Co-funded by the Erasmus+ Programme of the European Union

Innovative and scientific approaches in water resources management

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University of Rijeka, Faculty of Civil Engineering (UNIRIFCE)

Theme-based training of teaching staff for acquiring new teaching and learning methods, Rijeka, 19/09/2019

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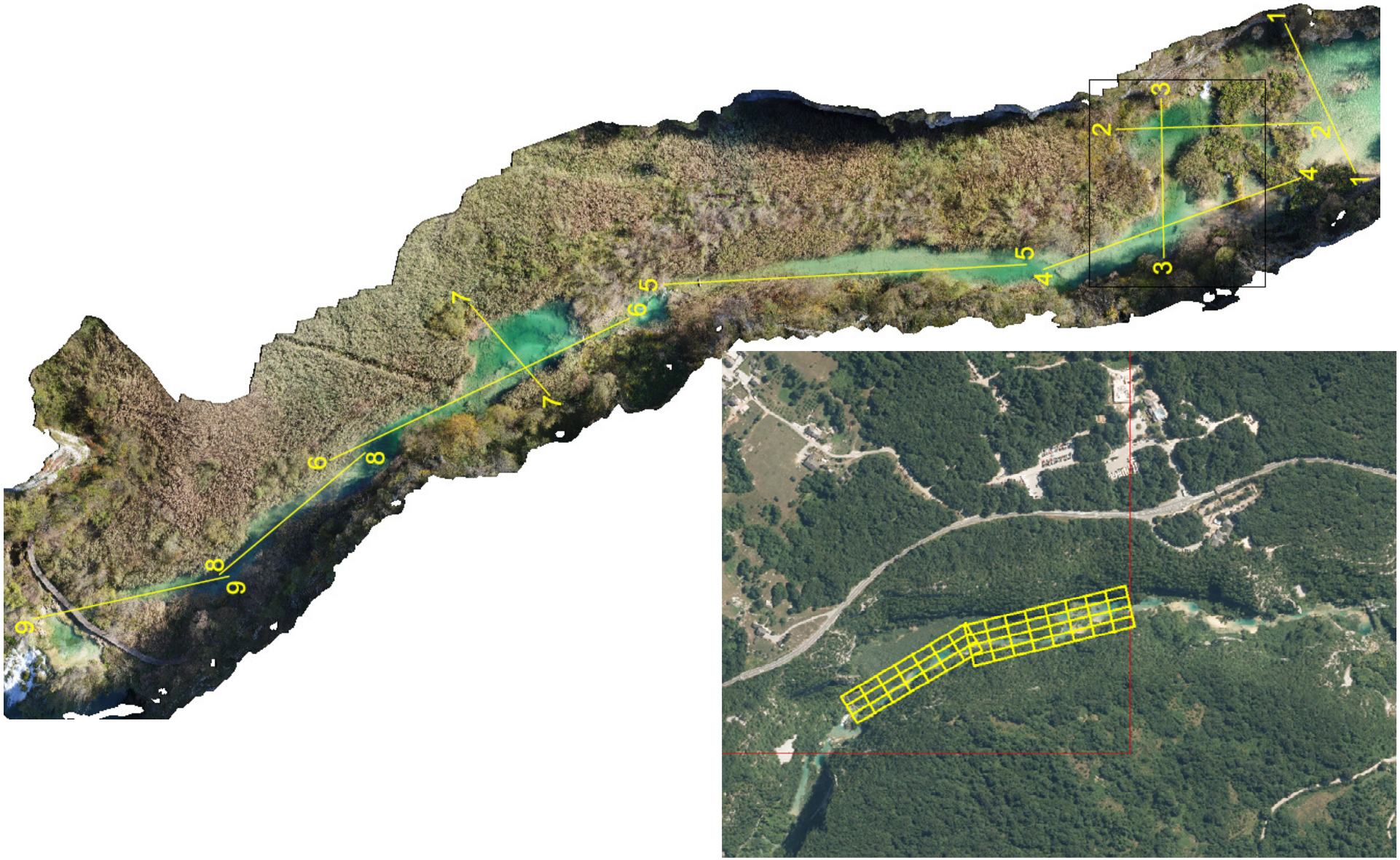
Application of 3D technologies

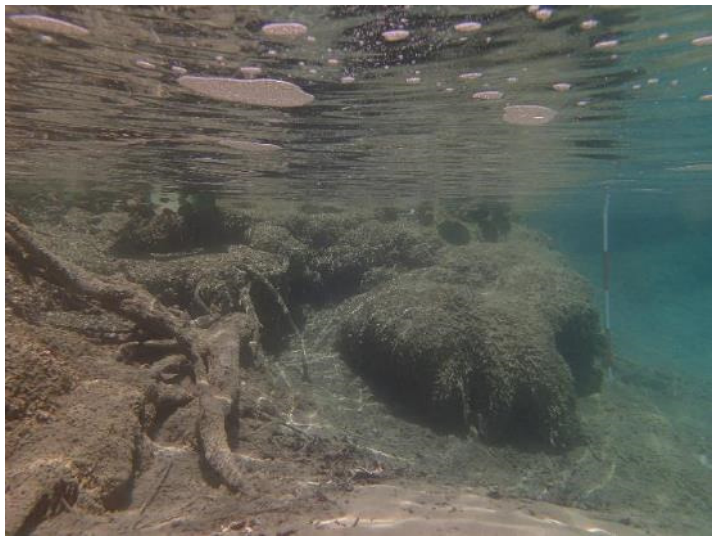
- SfM photogrammetry - Monitoring of morphological changes of the river Korana by SfM photogrammetry
- 3D monitoring and analysis of Bridges in Nin after the flood and damage of the bridges in 2017
- Measurement of groundwater and sea level in the Euphrasian Basilica complex in Poreč
- Coastal Vulnerability Indeks Analysis –the application of 3D technology

Plitvice Lakes National Park



Plitvice Lakes National Park

- Investigations of the morphological changes of the Korana River flow, Plitvice Lakes National Park.
- Monitoring: 3D point clouds generated from a image sets, taken by a UAV using Structure-from-Motion photogrammetry.
- More than 400 m of morphologically complex Korana river bed was recorded.



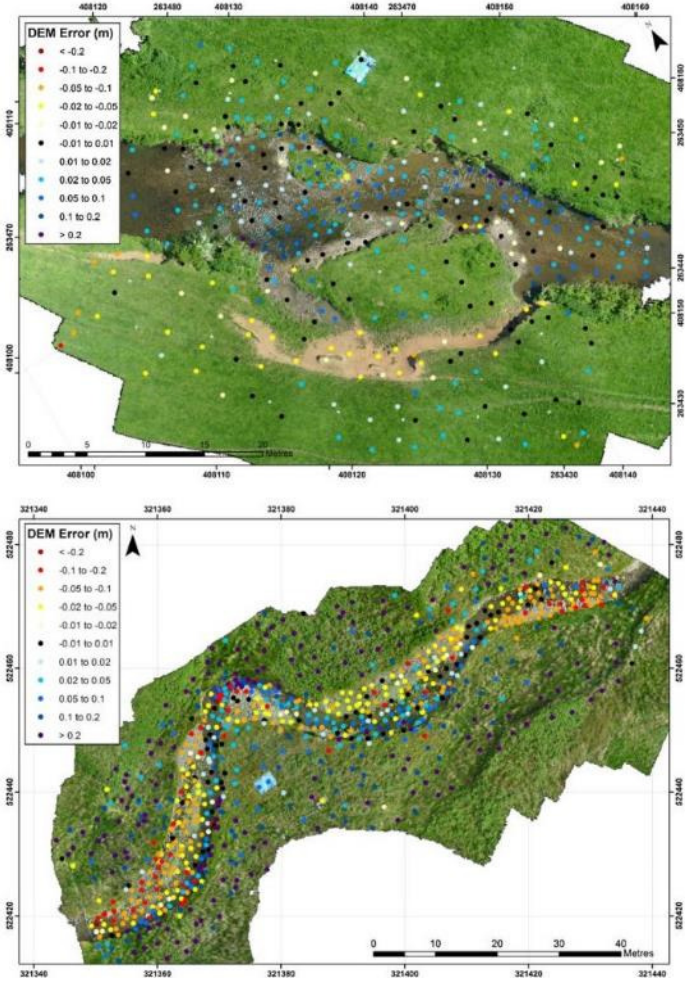
Plitvice Lakes National Park

The technologies for monitoring (Woodget et al., 2014)

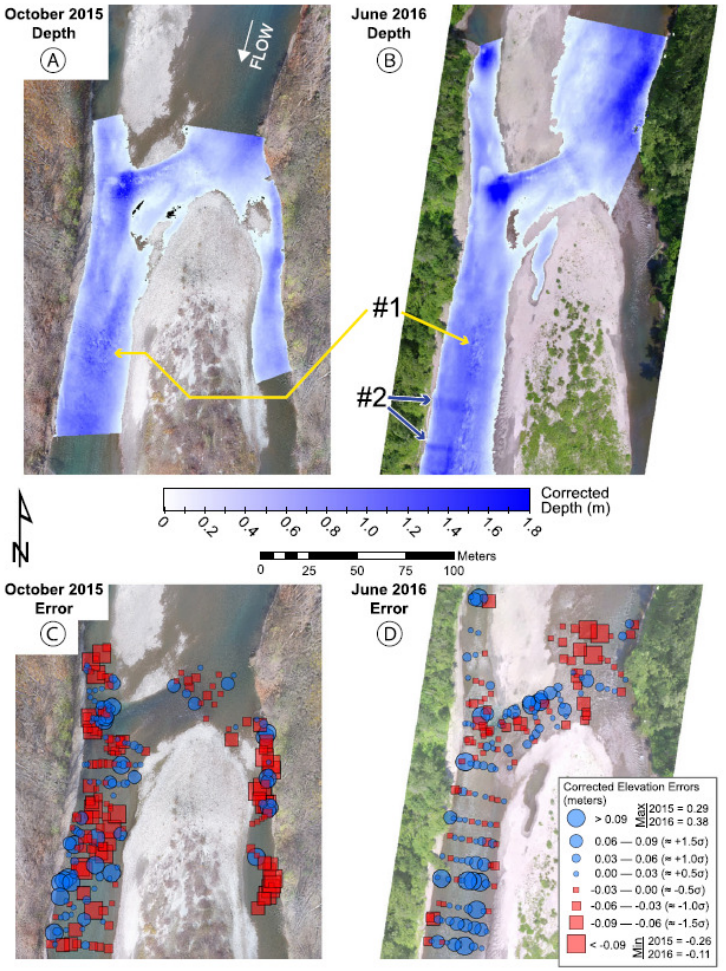
Table I. Comparison of topographic products obtained using remote sensing techniques during field tests. Values for submerged areas are shown in italics

Approach	Typical mean error (m)	Typical spatial resolution (m)	Typical mean water depth (m)	Typical max. water depth (m)	References
Spectral-depth relationship	*0.10*	*0.05 – 4.00*	*<1.00*	*1.00*	Winterbottom and Gilvear, 1997; Westaway *et al.*, 2003; Carbonneau *et al.*, 2006; Lejot *et al.*, 2007; Legleiter, 2012, 2013
Digital photogrammetry	0.05-0.17 *0.10*	0.05 – 1.00 *0.09*	N/a *<0.60*	N/a *0.60*	Westaway *et al.*, 2001; Westaway *et al.*, 2003; Lejot *et al.*, 2007; Feurer *et al.*, 2008; Lane *et al.*, 2010
Bathymetric LiDAR	*0.10-0.30*	*1.00*	*<1.00*	*3.90*	Kinzel *et al.*, 2007; Feurer *et al.*, 2008; Bailly *et al.*, 2010, 2012
TLS	0.004-0.03 *0.01-0.10*	<0.05 *1.00*	N/a *0.10*	N/a *0.50*	Heritage and Hetherington, 2007; Bangen *et al.*, 2014; Smith and Vericat, 2013

