SETOF Soil Erosion and TOrrential Flood Prevention: Curriculum Development at the Universities of Western Balkan Countries

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Feasibility study , preliminary design and programme for preparation of main design for decrEase of flood risk of regional road Tetovo-jazince by pOrojska reka

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FEASIBILITY STUDY , PRELIMINARY DESIGN AND PROGRAMME FOR PREPARATION OF MAIN DESIGN FOR DECREASE OF FLOOD RISK OF REGIONAL ROAD TETOVO-JAZINCE BY POROJSKA REKA

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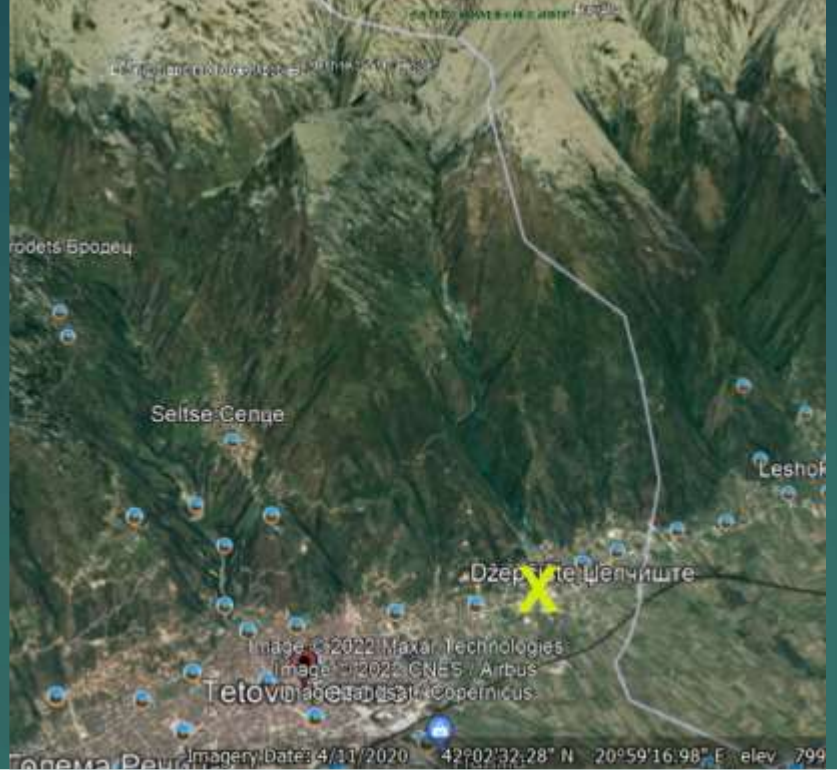
Geodetic team

Team for geomechanics

Team for statics

16.6.2022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ToR

The technical documentation will consist of:

- a) preliminary feasibility study in which at least 3 alternative solutions will be considered and
- b) Preliminary design for the selected solution.

- c) Additionally, as part of the technical documentation in question, it will be necessary to prepare a detailed Project Program for preparation of the Basic Design and other documentation necessary to provide the necessary permits and organize the construction activities.

Content of Feasibility Study and Preliminary design

- 1. INTRODUCTION
- 2. BACKGROUND DATA AND DESCRIPTION OF THE POROJKA RIVER BASIN
- 3. Erosion and sediments
- 4. HYDROLOGICAL ANALYSIS5.
- 5. HYDRAULIC ANALYSIS IN THE CURRENT CONDITIONS.
- 6. HYDRAULIC ANALYSIS IN THE DESIGN CONDITIONS
- 7. EXISTING FACILITIES.
- 8. PROPOSED SOLUTION
- 9. INVESTEMENTS
- 10.ANNEXES

Introduction

- The most frequent torrent in the country. Registered a lot of floods in the history , only in the 21 century in 2002, 2004, 2005, 2006, 2008, 2010, 2015 and 2017 . And the name of the village is Torrent

- Problems:
- Closure of bridge on the road Tetovo – Jazince and torrent bed with sediments (the highest big boulder with volume up to 30 m^3)
- Flooding of the road, and usually stop of traffic for days or traffic jam in a case of small flooding
- Flooding of agricultural land downstream from the road
- Possible damages on the railway
- Huge quantity of sediments

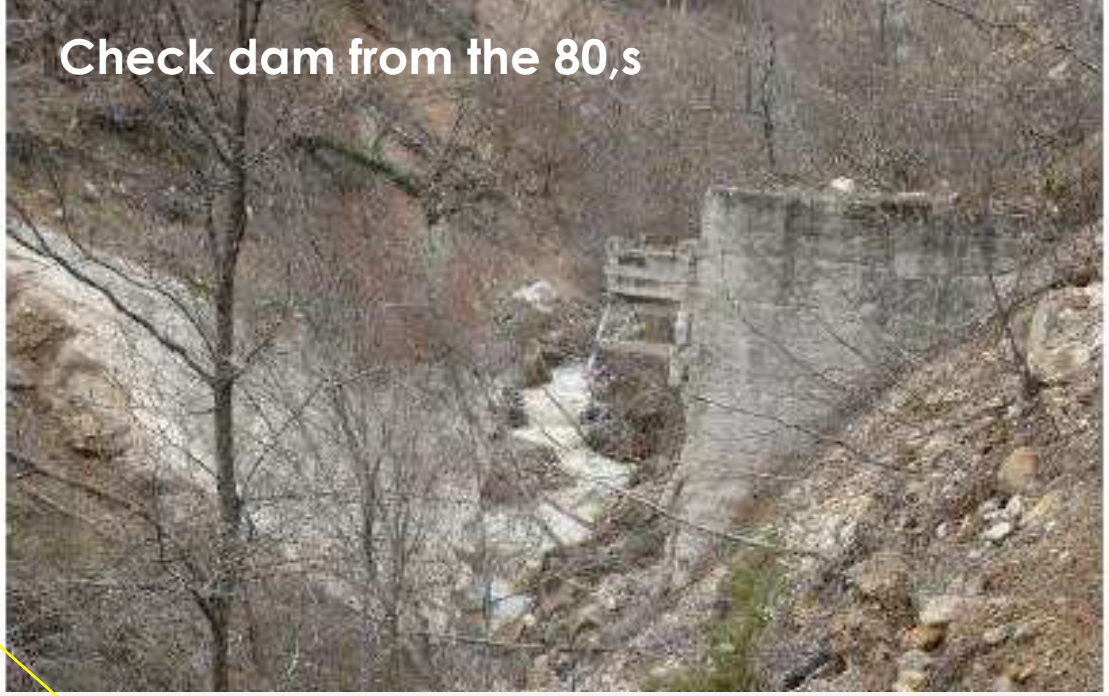
- Local population knowing the danger from this torrent has always avoided to settle the critical zones.

Torrent management projects in the past

- 1 – in the 30,s
- 2 - in the 50,s - canalizing of the torrent bed , classical closed check dams, all made by stone in cement mortar
- 3 – in the early 70,s – construction of open check dams – Herheulidze type
- These open check dams were destroyed later 1979 and later. Causes for this were: huge discharge, big boulders probably the biggest one registered (cca 30 m^3) , and low quality of construction (used local material, and concreting was done in situ that result in low concrete grade.

- Check dam from the 50,s
- Hk < 10 m and rests of small check dam

Слика 2. Проф. Херхеулидзе код прве изграђене преграде на Цепчишком потоку



Rests of Former Open Check Dams ms

Used Data

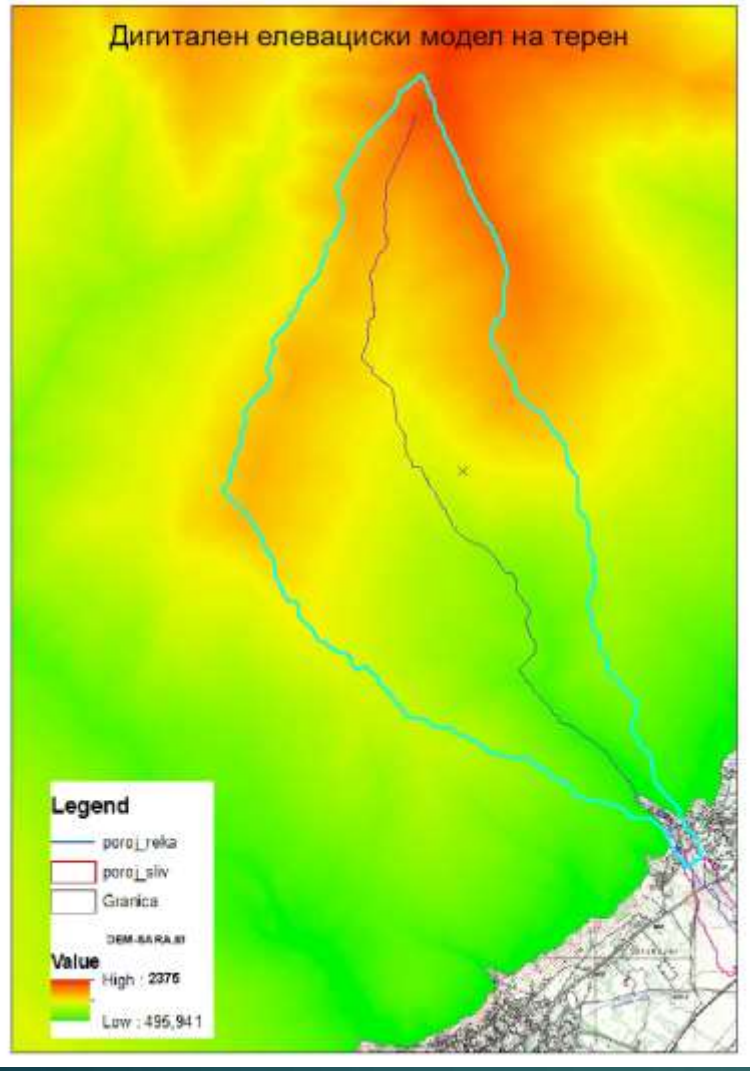
- Basic Maps, textual and tabular data
- - Topography, geology, soils, land cover/use, climate
- Various plans (forest management plan…..

