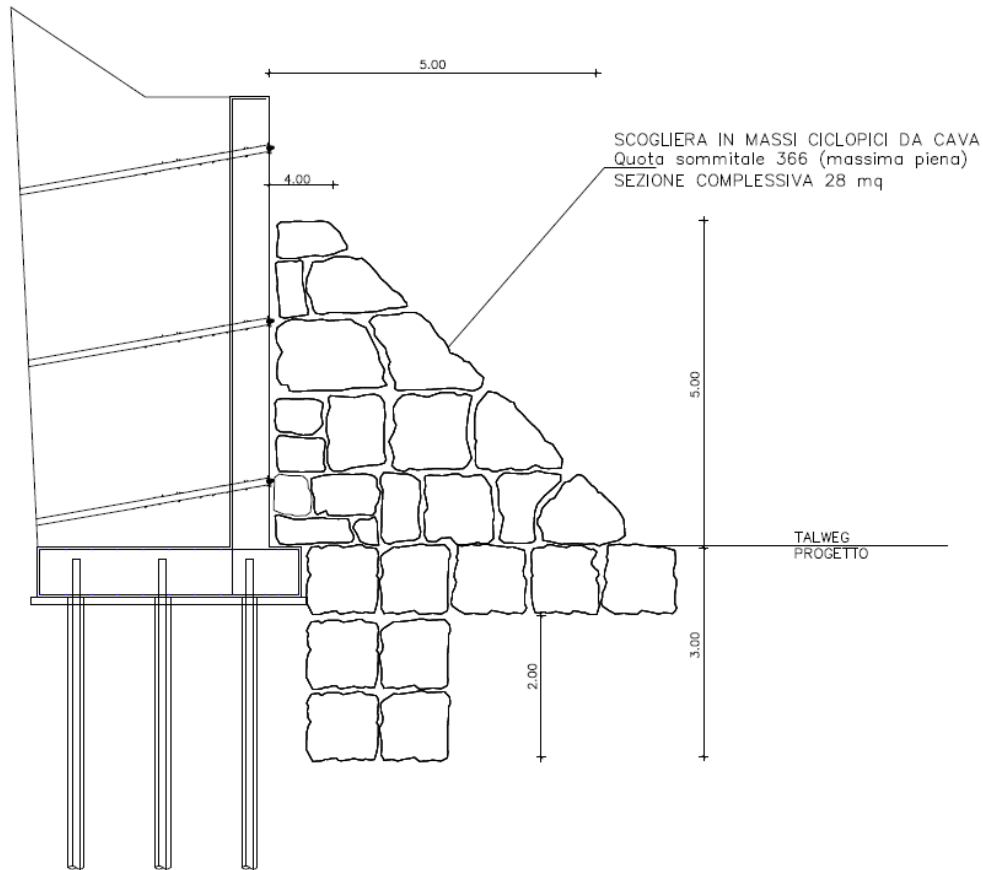
SCENARIO 3: SIMULATION OF THE DEC. 2020 EVENT



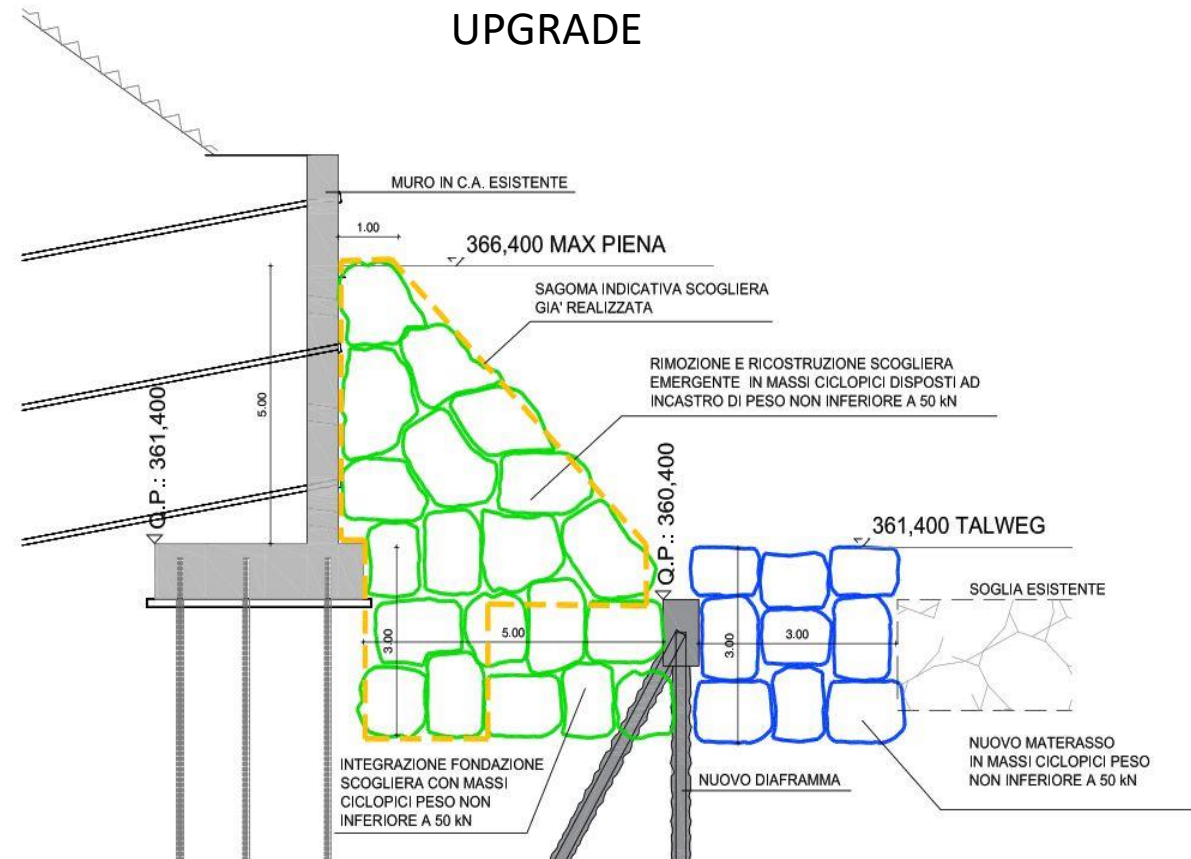
SCENARIO 3: SIMULATION OF THE DEC. 2020 EVENT



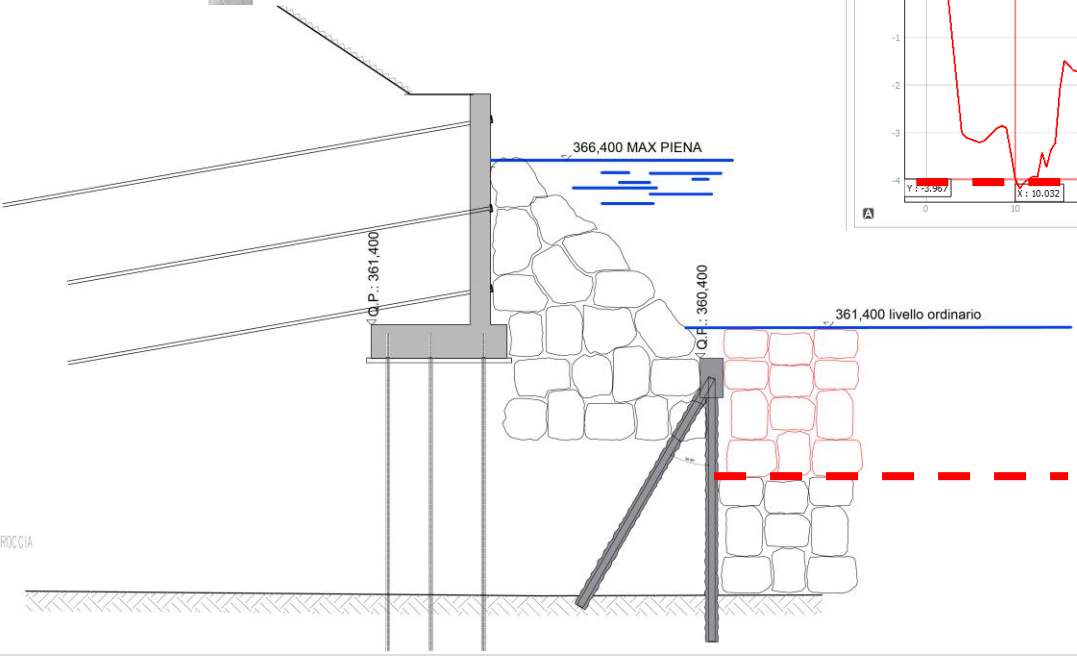