Plitvice Lakes National Park

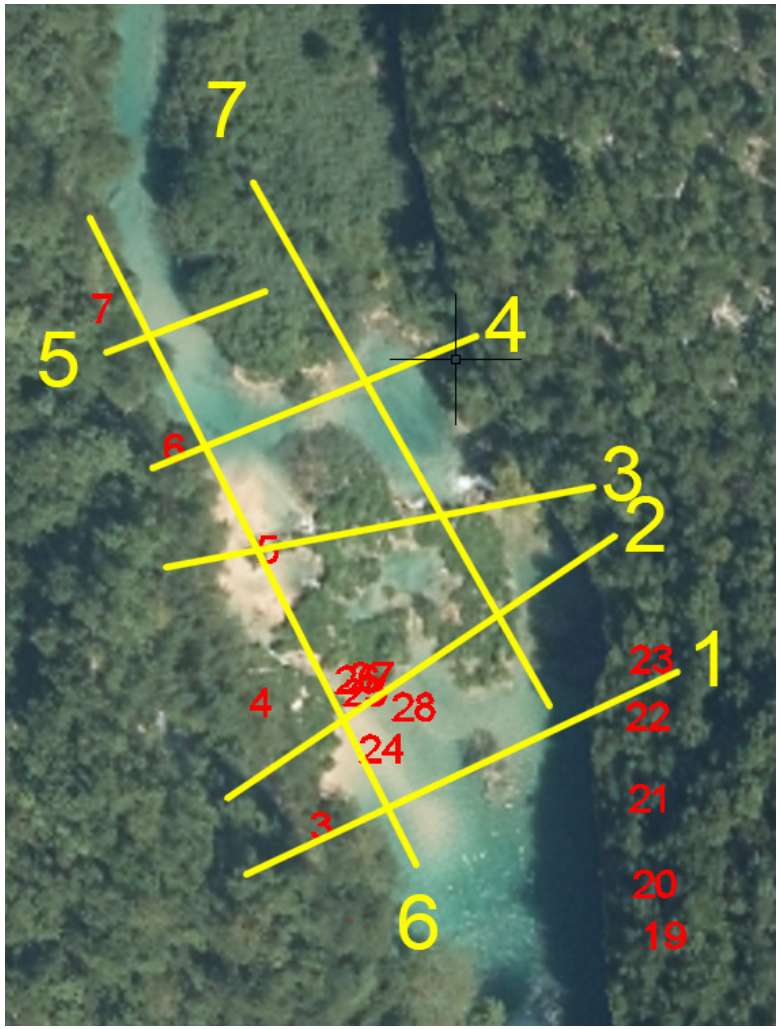


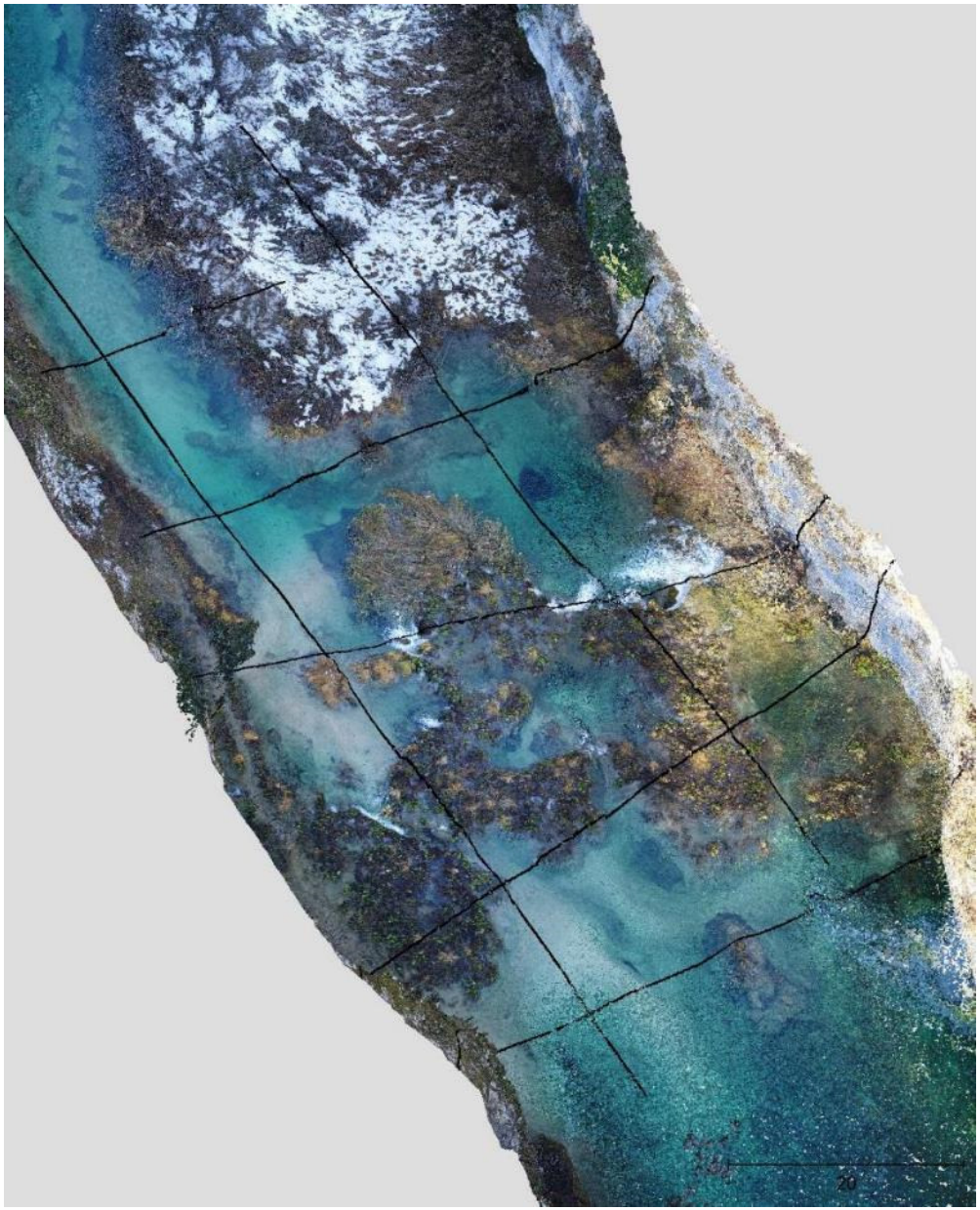
Woodget i drugi, 2015



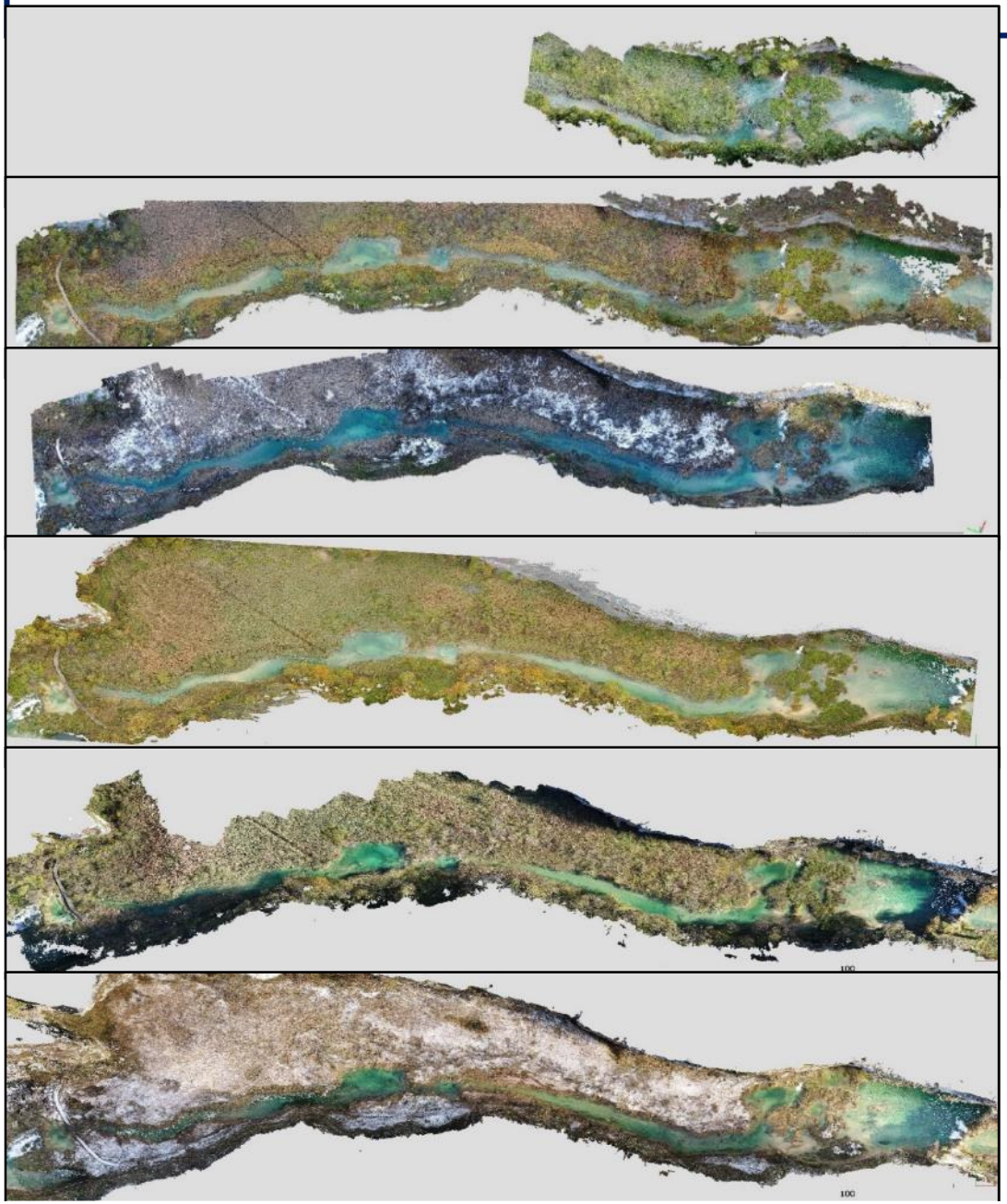
Dietrich i drugi, 2015

Plitvice Lakes National Park



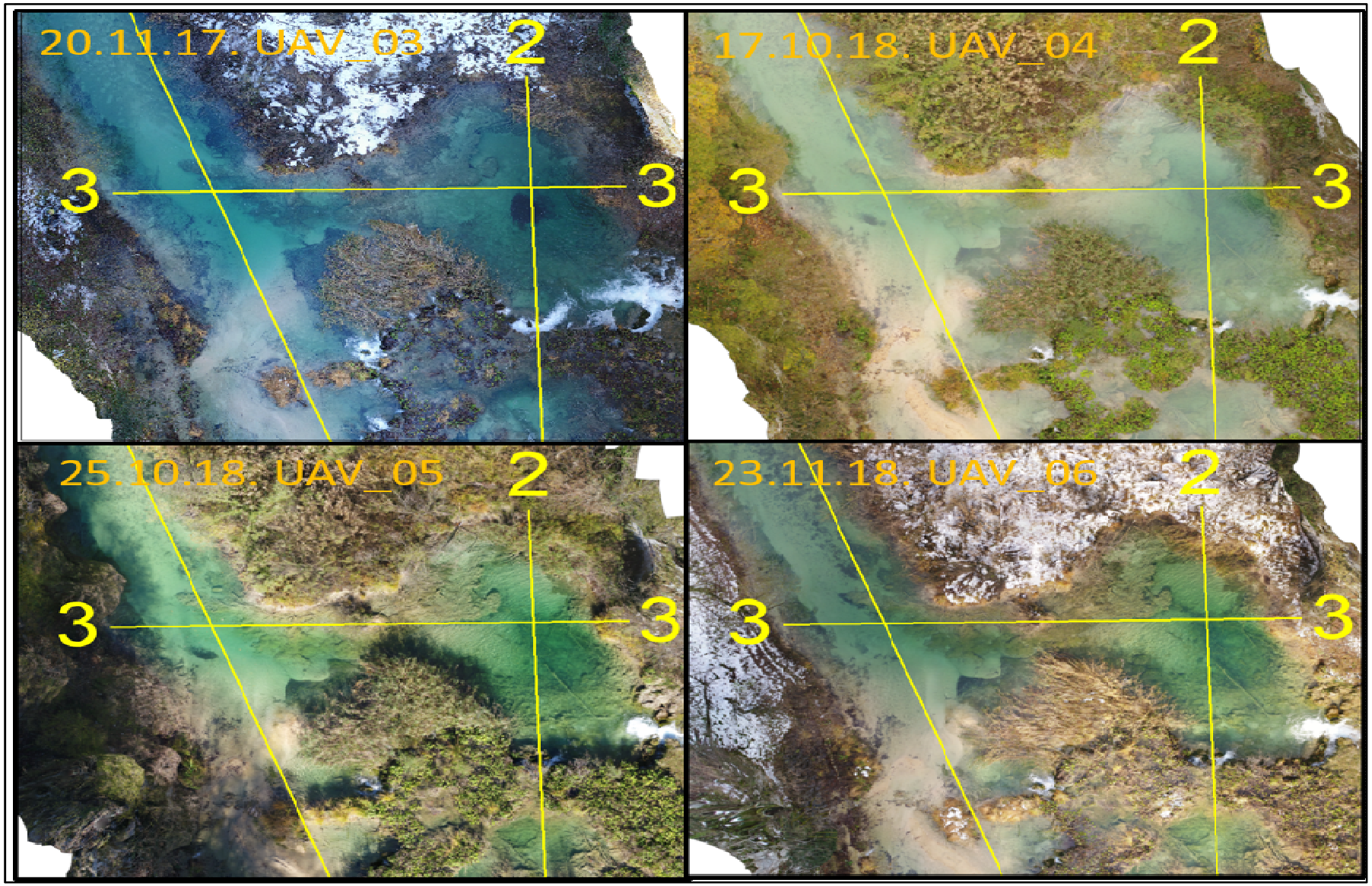


Plitvice Lakes National Park

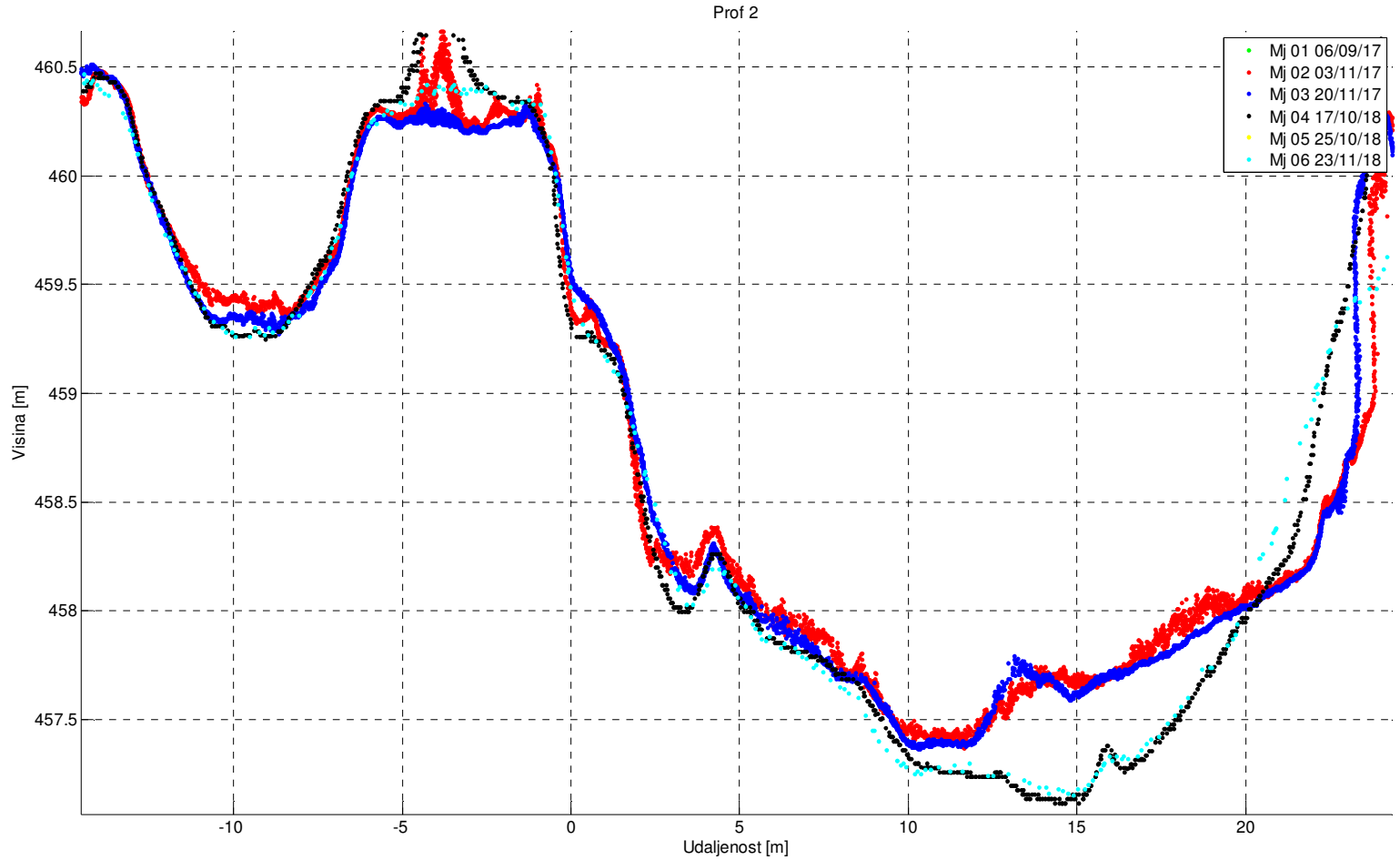


R. Br.	Datum snimanja	Oznaka mjerenja
1	06.09.17.	UAV_01
2	03.11.17.	UAV_02
3	20.11.17.	UAV_03
4	17.10.18.	UAV_04
5	25.10.18.	UAV_05
6	23.11.18.	UAV_06