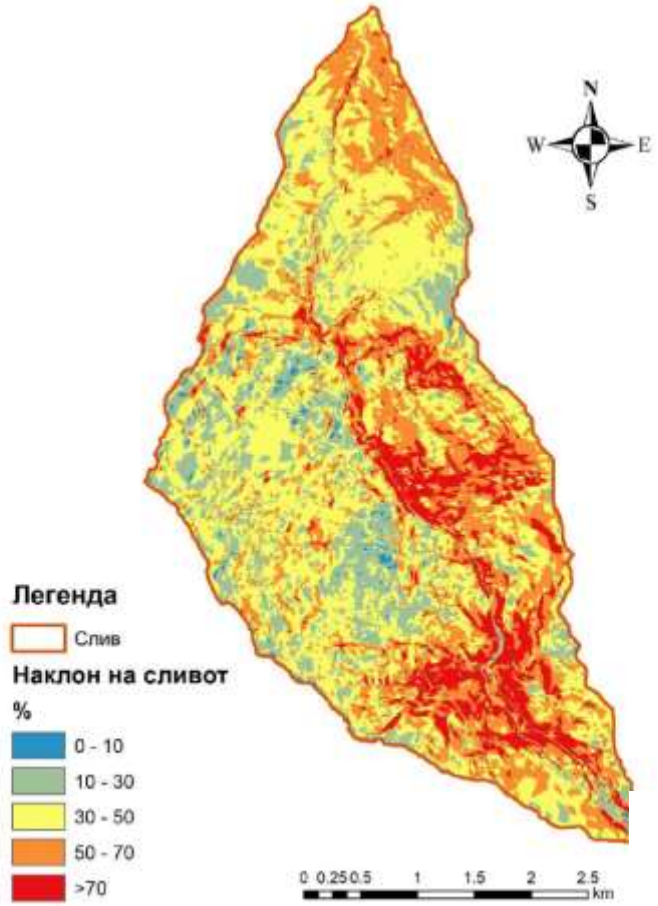
Aerial photo images (Google, LiDAR..) additional geodetic measuring by GIM team