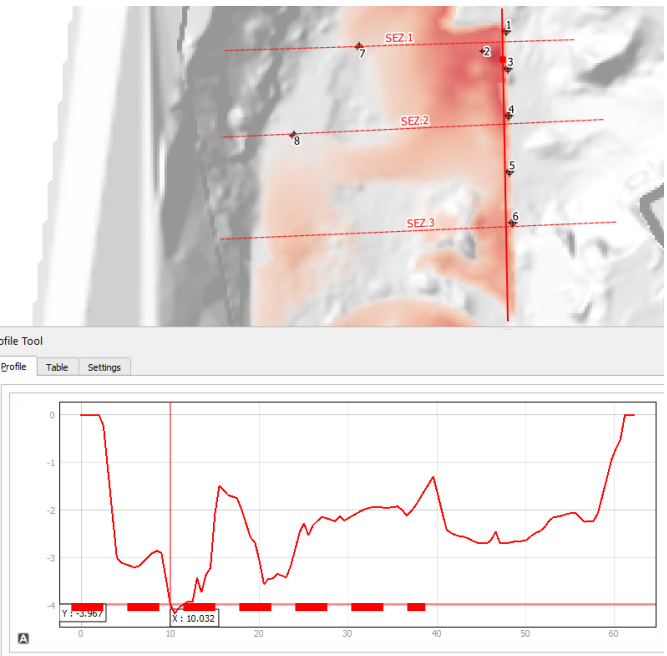
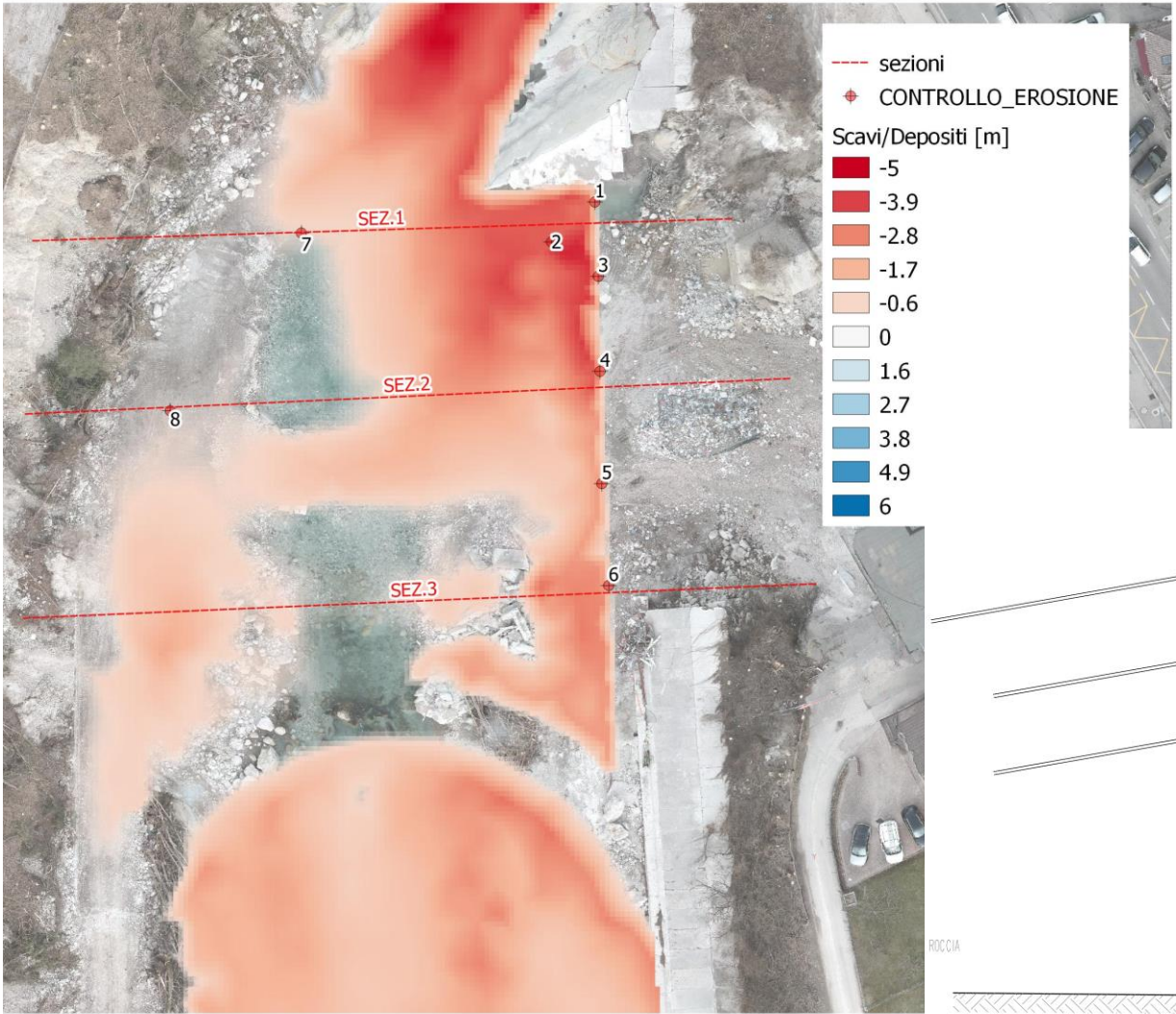
FIRST DESIGN



UPGRADE



SCENARIO 4 : WORKS UPGRADE





The model illustrates with a good level of accuracy the actual hydraulic and morphological dynamics observed

The model facilitates the assessment of the excavation behind the retaining wall

The model helps to determine the shape, size and position of the works



Thank you for your attention

Gaspare Andreella | Marika Righetto
BASEMENT users meeting 2021