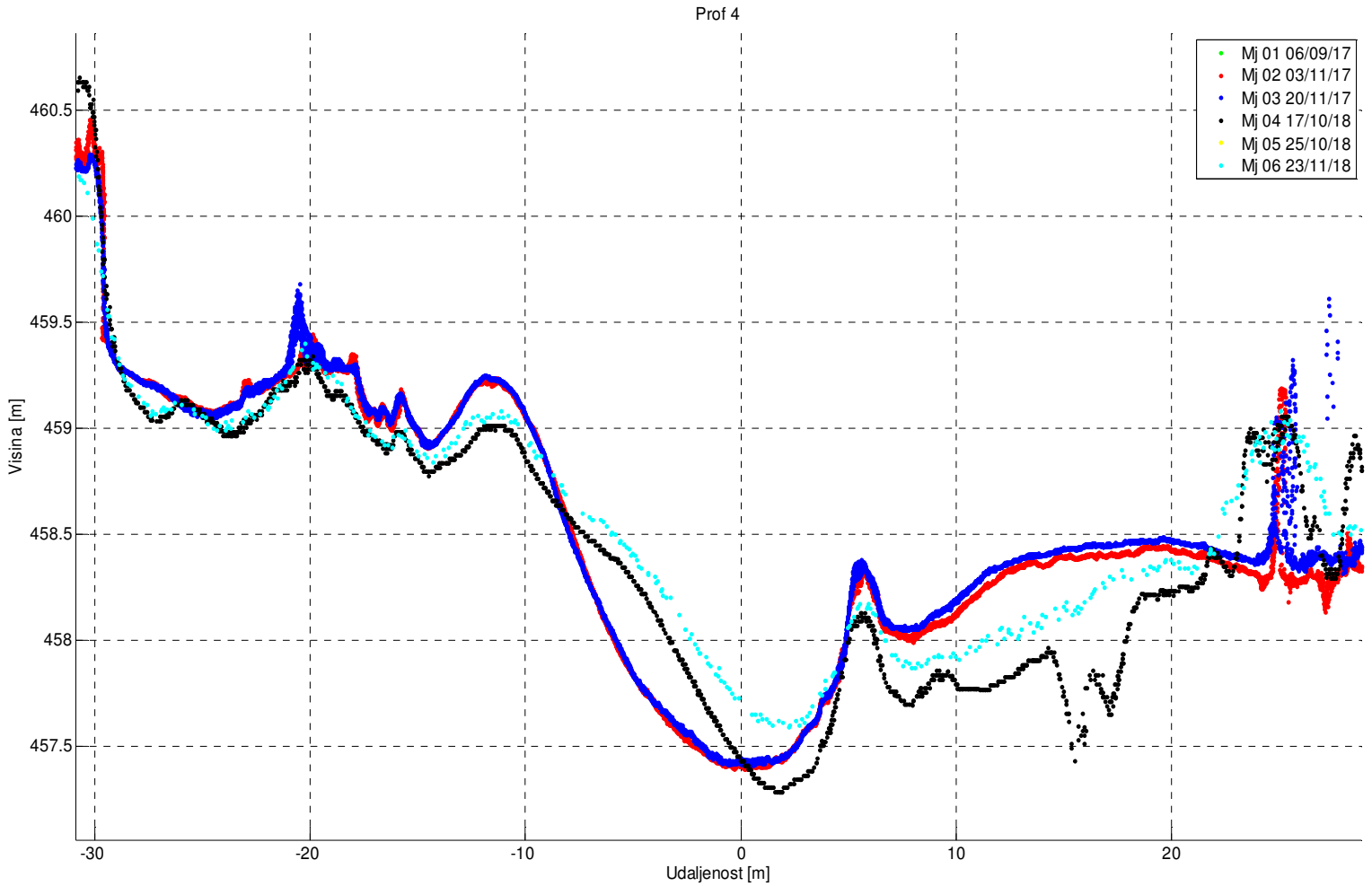
Plitvice Lakes National Park

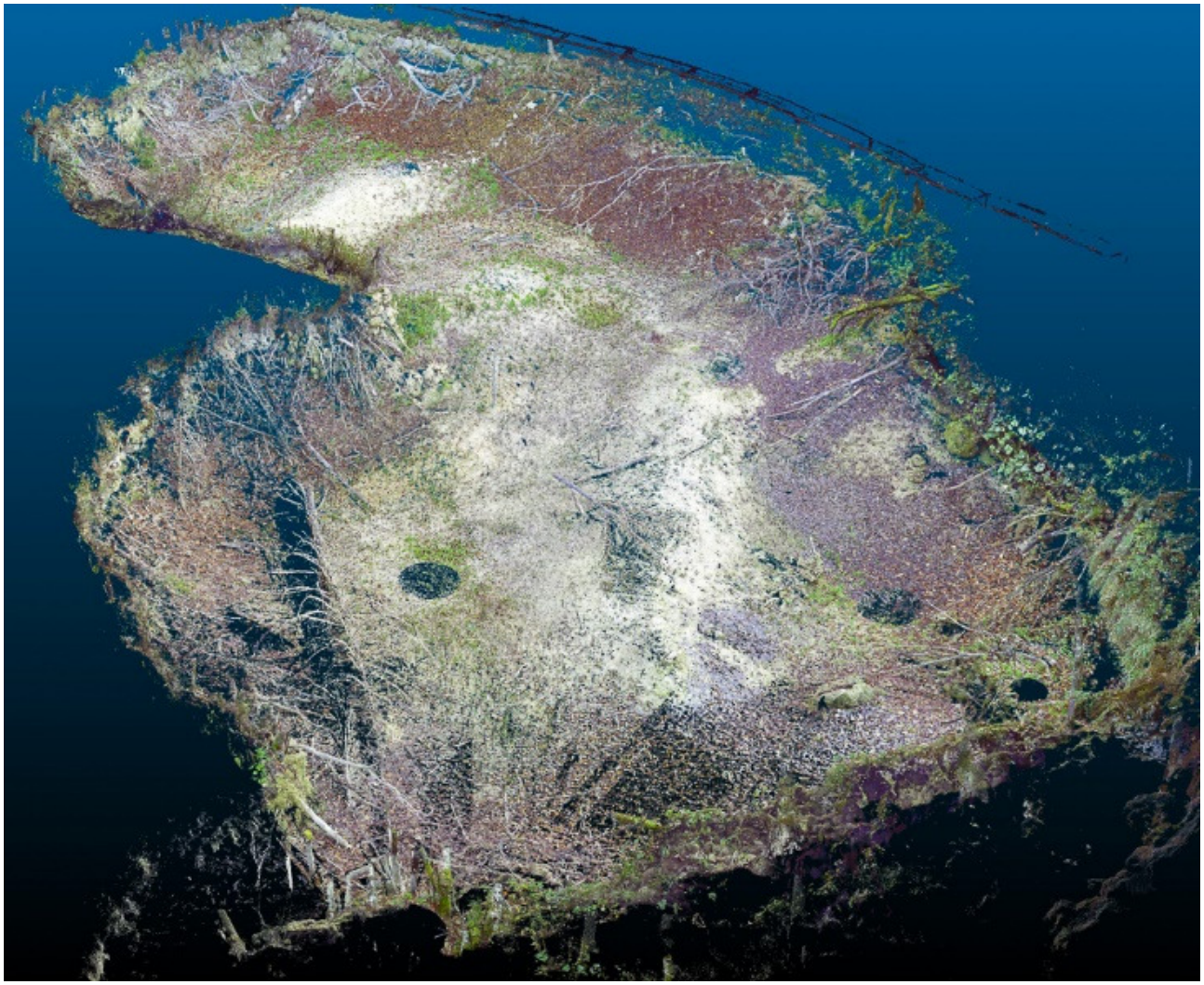


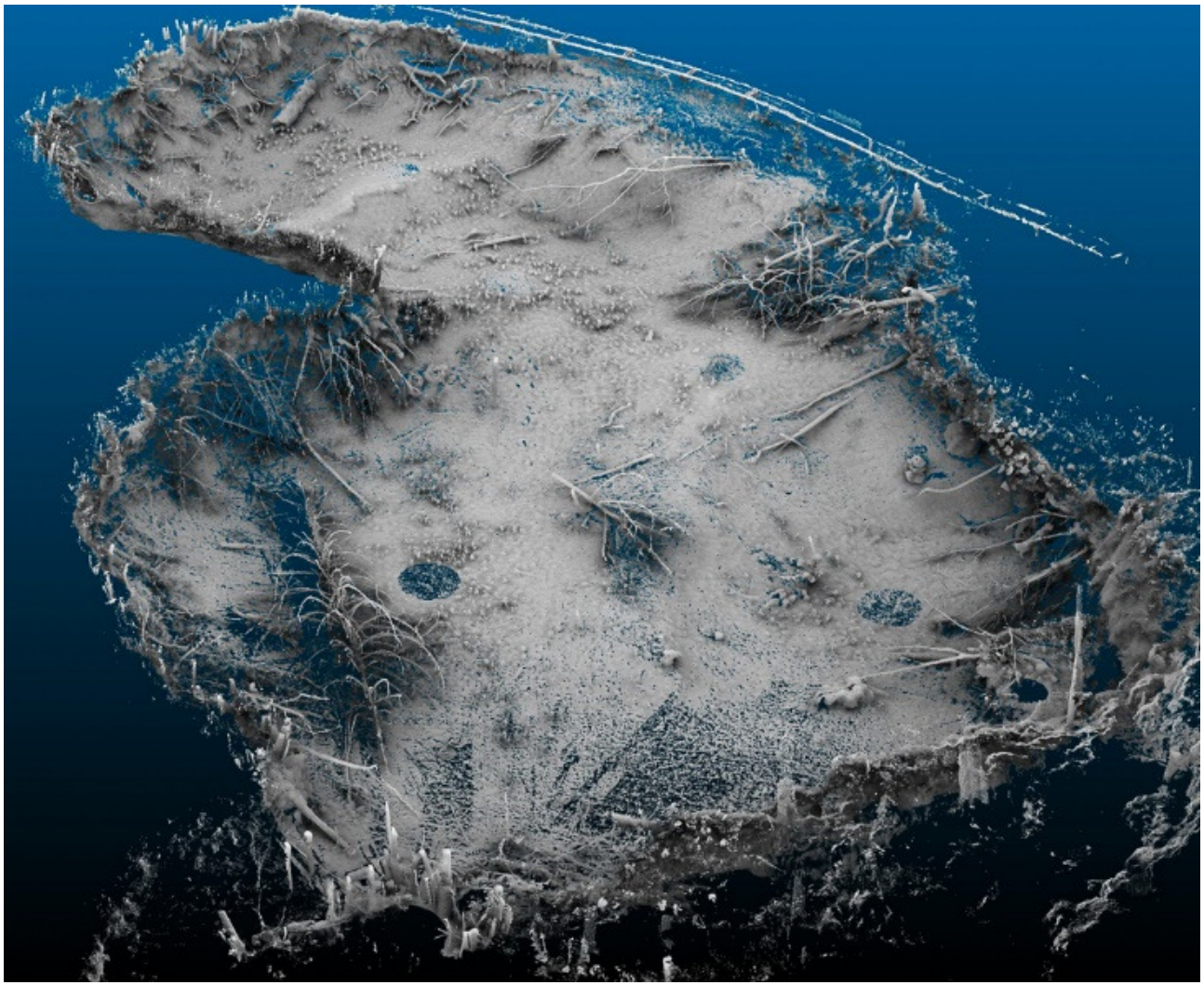
Plitvice Lakes National Park

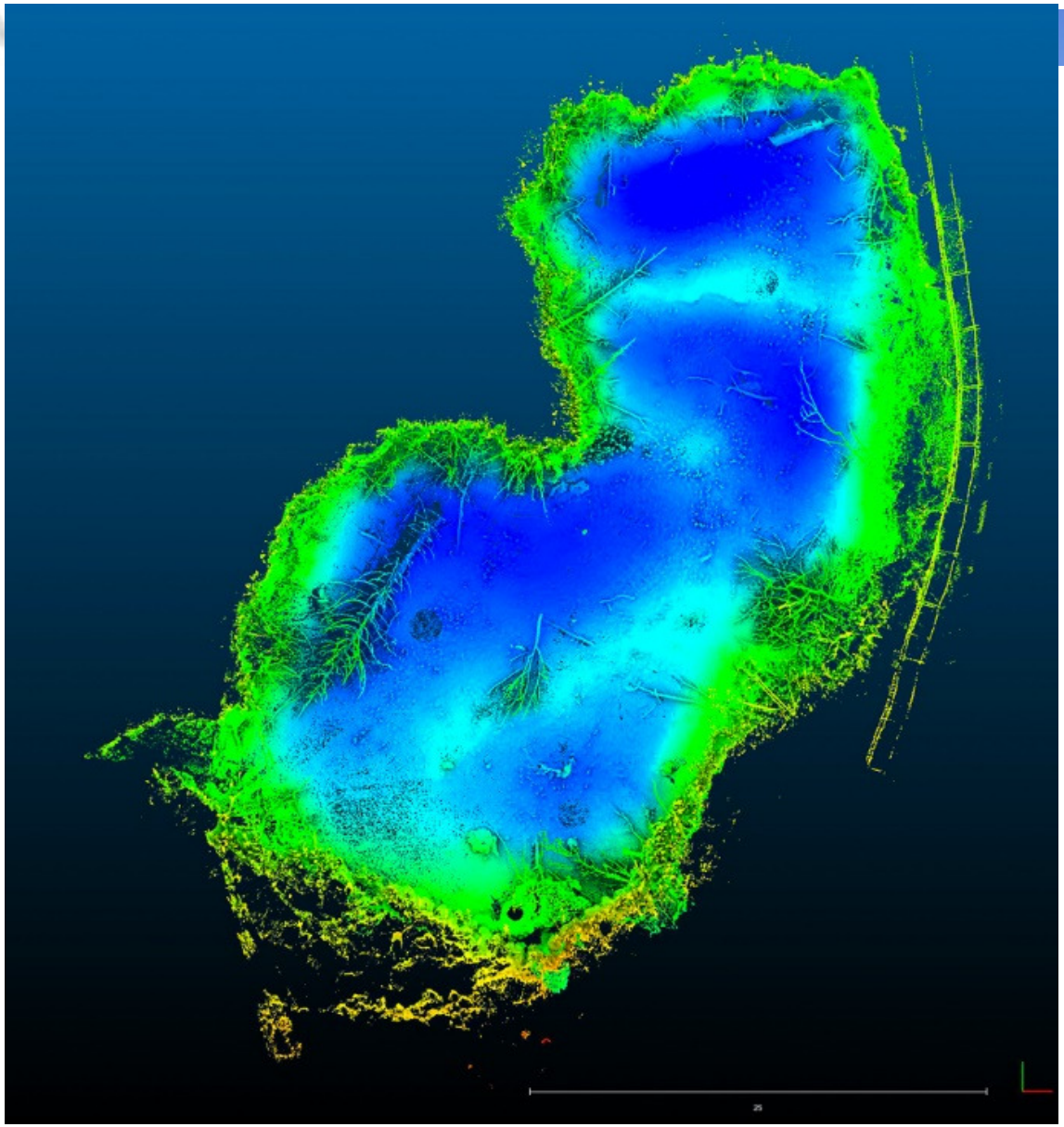


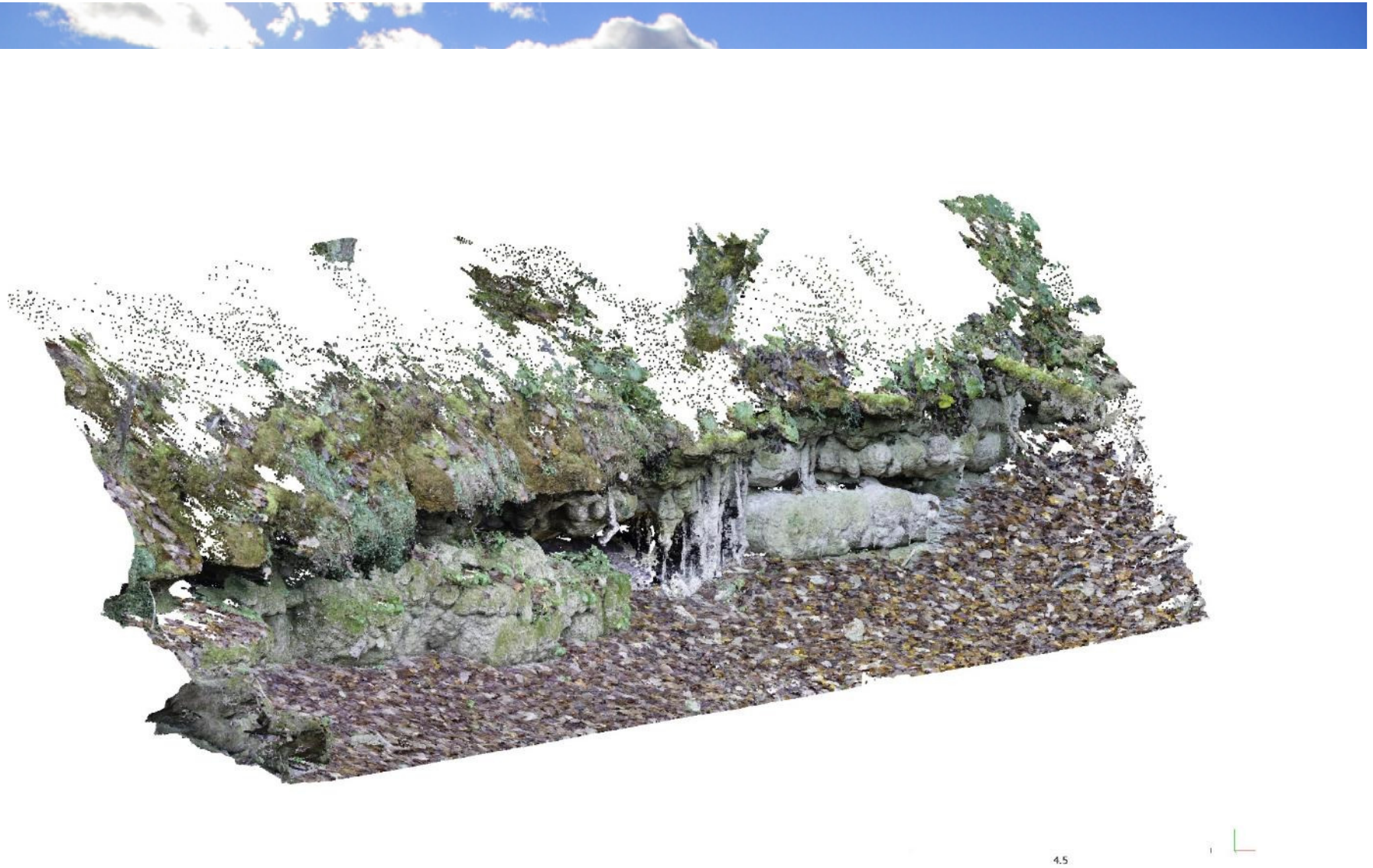
Plitvice Lakes National Park







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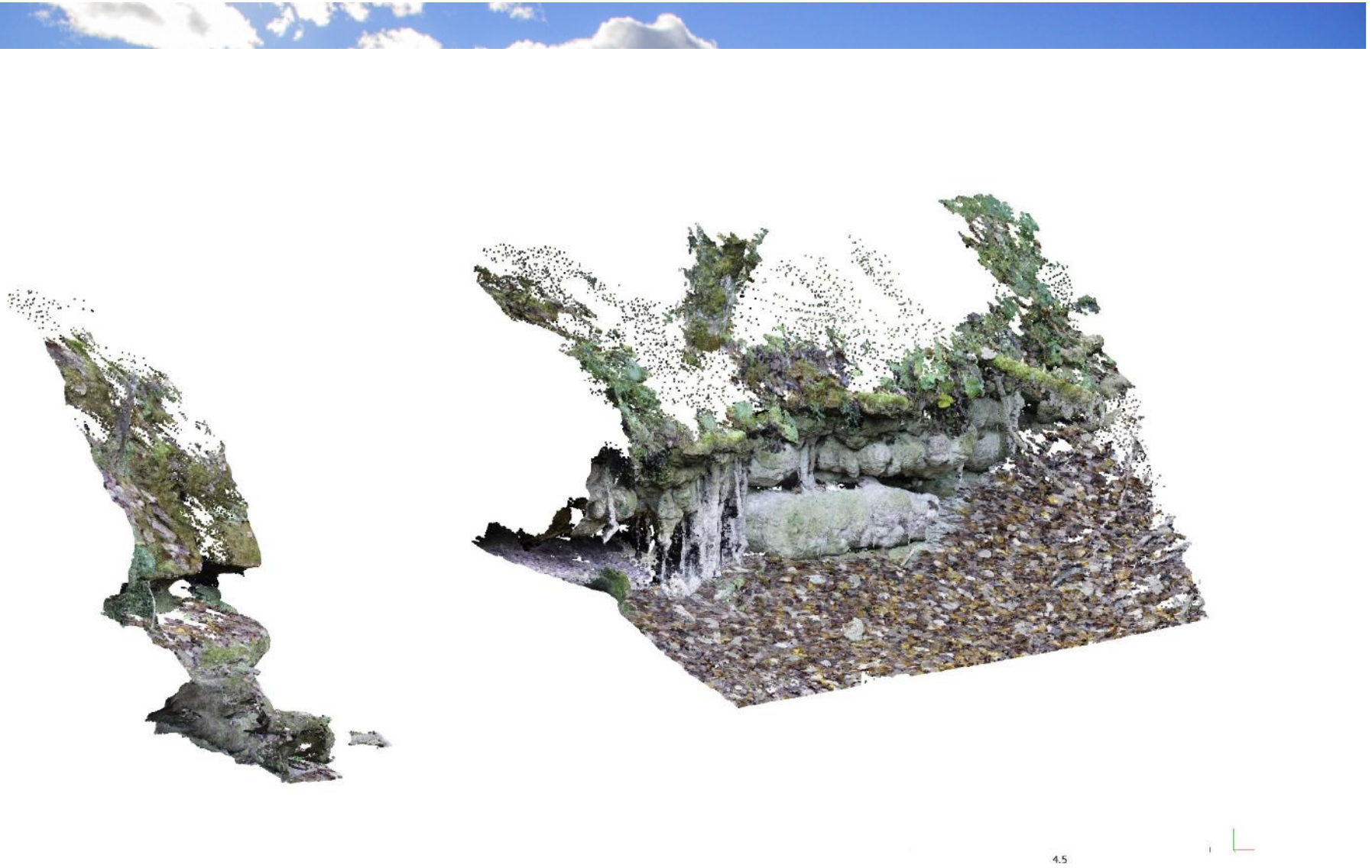
4.5

City of Nin: 3D monitoring of Upper and Lower City Bridge after the flood damage in 2017

- 3D snimak i analiza geometrije i stanja podmorskog dijela konstrukcije Gornjeg i Donjeg mosta u Ninu nakon poplave i oštećenja mosta 2017. godine

UNIRI-GRADRI 2017: Ružić, Krvavica, Kalajžić:

- **THREE-DIMENSIONAL MEASUREMENT AND ANALYSIS OF THE LOWER BRIDGE IN NIN AFTER THE FLOOD AND DAMAGE OF THE BRIDGE IN 2017**