Personal notices and photoset from past

Related projects and papers

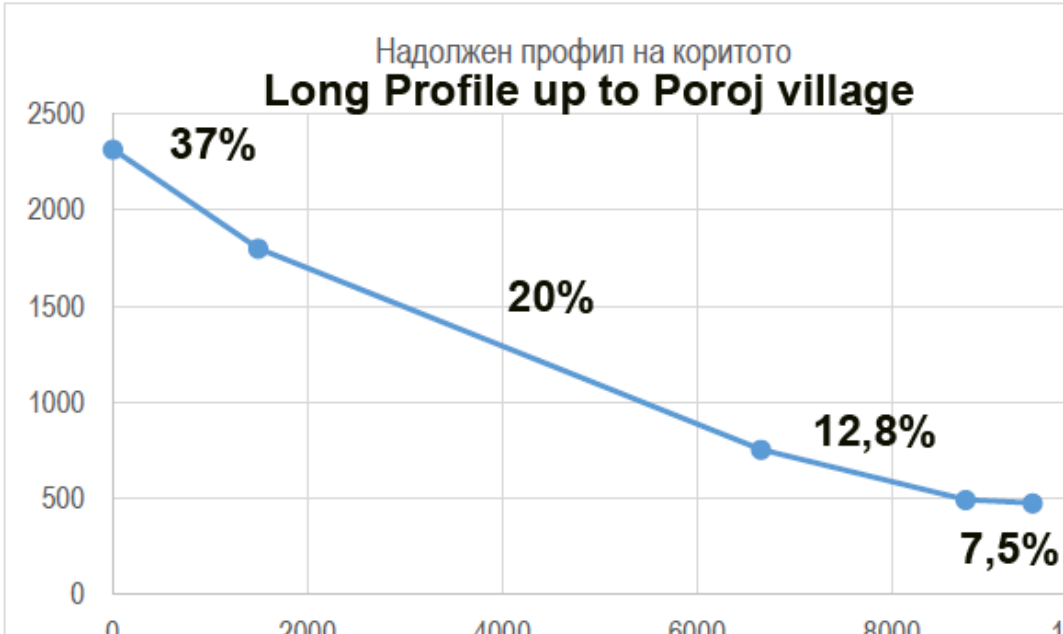
Basic characteristic



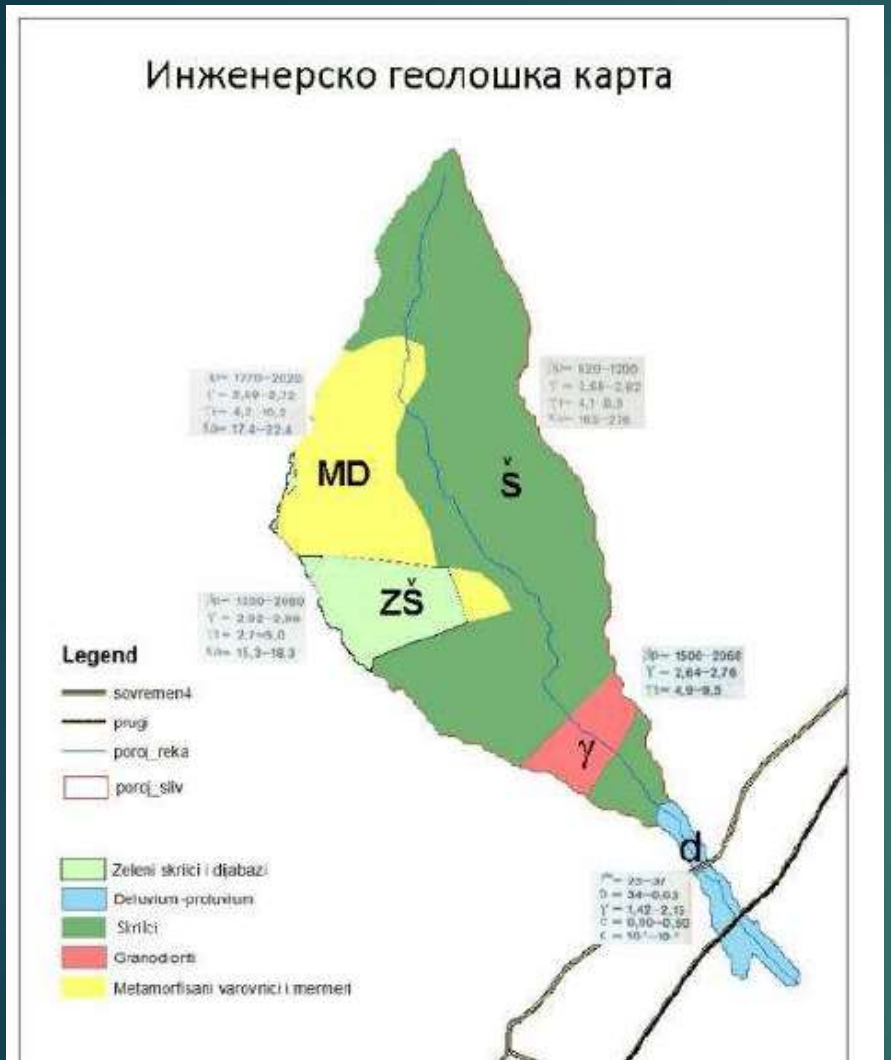


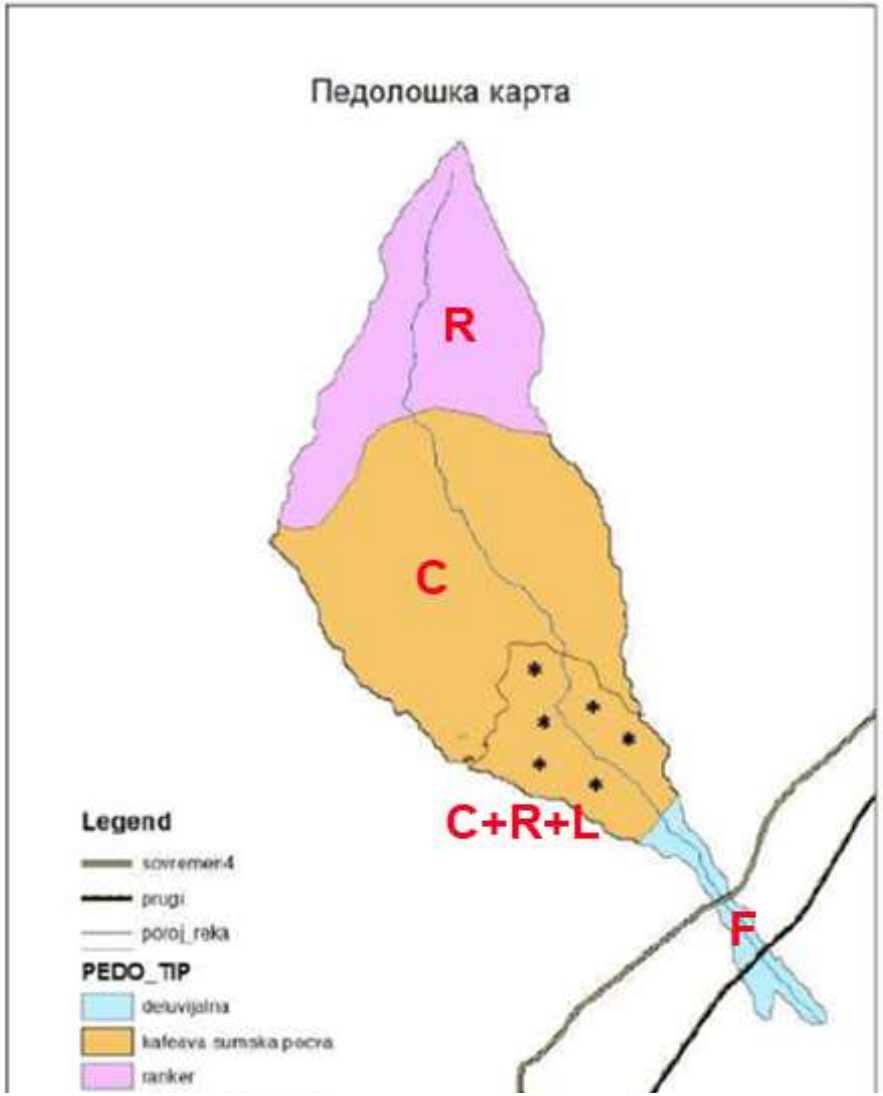
$A = 15{,}74\ km^2$

478 – 2376 masl



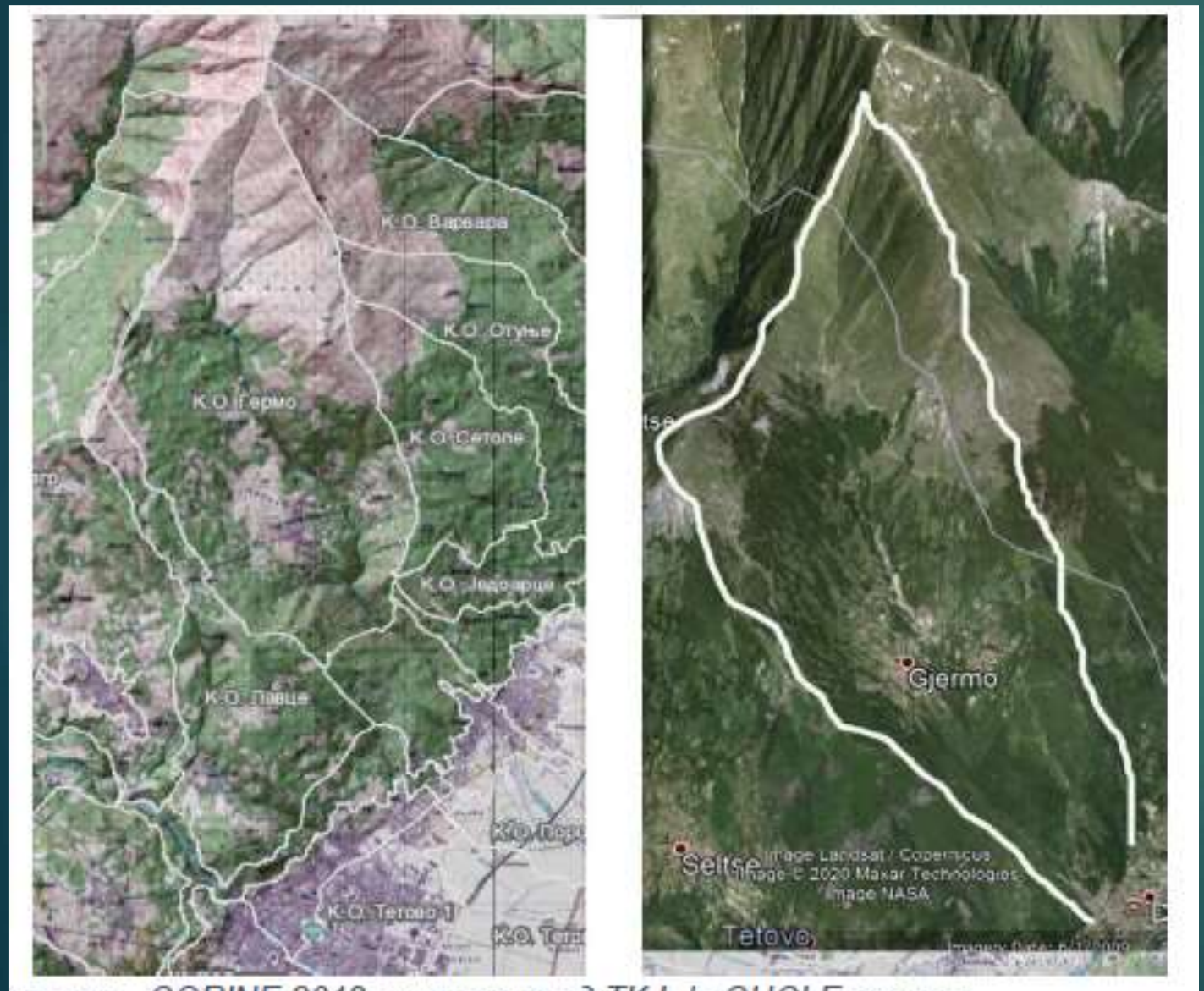
Geology and Soils

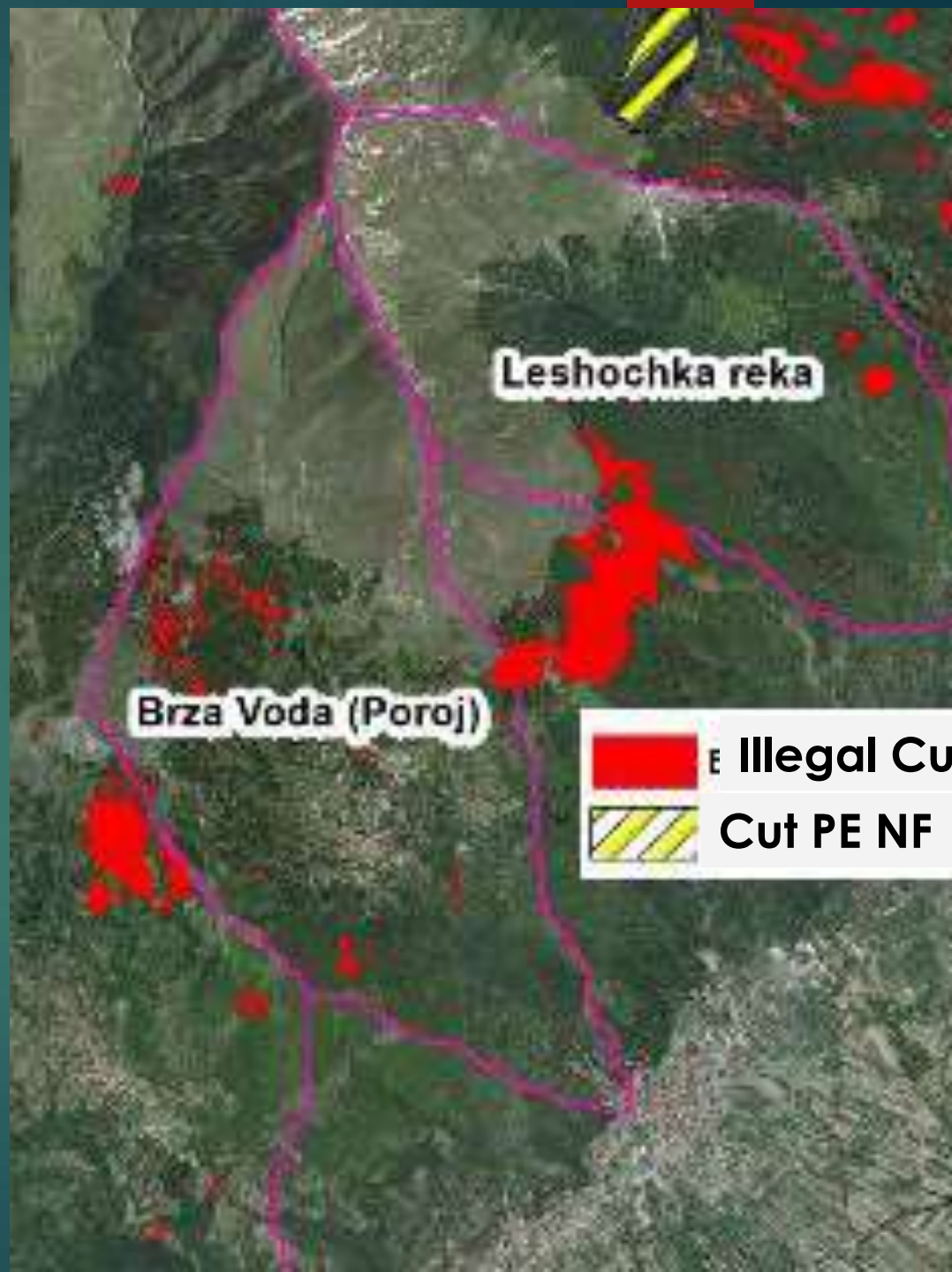




Почвен тип - Soil type		Depth	Txture class	water permeability	Hydraulic conductivity		pFC - 50 l//m2
Filipovski	WRB	cm (from-to)	C. L. S	low-high	K < 10 cm/day	K > 5 cm/d	low - medium to high
Камбисол	Cambisol	40-70	sandy loam	high	no	yes	medium to high
Ранкер	Mollic and Umbric Leptosol	50-60	skeJet sandy loam	good	no	yes	medium to high