- **THREE-DIMENSIONAL MEASUREMENT AND ANALYSIS OF THE UPPER BRIDGE IN NIN AFTER THE FLOOD AND DAMAGE OF THE BRIDGE IN 2017**
- **ANALYSIS OF GEOMETRIC PARAMETERS AND UNDERSEA CONSTRUCTION OF THE LOWER BRIDGE IN NIN AFTER THE FLOOD AND DAMAGE OF 2017**
- **ANALYSIS OF GEOMETRIC PARAMETERS AND UNDERSEA CONSTRUCTION OF THE UPPER BRIDGE IN NIN AFTER THE FLOOD AND DAMAGE OF 2017**

Europska unija
Ulaganje u budućnost
FONDOVI
KONKURENTNA HRVATSKA
Ministarstvo znanosti, obrazovanja i sporta
Projekt je sufinancirala Europska unija iz Europskog fonda za regionalni razvoj.
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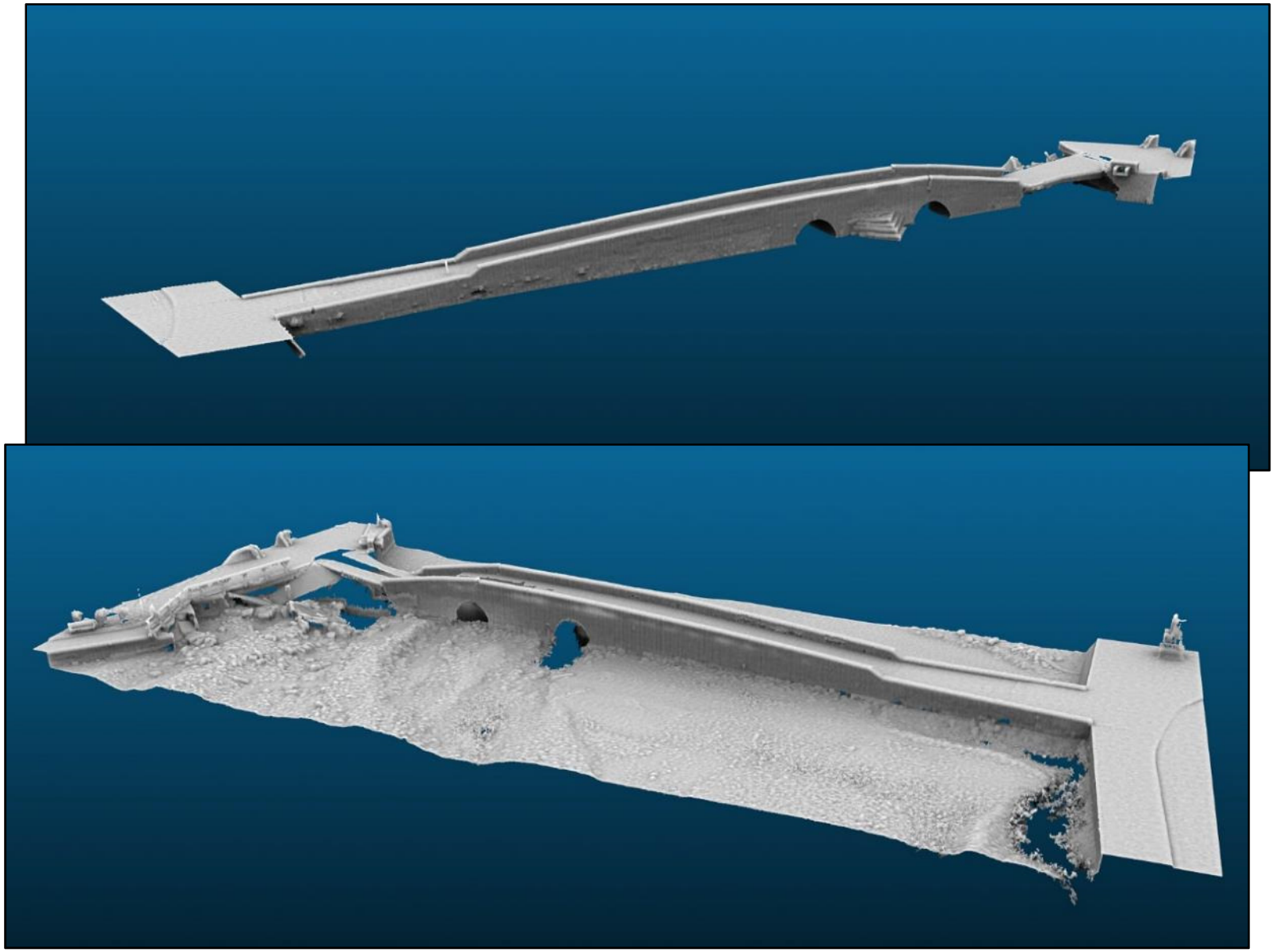
City of Nin: 3D monitoring of Upper and Lower City Bridge
after the flood damage in 2017



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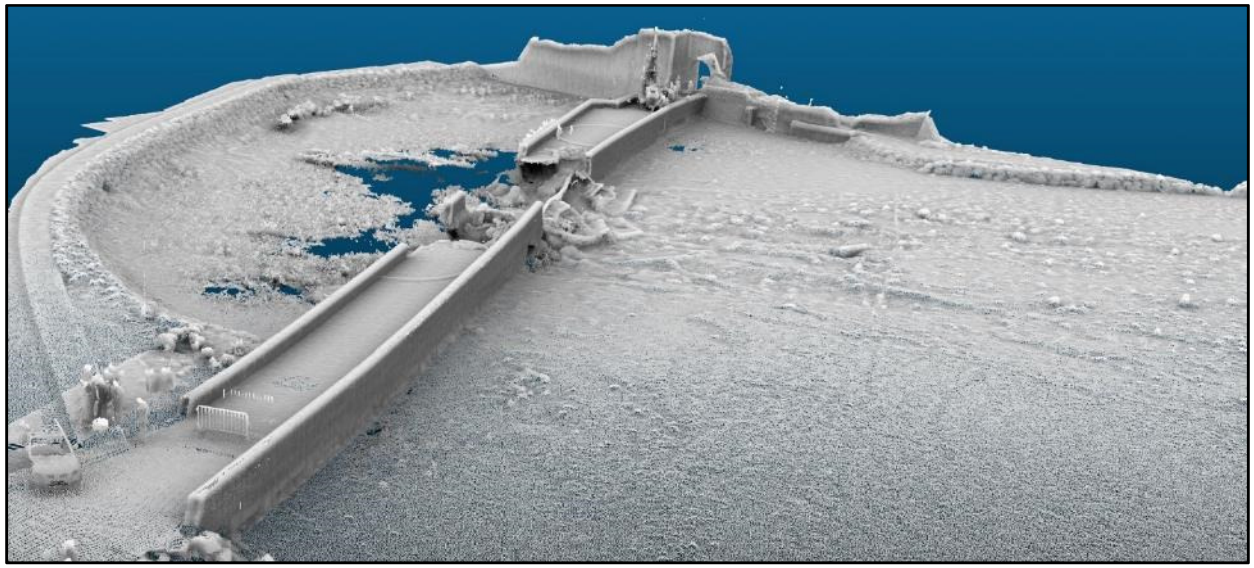

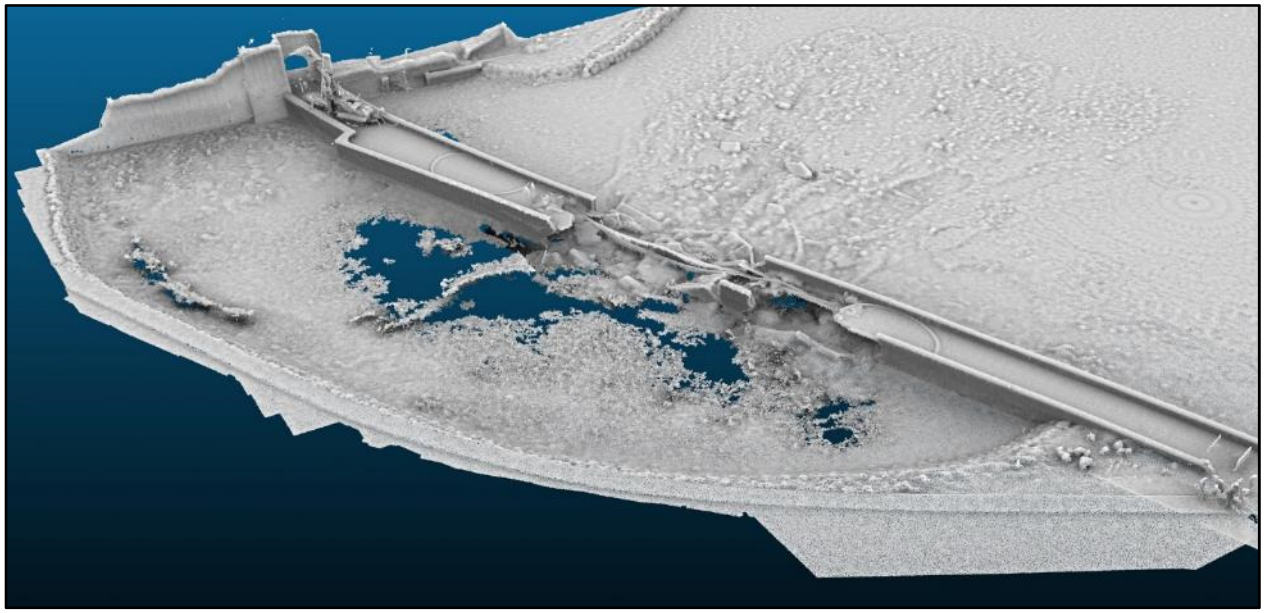

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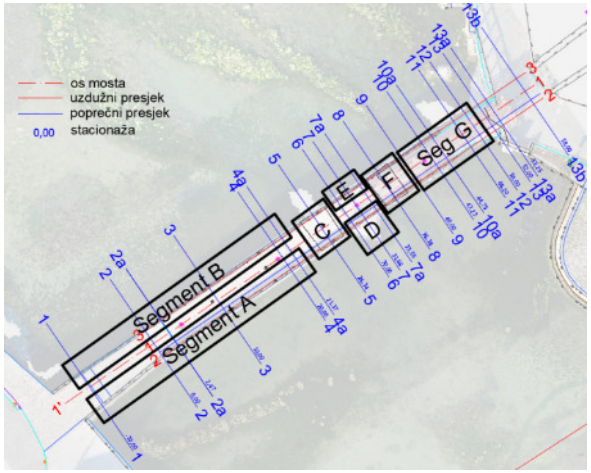

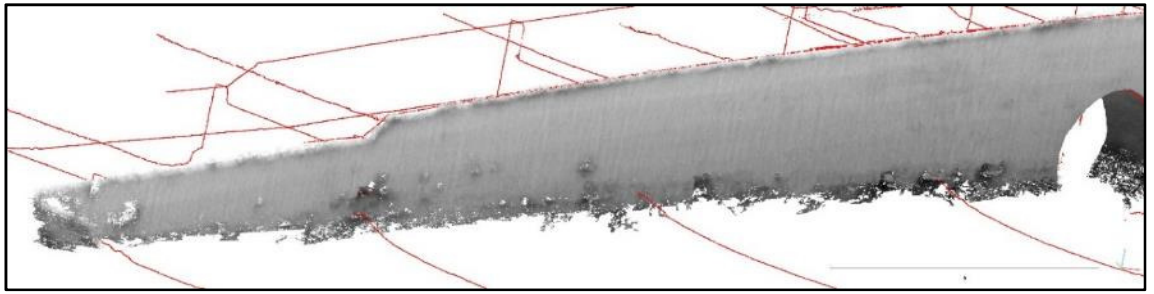

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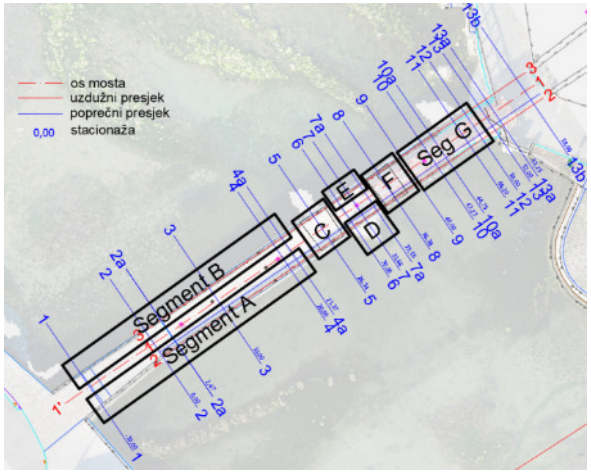

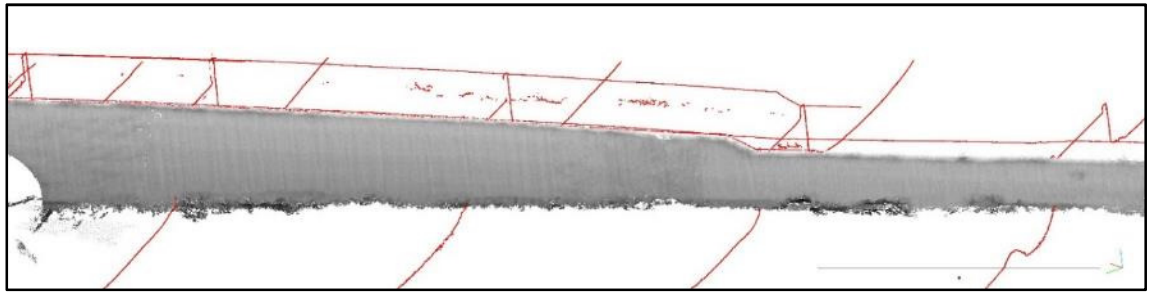

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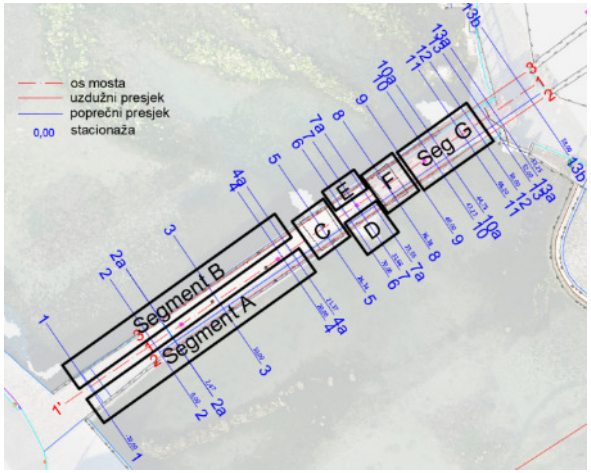

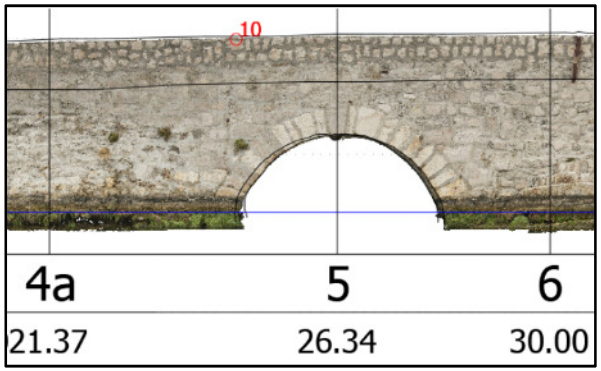

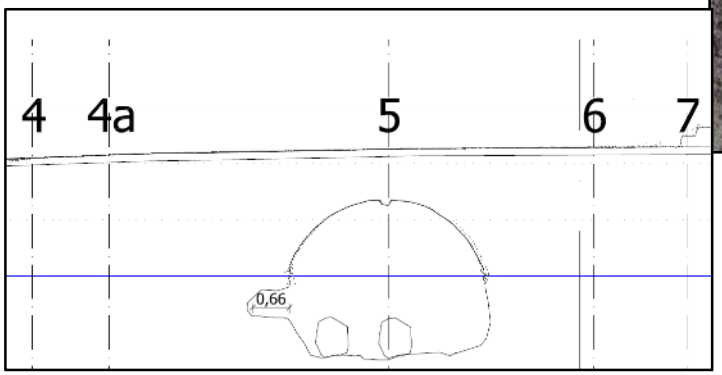

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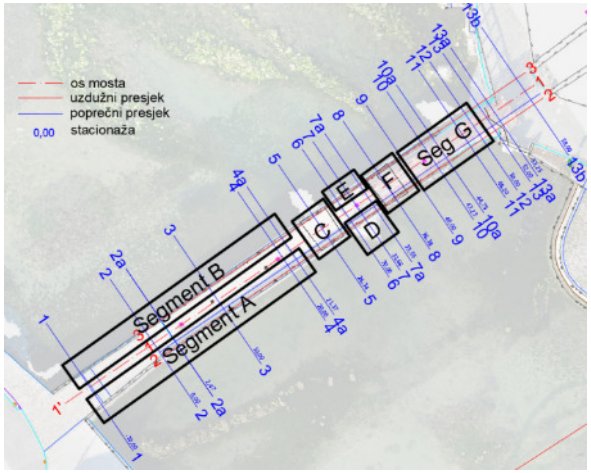

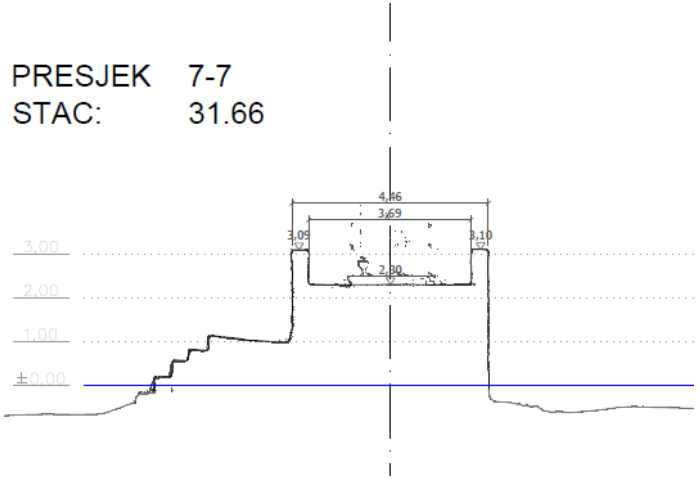

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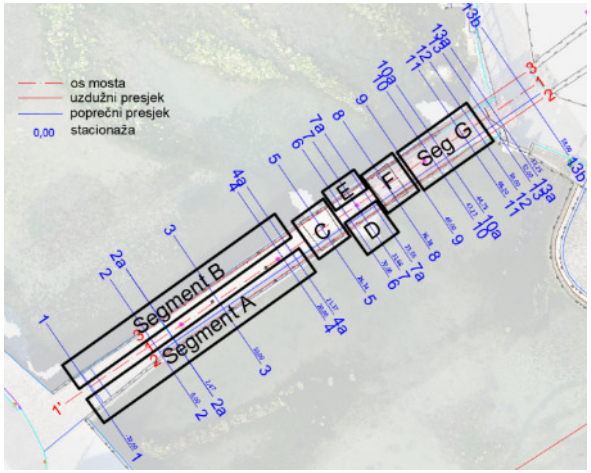