Литосол (Лептосол)	Leptosol	до 20	skeleton-sandy	high	no	yes	medium to high

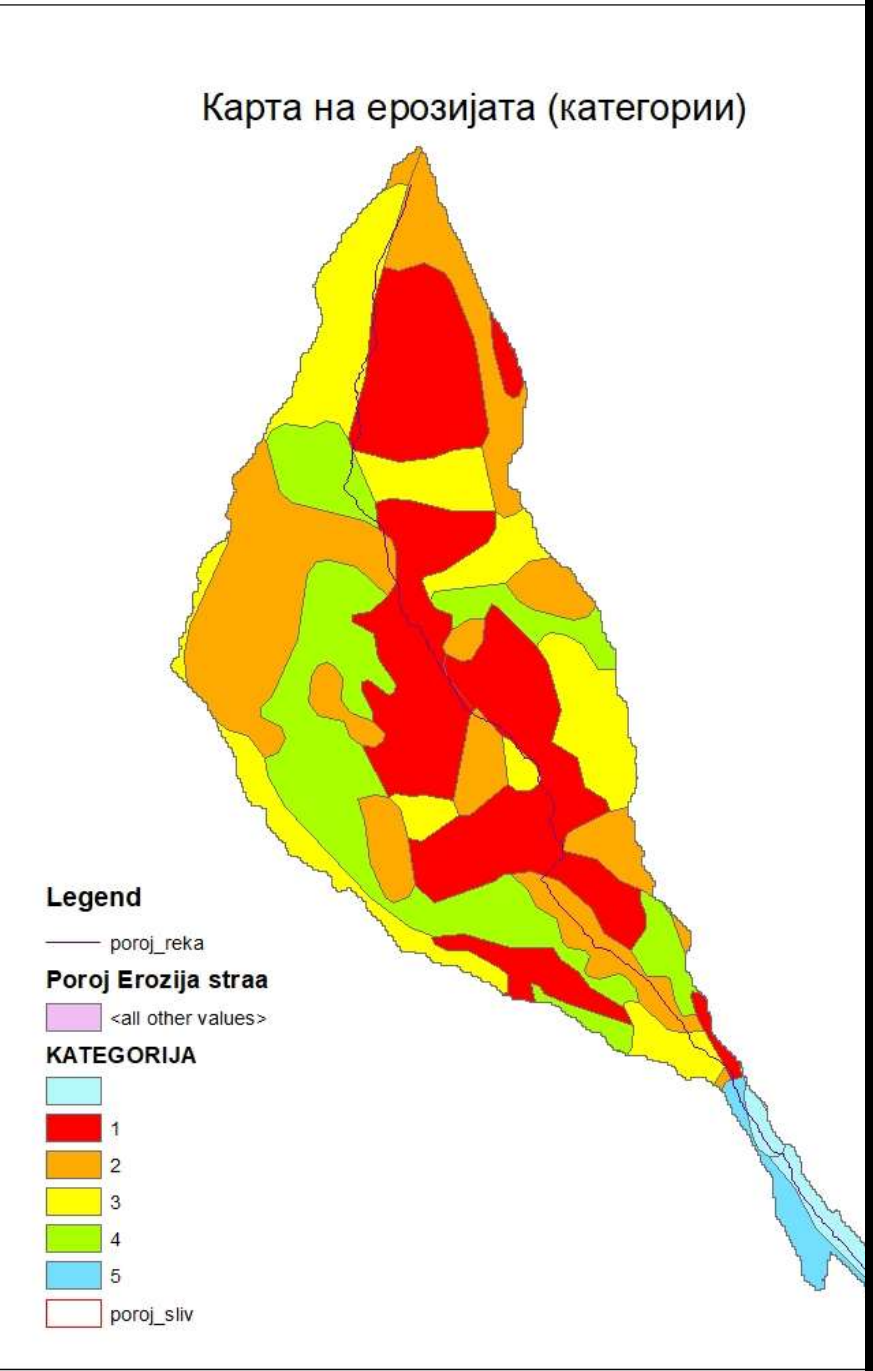
Land cover/use





Erosion and Sedimentation

- The main reason for high erosion process in Porojska Reka basin are:
- - extremely strongly developed relief, strong to extreme inclination of slopes and torrent bed that increase runoff and fast concentration of flood water;
- - shallow soils and rock types that are medium to highly susceptible to erosion processes;
- - frequent intensive short-term precipitation that cause intense rainsplash erosion, huge runoff, and in a combination of other factor erosion on slopes, fluvial erosion and mass movement erosion into t he torrent bed



Erosion coefficient

Z = 0,75

Production of erosive material

W = 30784 m^3/ann

Wsp = 1904 m^3/km^2 ann

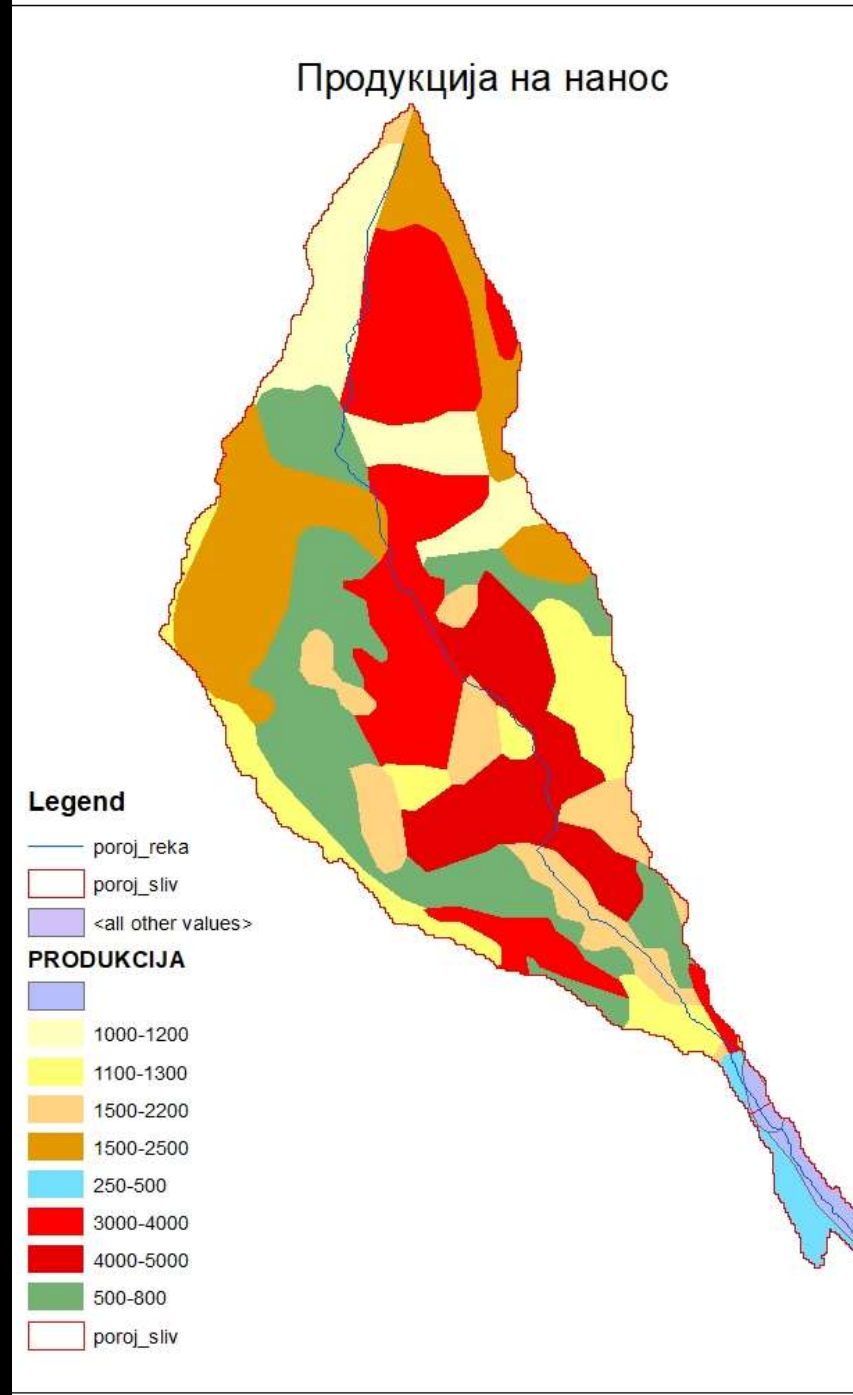
Rn – sediment delivery ratio

Rn = 0,85

Transported sediments

G = 26136 m^3/ann

Gsp = 1618 m^3/km^2 ann



Torrent classification - Aulitzky

- Criteria I – Danger - Debris flow torrent
- Criteria II – Generic class - all types of erosion

- Torrent characterization – 2,75 – potential for debris flows

- Torrent index – 3,7 - the most endangered

TASKS

- 1 – Sediment management upstream of the village
- 2 - Localized solution to reduce flooding on the regional road Tetovo - Jazince through a combination of measures that would include changes in road level, increasing the capacity of the bridge, construction of a new bridge, and object to capture the sediment.
- 3 – Solution for torrent flow in the part before the railway

1. Proposed solution for sediment management upstream from the village

- 1 - Decrease production of sediment as a results of rain bombing and slope runoff
- 2 - Decrease of production of sediments into the torrent bed as a result of fluvial erosion
- 3 – Retention of sediment
- 4 - Enabling disharge of suspended sediments

1 - Decrease of production of sediment as a results of rain bombing and slope runoff

- The only solution is improve of land cover

- - Afforestation of barelands
- - Planning and implementation sustainable forest management (possible measures is proclaiming of forest as Protective forest
- - Elimination (decrease) of illegal cut
- - implementing sustainable agricultural activities

2 - Decrease of production of sediments into the torrent bed as a result of fluvial erosion

3 – Retention of sediment

4 - Enabling disharge of suspended sediments

- Combination of check dams constructed on existed ruined structures.

- There are foundations walls and basement (they are in a good condition) that could be used for new structures

The most upstream dam

- Open dam - for stopping the biggest boulders (steel or armature concrete)

The mid check dam - lattice construction
(steel or armature concrete or combination)

Open dam - for stopping boulders

The lowest check dam - classical dam (armature concrete) + possible barriers made of steel mesh

2 - Localized solution to reduce flooding on the regional road Tetovo - Jazince through a combination of measures that would include changes in road level, increasing the capacity of the bridge, construction of a new bridge, and object to capture the sediment.

Hydrology

The calculation of the relevant flood flows with a low frequency of occurrence in this study was performed using two most commonly used hydrological methods:

- Rational theory and
- Synthetic Hydrograph Method

Hydrology

Despite these calculations, we performed an analysis of the flooding and by using several well known empirical methods.

- Anvelope curves
- Method of Gavrilovic
- An analysis of the hydraulic parameters of the flow for determined traces in the village of Poroj during the floods occurred in 2017, on the basis of which the maximum flow rate was defined.

Hydrology

	Applied method	Q_{100} (m^3/s)
1	Rational method	44.3 (52)
2	SCS CN method	9.6 (37.7)
3	Anvelope curves of I.J. Cherny	29.2 - 50.5
4	Gavrilovic Method	56
5	Directly through field investigations *	72

* In this method the return period of the event can not be determined

Qdf = 5-40 Qwf

Hydrology

Starting from the principle of providing the necessary degree of protection of the regulation and all infrastructure facilities that interact with it, the following recommendations are given for the adoption of the relevant flows for dimensioning the facilities of the torrent regulation:

- Facilities to be dimensioned on flood flows with a return period of 100 years.
- Due to the large amount of debris flow , fallen trees and various coarse waste, the clearance (especially at the bridge on the regional road Tetovo - Jazince) to be adopted 1.5 - 2 m.
- The relevant flows with a return period of 100 years to be adopted in the order of size of 50 - 55 m^3/s.
- To the water quantities defined in this way, add the presence of sediment in an amount of 30-50% of the adopted water quantity.

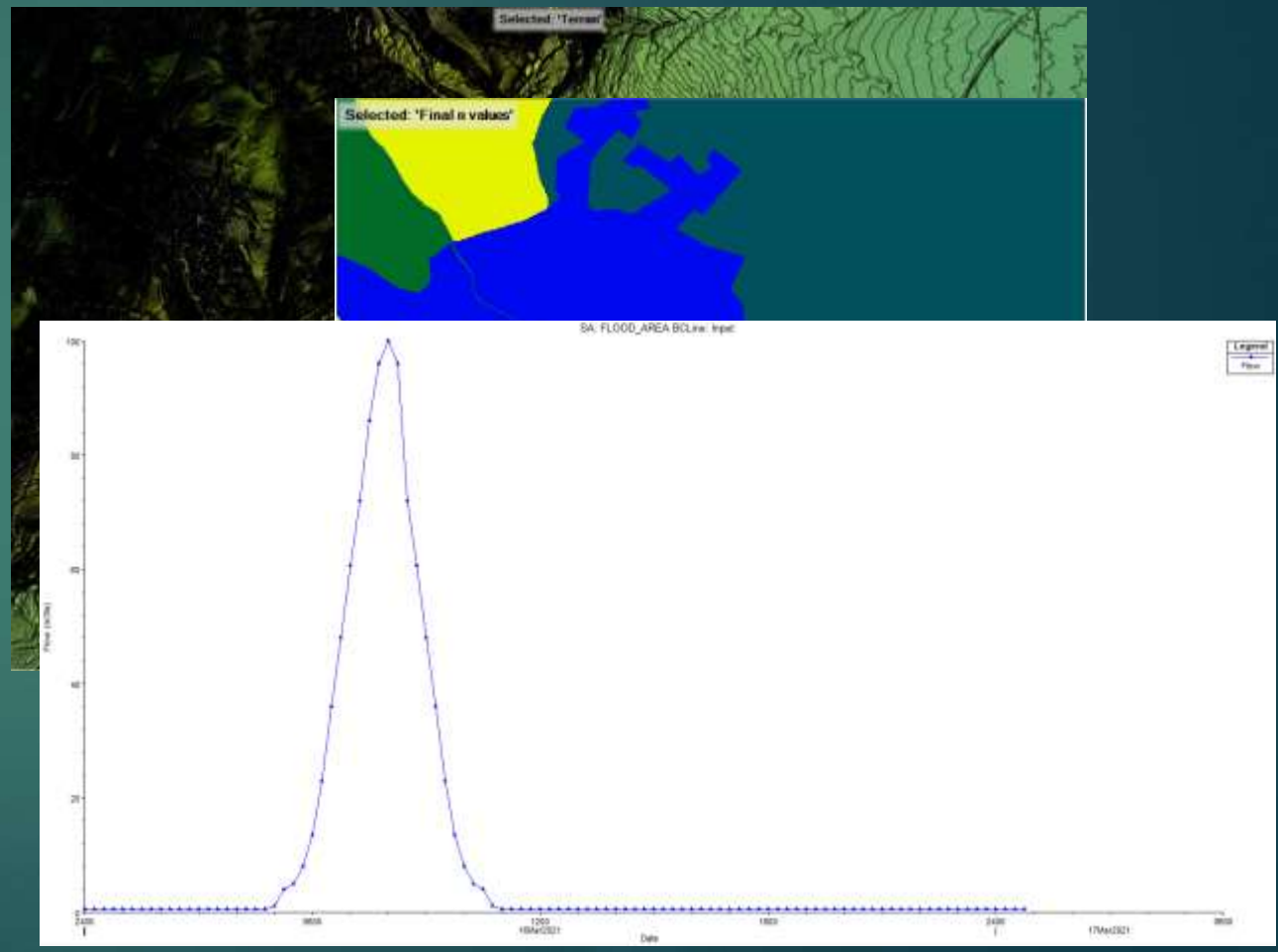
Hydraulic analyses

In the hydraulic analysis of the current condition of the river Poroj, the software HEC - RAS 2D with two-dimensional concept was used.