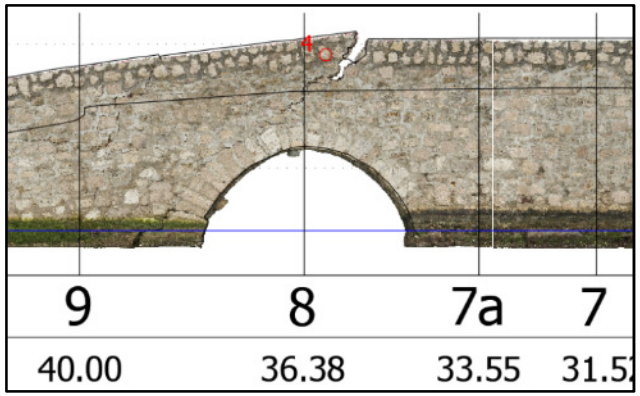

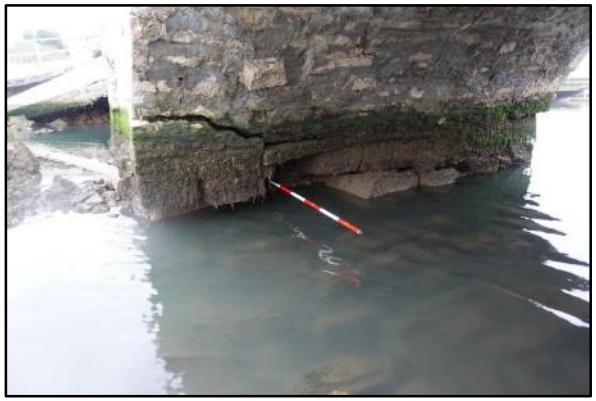

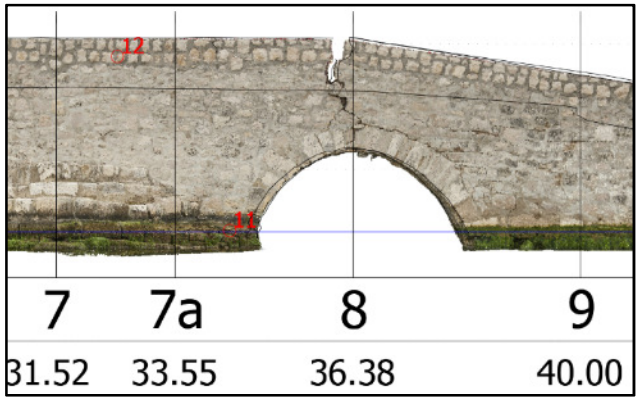

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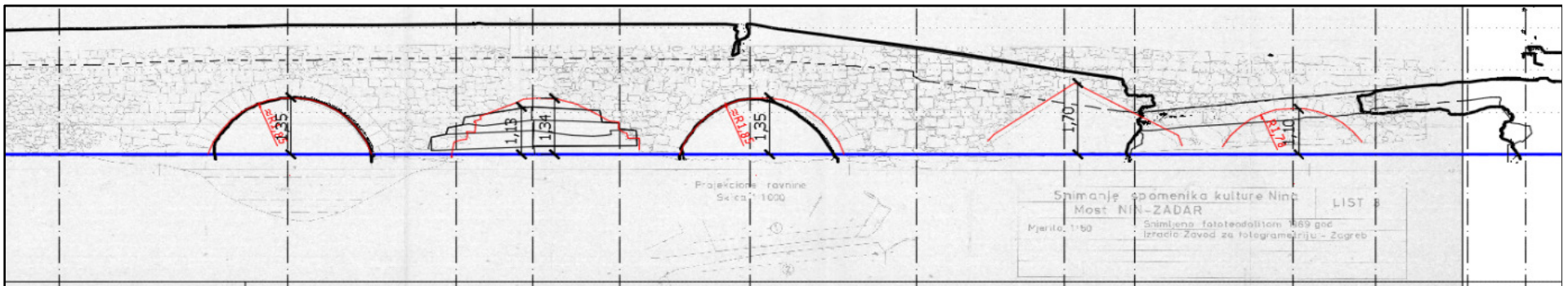
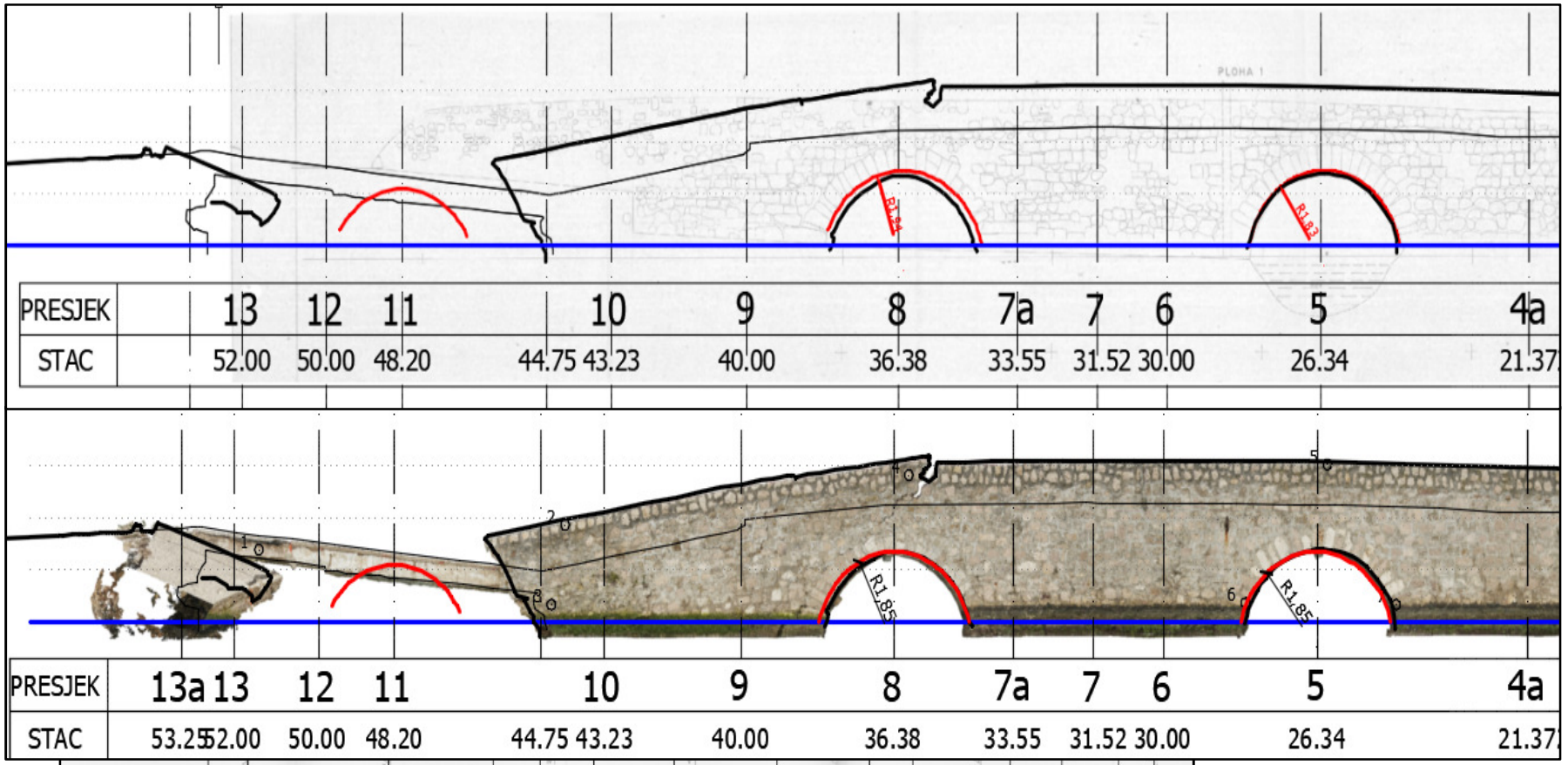
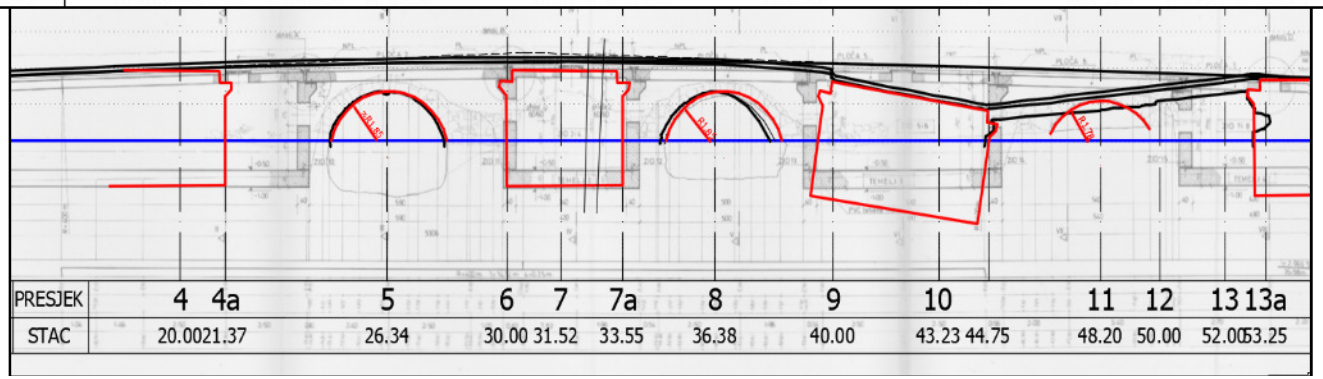


POPREČNI PRESJEK	5	6	7	7a	8	9	10		11	12	13	13a
NIVELETA	2.25	2.29	2.30	2.28	2.24	2.14	2.05	2.01	1.92	1.87	1.81	1.78
STACIONAŽA	26.34	30.00	31.52	33.55	36.38	40.00	43.23	44.75	48.20	50.00	52.00	53.25

City of Nin: 3D monitoring of Upper and Lower City Bridge after the flood damage in 2017





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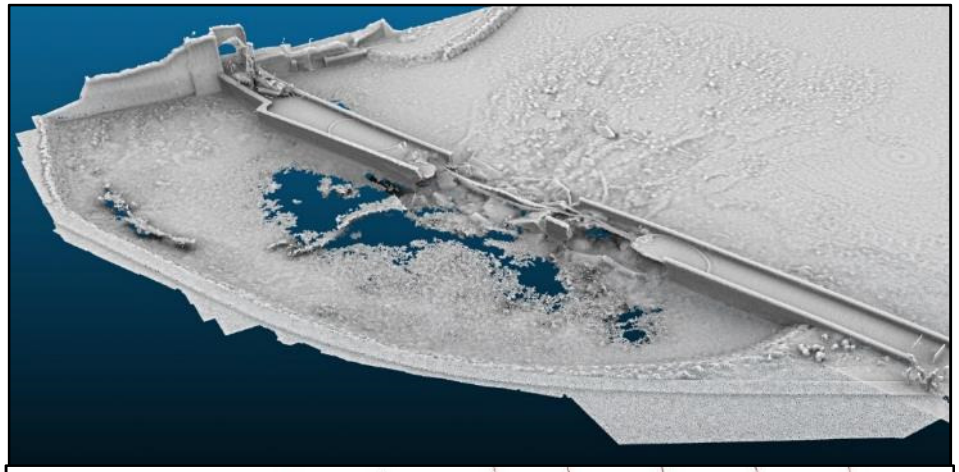

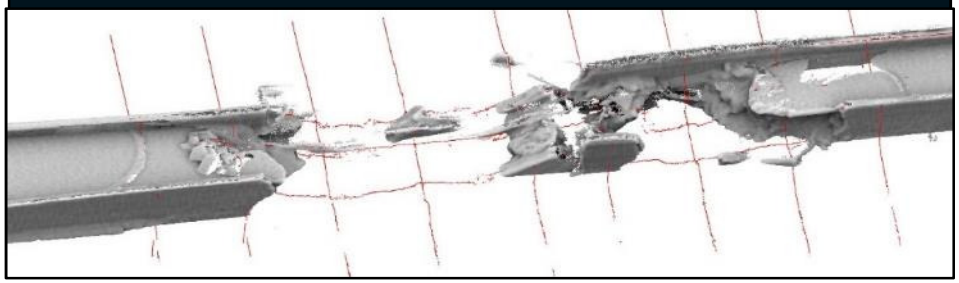

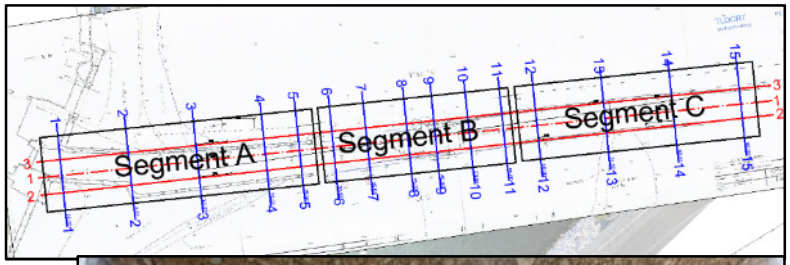

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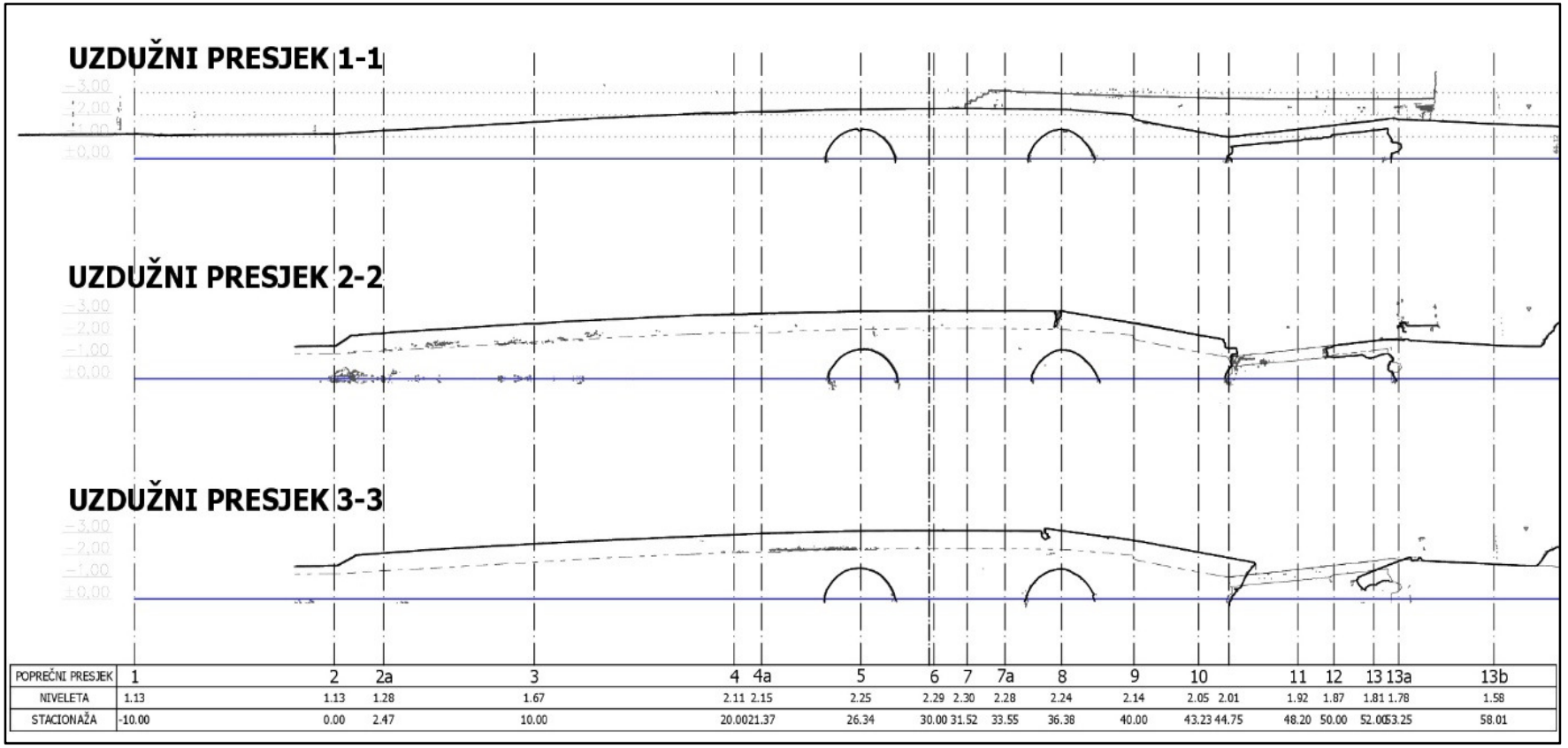
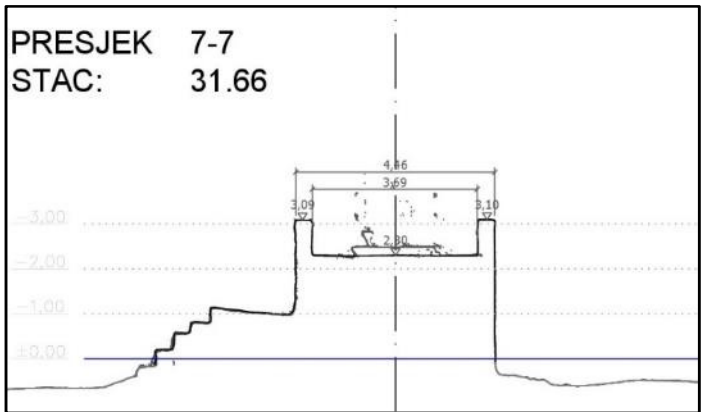
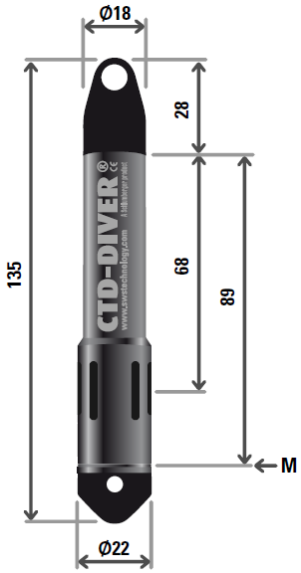


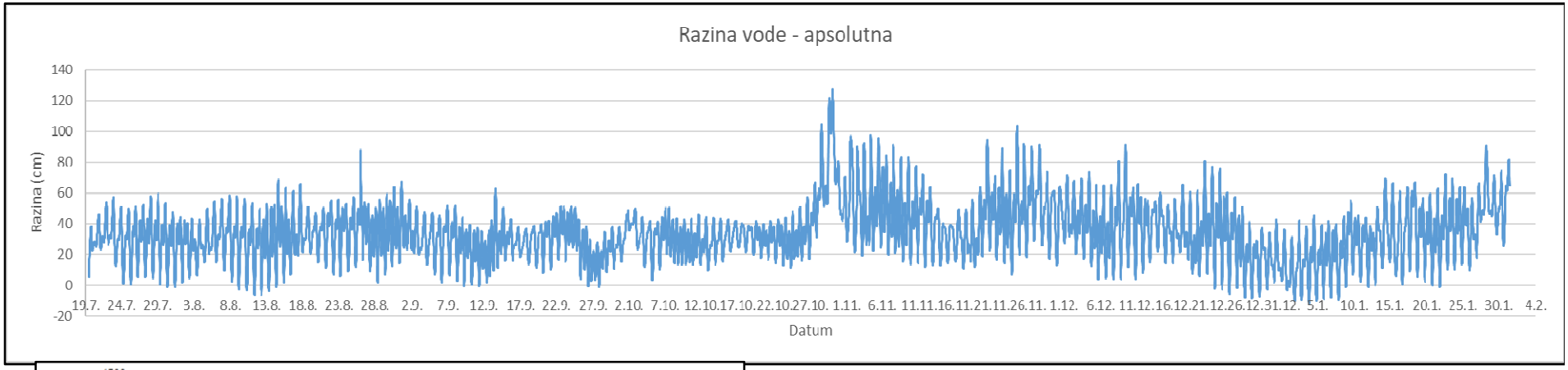
POPREČNI PRESJEK	1	2	2a	3	4	4a	5	6	7	7a	8	9	10		11	12	13	13a	13b
NIVELETA	1.13	1.13	1.28	1.67	2.11	2.15	2.25	2.29	2.30	2.28	2.24	2.14	2.05	2.01	1.92	1.87	1.81	1.78	1.58
STACIONAŽA	-10.00	0.00	2.47	10.00	20.00	21.37	26.34	30.00	31.52	33.55	36.38	40.00	43.23	44.75	48.20	50.00	52.00	53.25	58.01

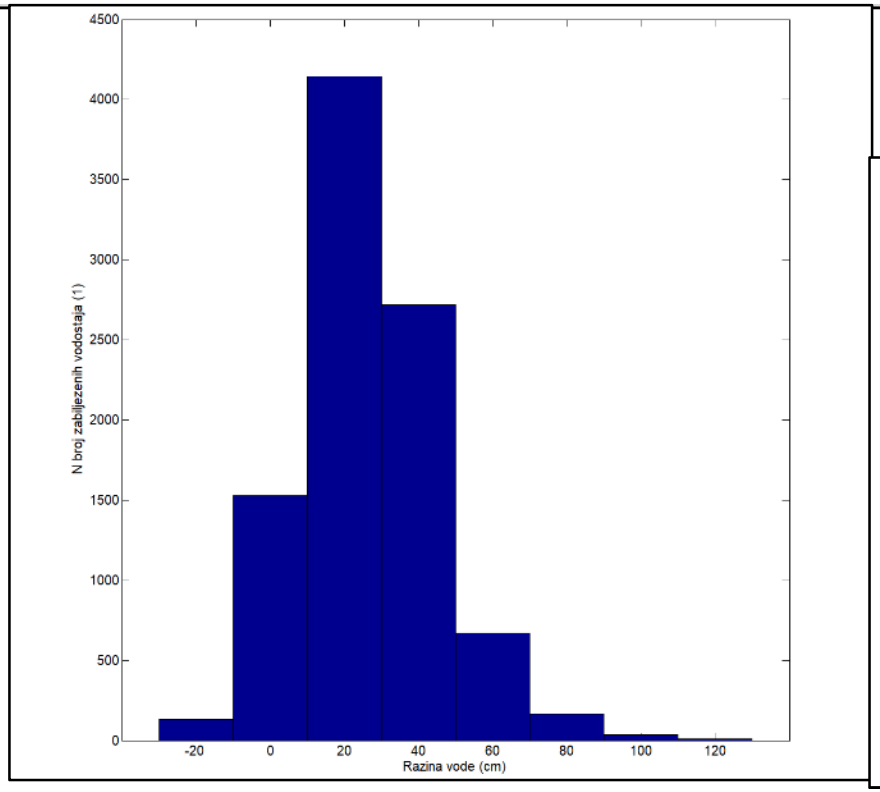


Measurement of groundwater and sea level in the Euphrasian Basilica complex in Poreč

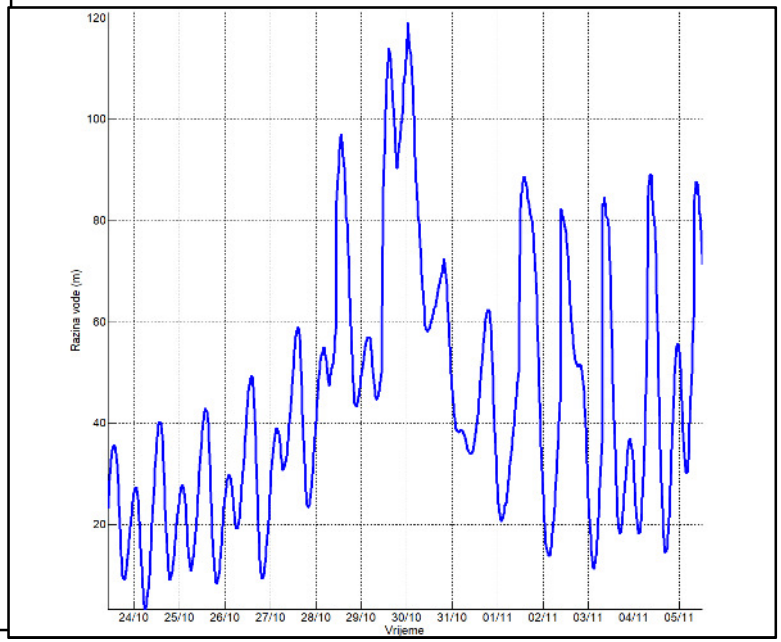


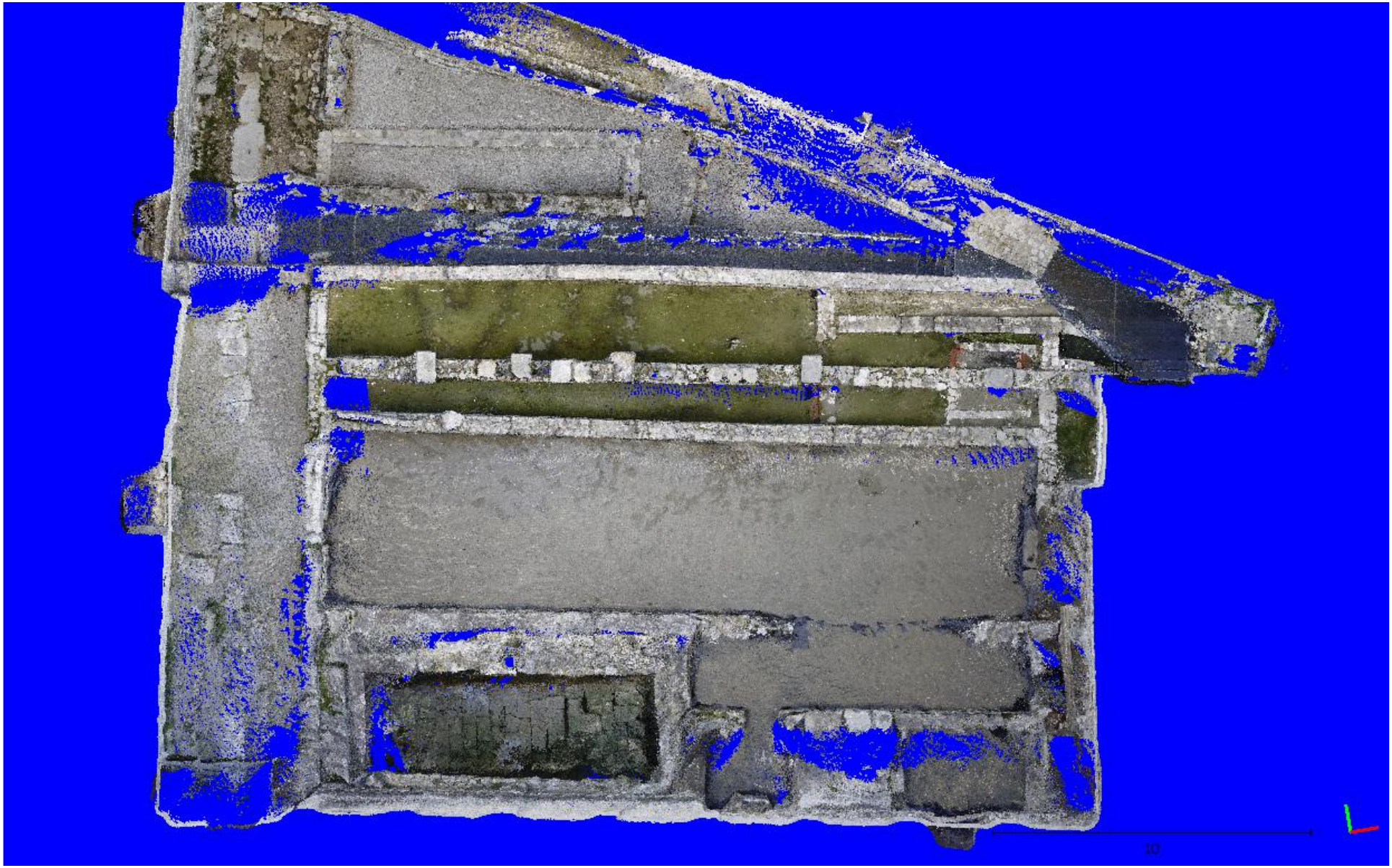
Eufrazijeva bazilika u Poreču





Maksimalna zabilježena razina: +119,0 cm n.m.