Hydraulic analyses

INPUT DATA

- DEM
- LAND COVER DATA
- INPUT HYDROGRAPH



Hydraulic analyses

OUTPUTS

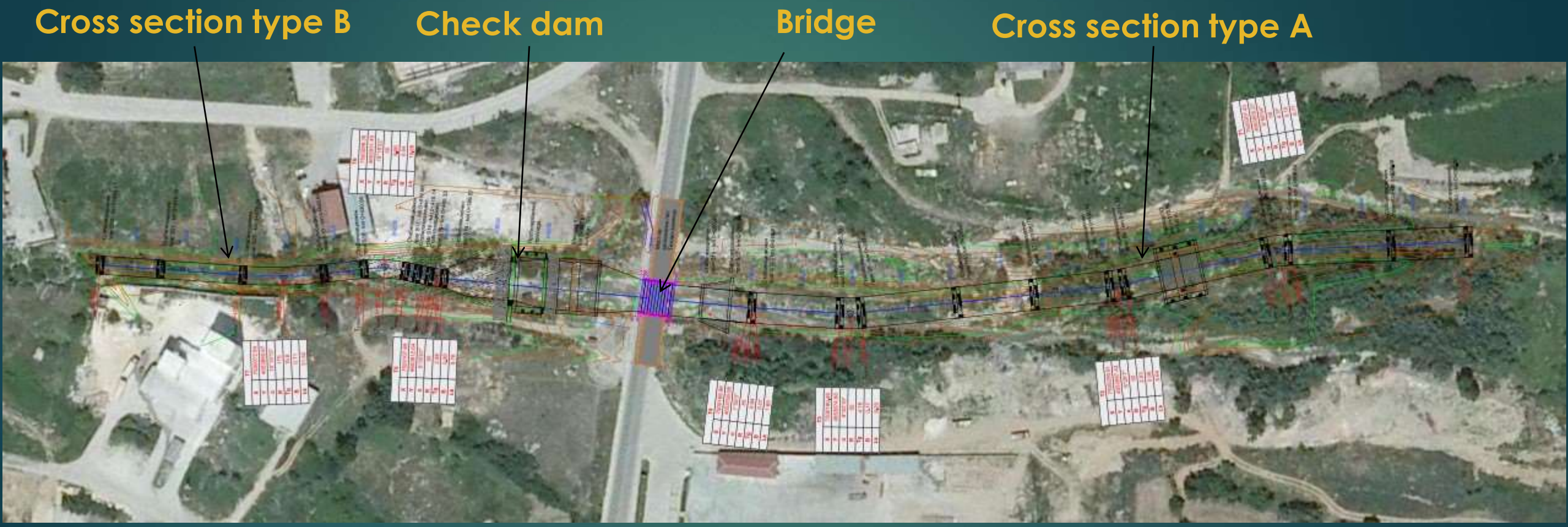
- WATER DEPTHS
- VELOCITIES
- SHEAR STRESS

Hydraulic analyses

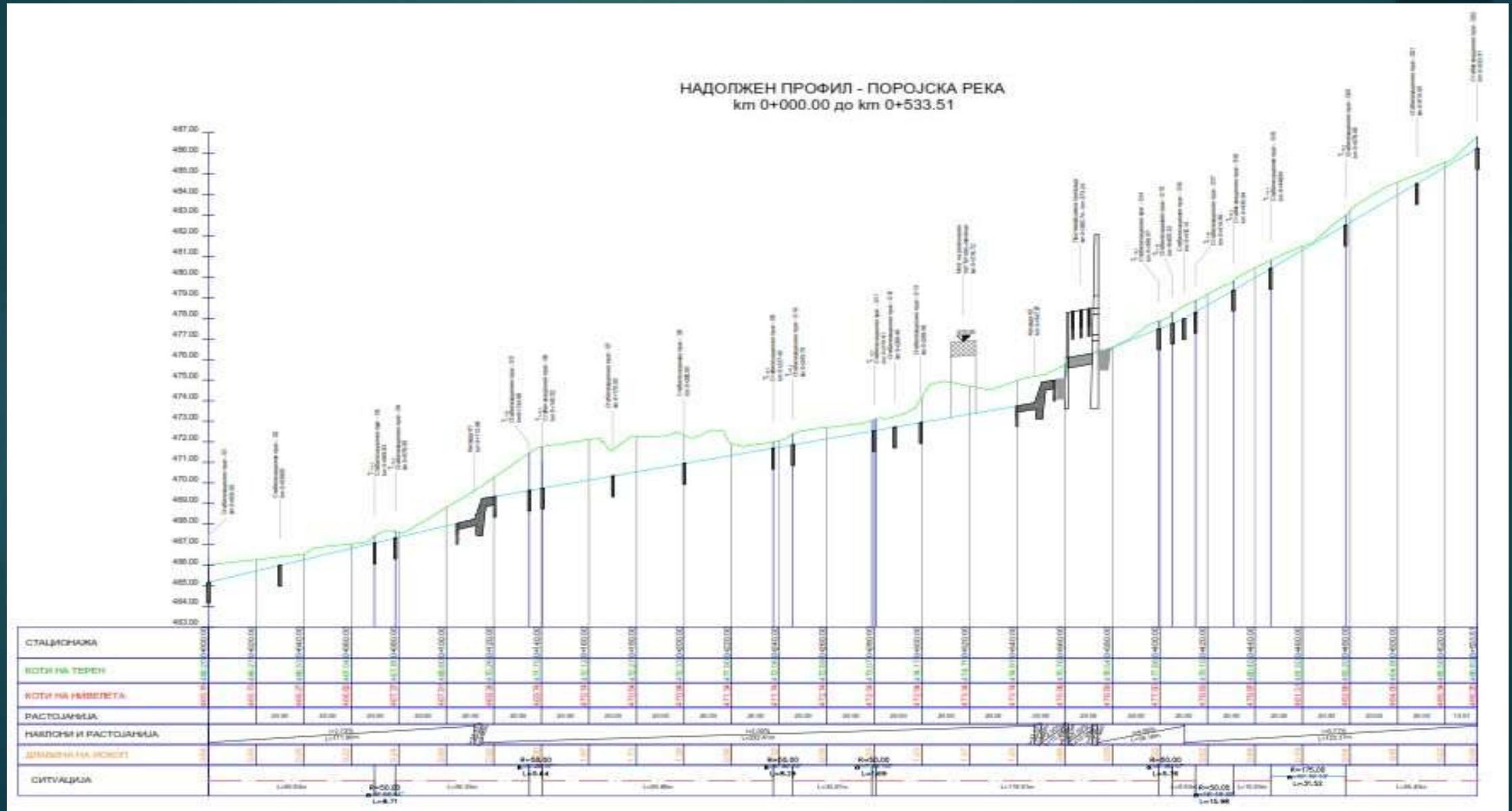
CONCLUSIONS

- The natural riverbed of the Porojska river in the village of Poroj in current conditions (state 2020), has a capacity of about 100 m^3/s. This is due to the large longitudinal slope which is about 7%.
- The local floods upstream from the bridge on the regional road Tetovo - Jazince occurs due to the narrowing (clogging) of the river in the zone of the existing bridges and the pipe culvert.
- The bridges in the village of Poroj, and especially the bridge on the regional road Tetovo-Jazince have a capacity of about 80 m^3/s
- Maximum calculated velocities of 12 m/s (15 m/s) and shear stresses of 800 N/m^2 (1000N/m^2) indicate destructive erosive forces that caused erosion in the riverbed and transport of sediment downstream.

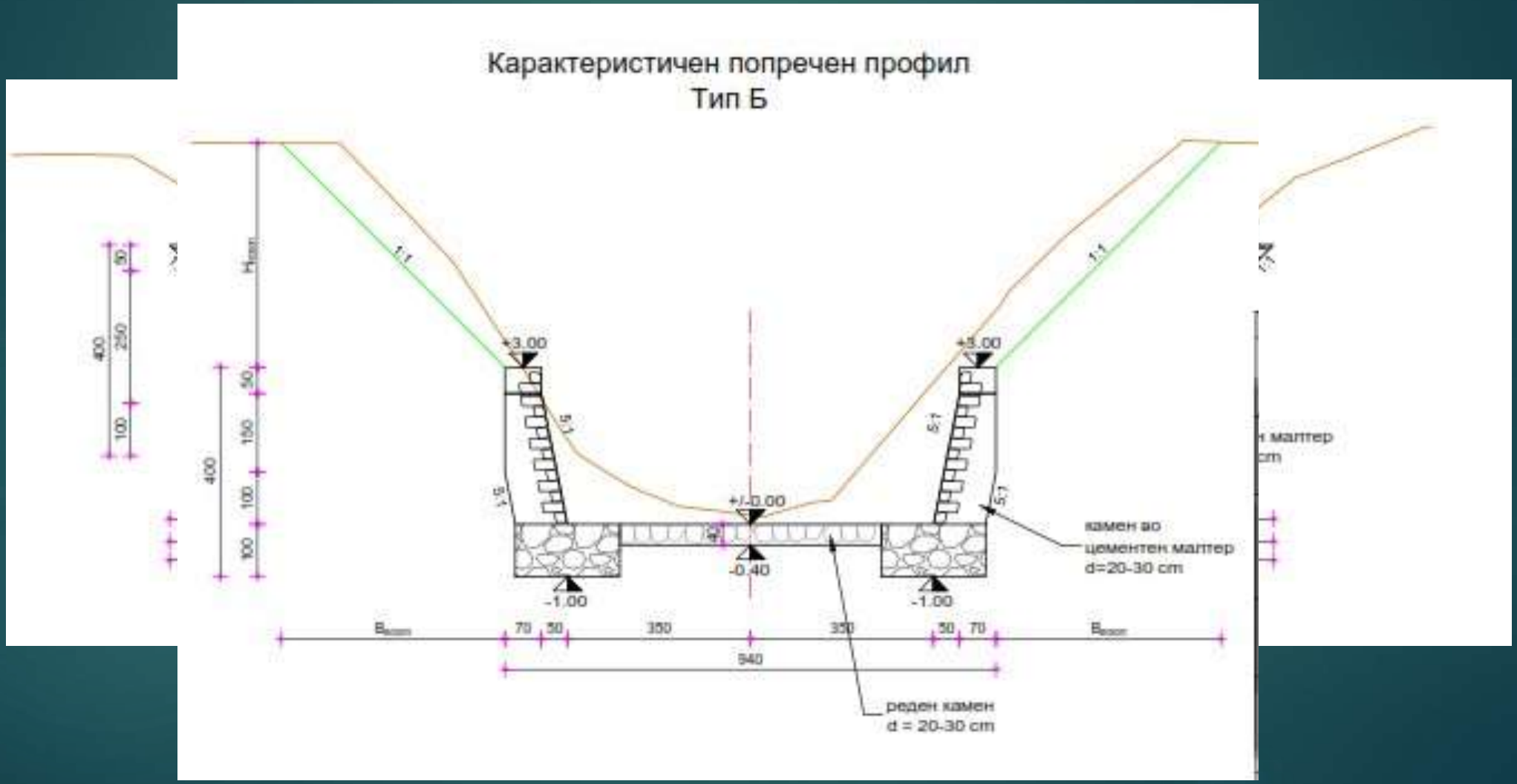
Technical proposal - plan



Technical proposal – longitudinal section



Technical proposal – cross sections

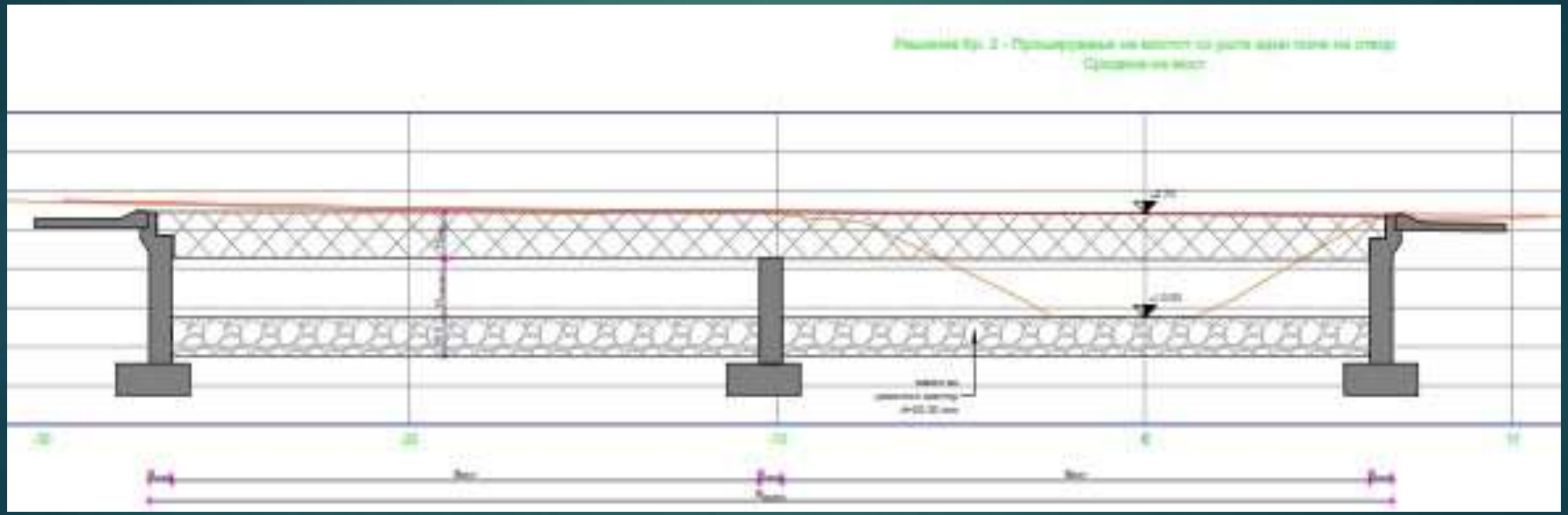


Technical proposal – bridge 1

Price: 721,000.00 EUR

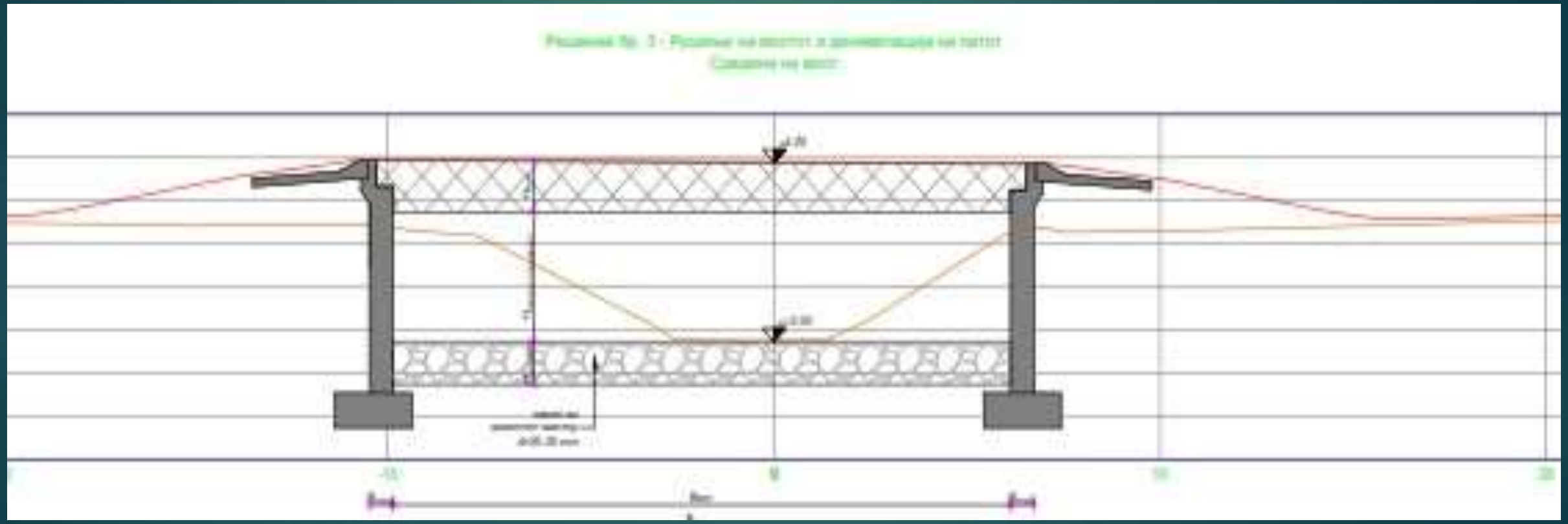
Technical proposal – bridge 2

Price: 1,276,000.00 EUR

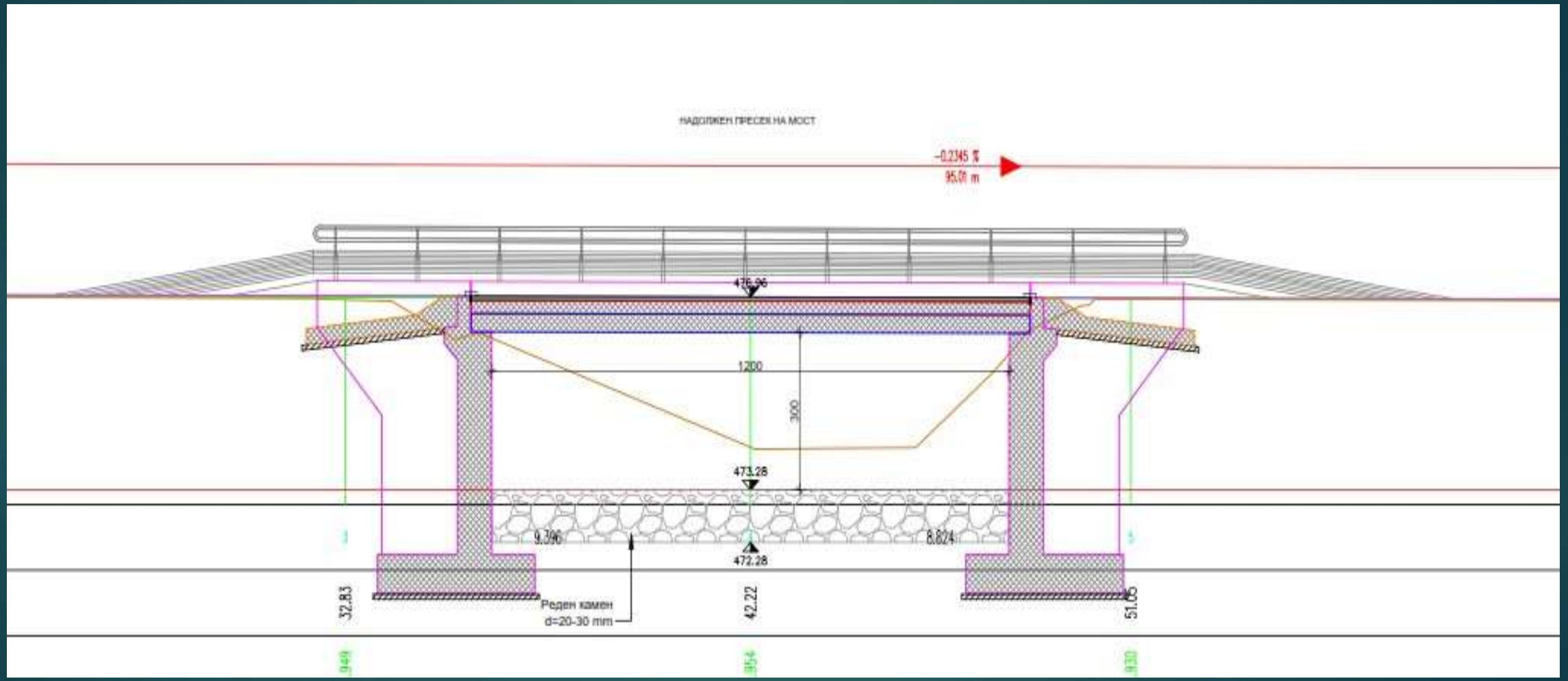


Technical proposal – bridge 3

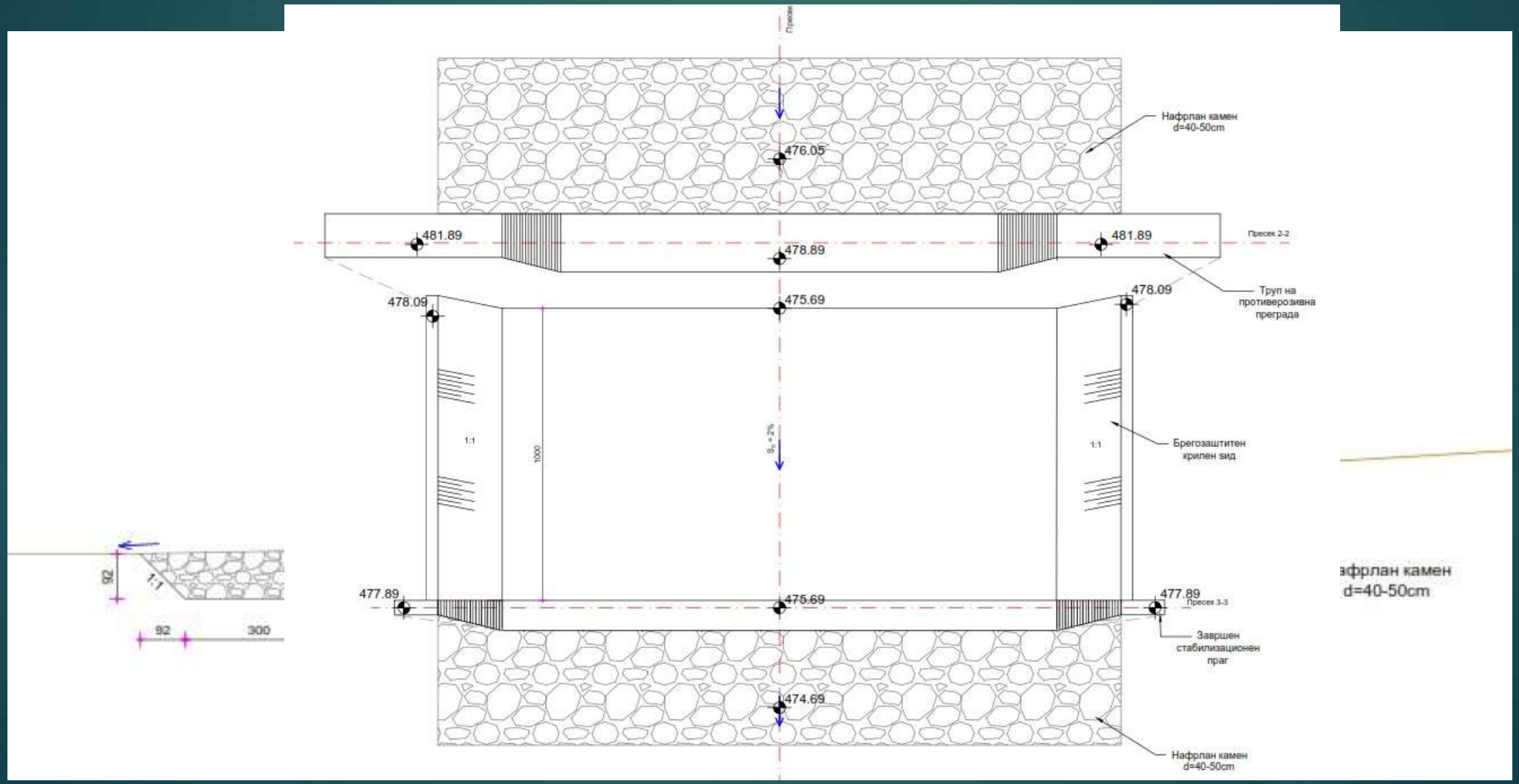
Price: 1,076,000.00 EUR



Technical proposal - bridge



Technical proposal – check dam



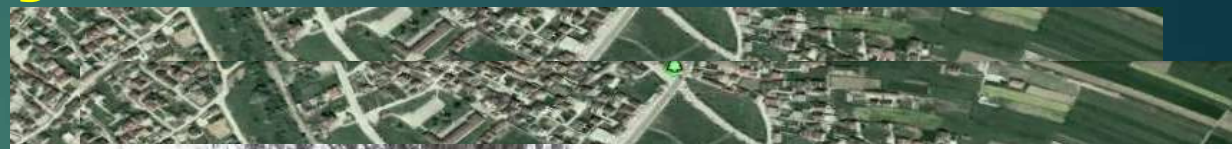
3 – Solution for torrent flow in the part before the railway

First solution

- to build an embankment on the left side,
- to allow controlled flooding of the right inundation

Second solution

- clearing of a landfill from construction debris and
- opening of a new riverbed (the old riverbed of the river Porojska)



ABANDON
agricultural
land
now is forest

Original torrent bed

Abandon arable land > 15 years

Ecosystem based adaptation

Possible redirection to original bed (neighborhood is abandon land).

Natural green area vs. Arable land

It is your choice!

THANK YOU FOR YOUR ATTENTION

- PHOTO 03.03.2021

SUPPLEMENTAL

- PHOTO 10.06.2021