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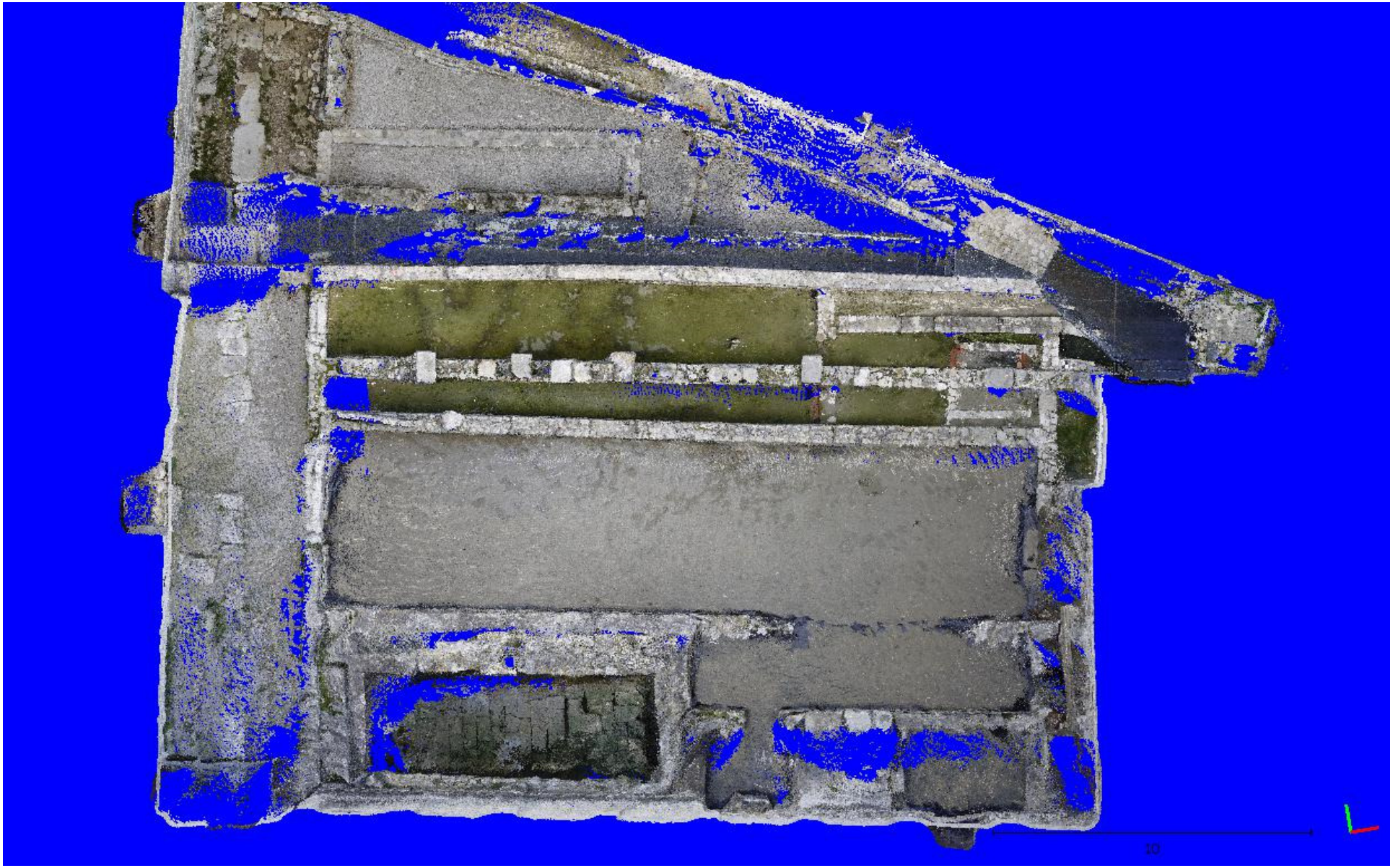
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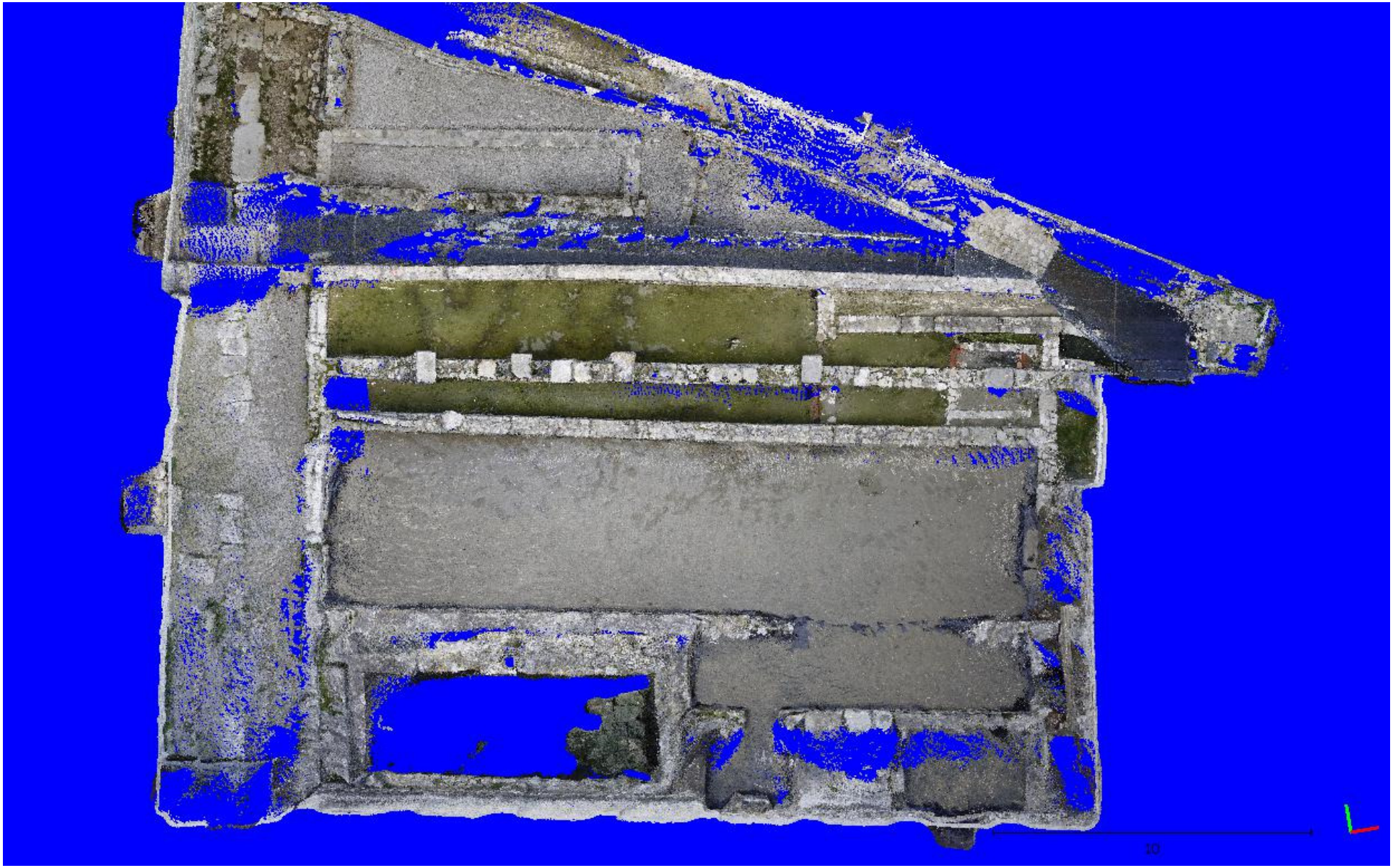
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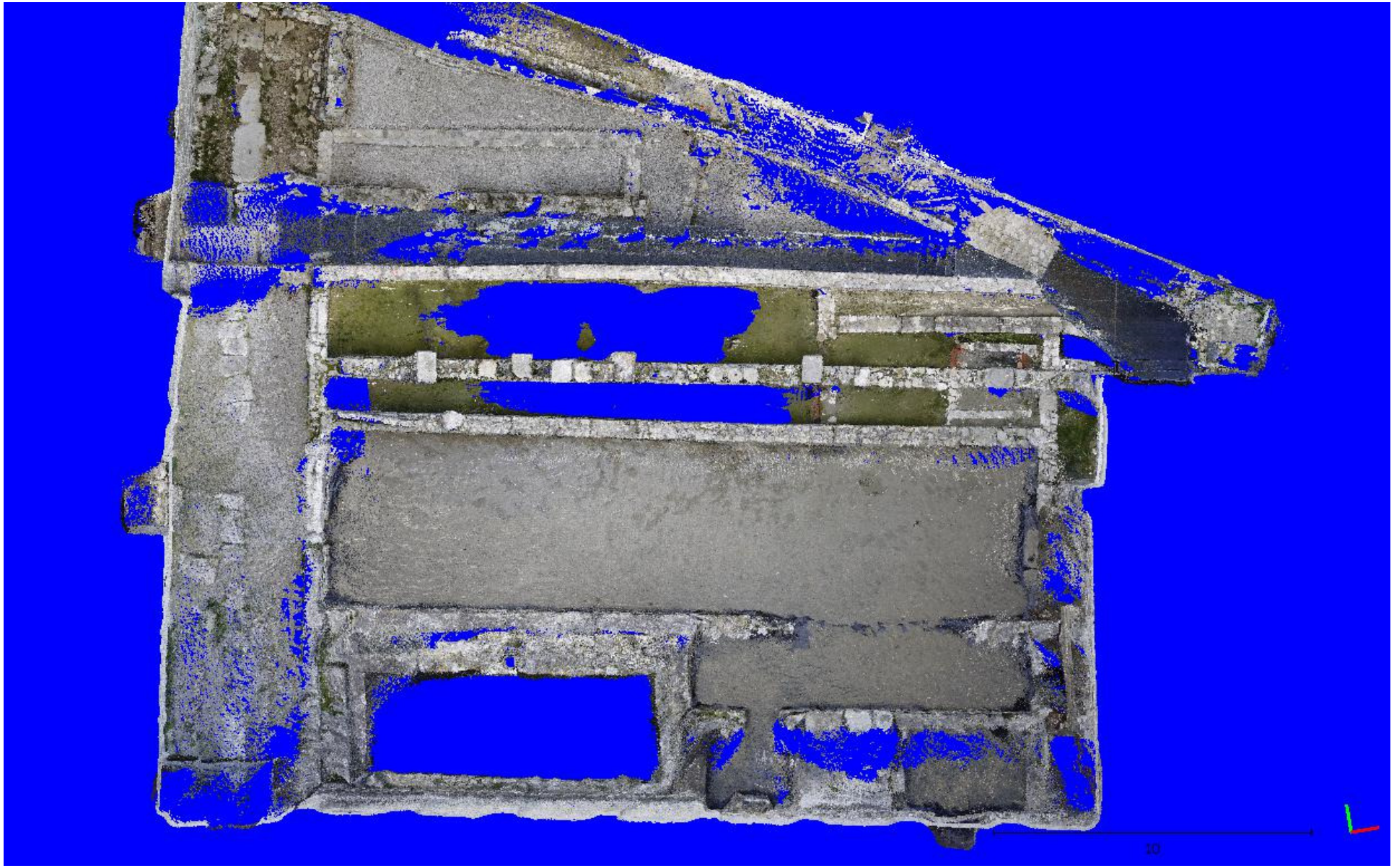
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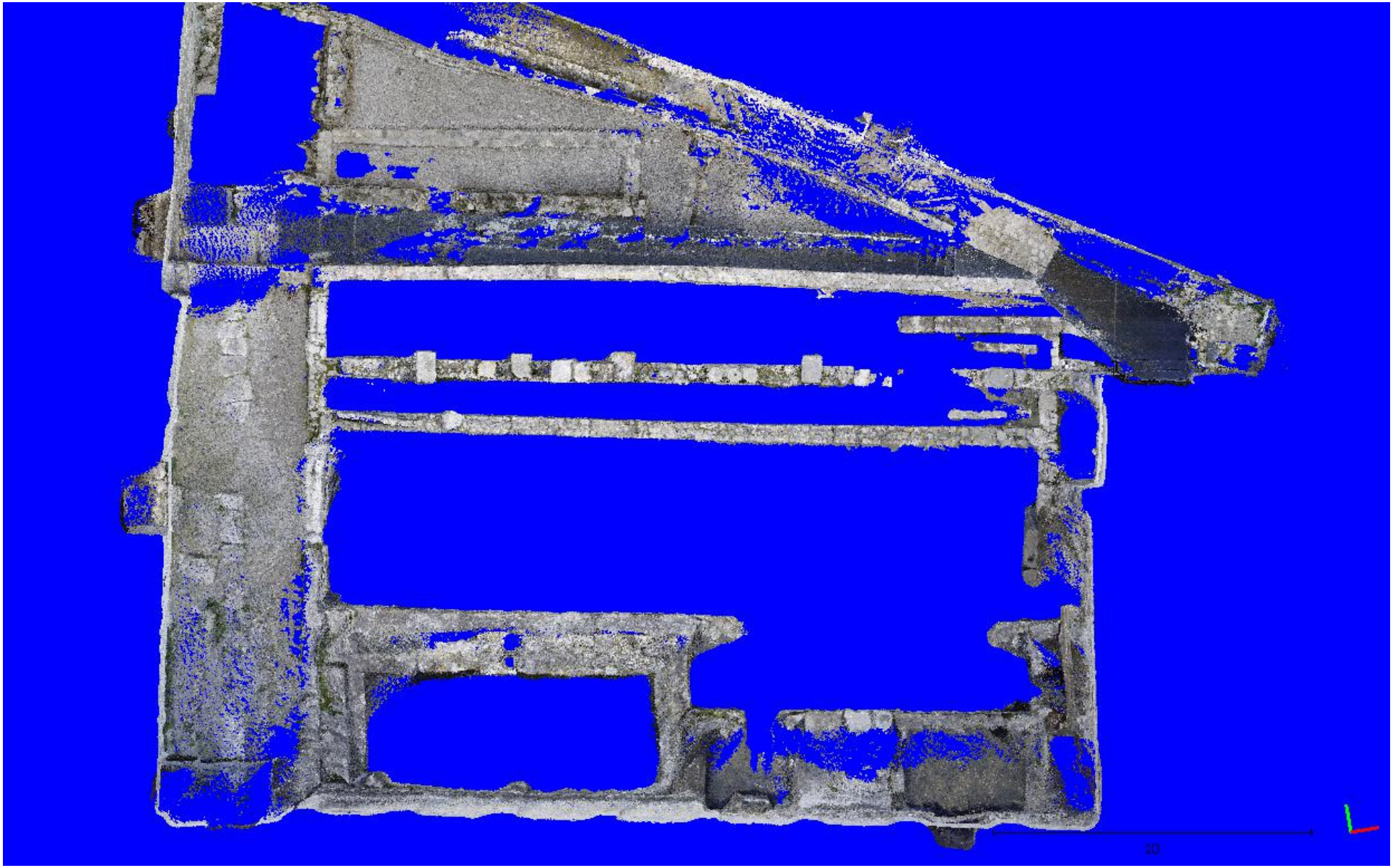
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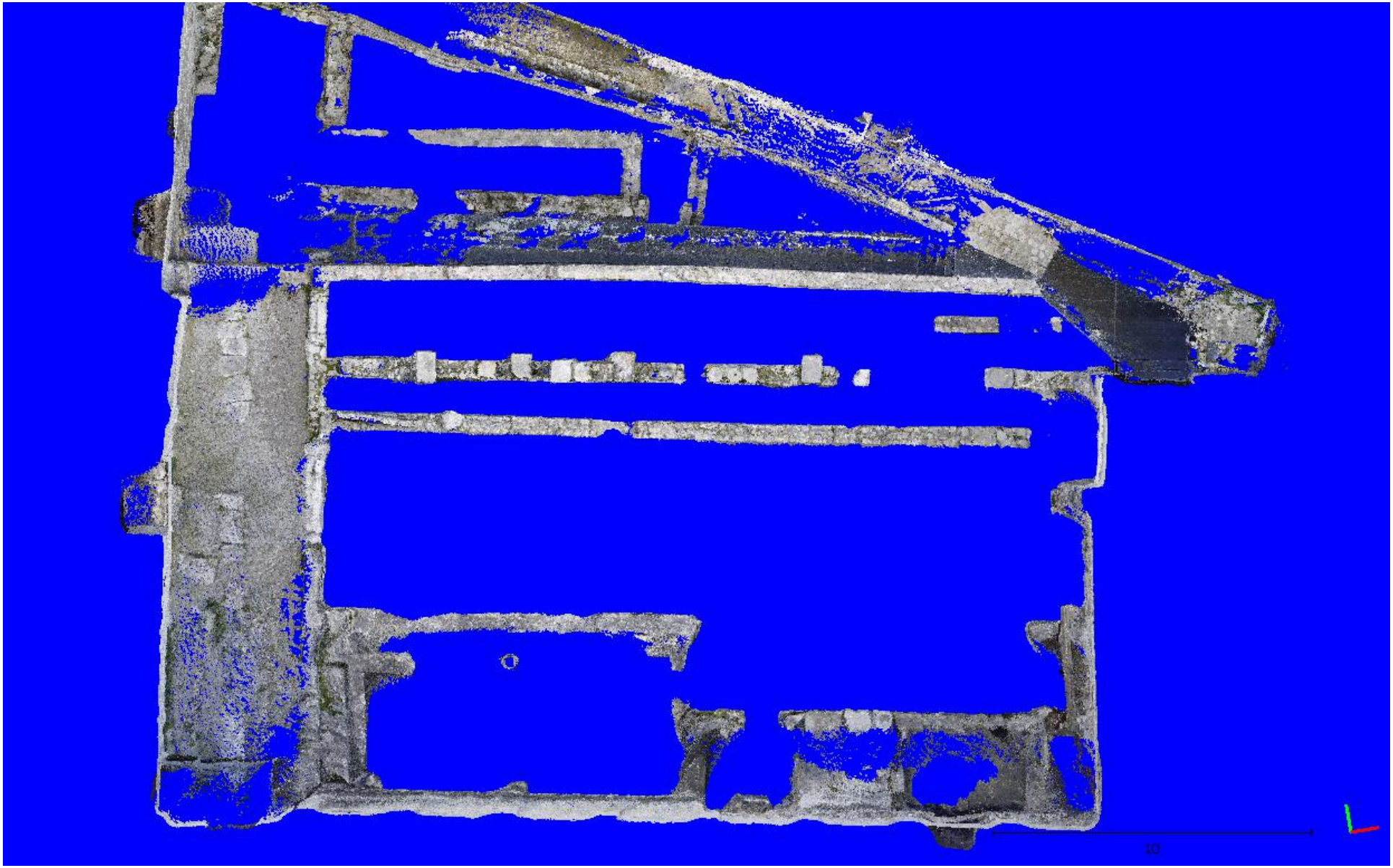
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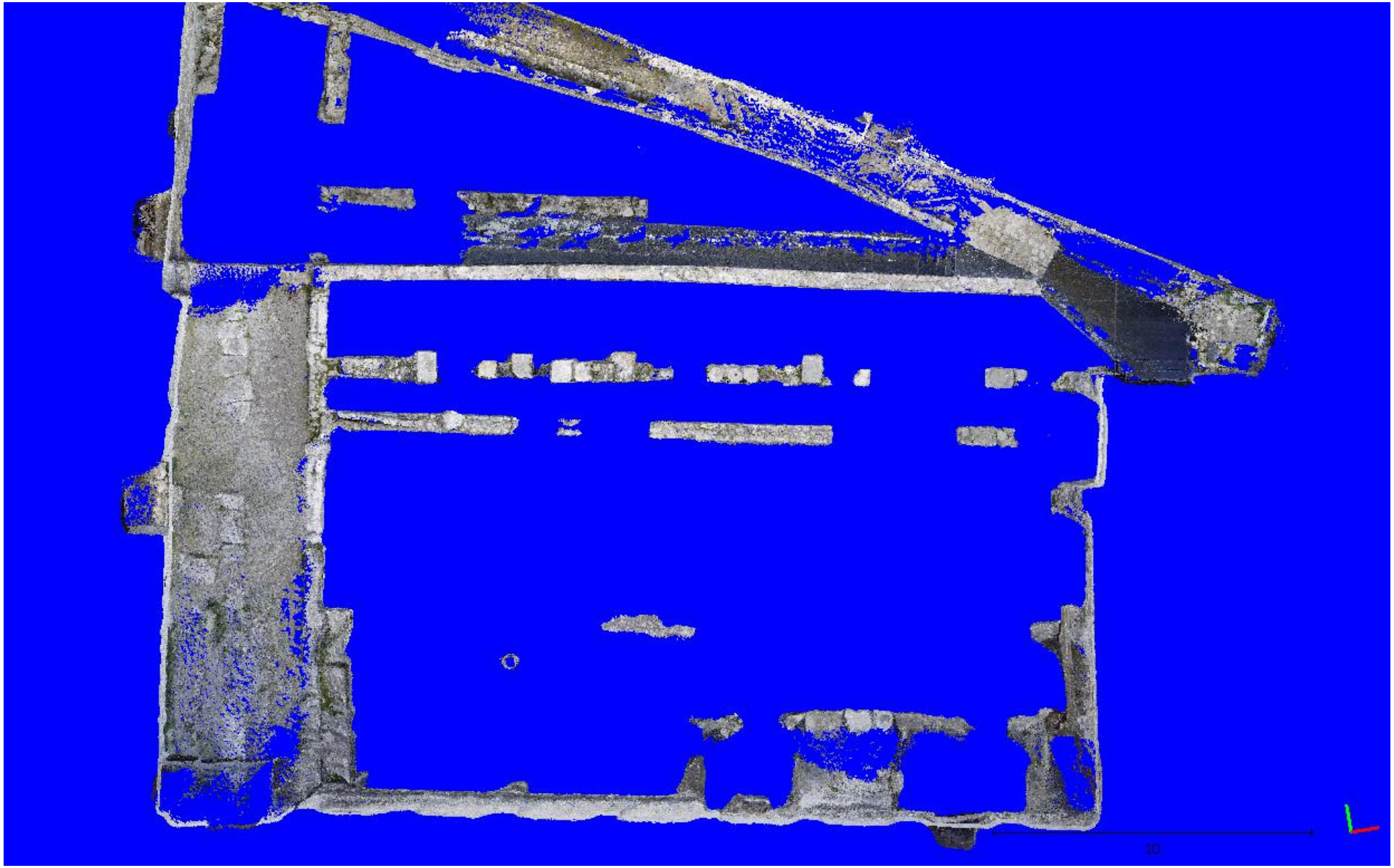
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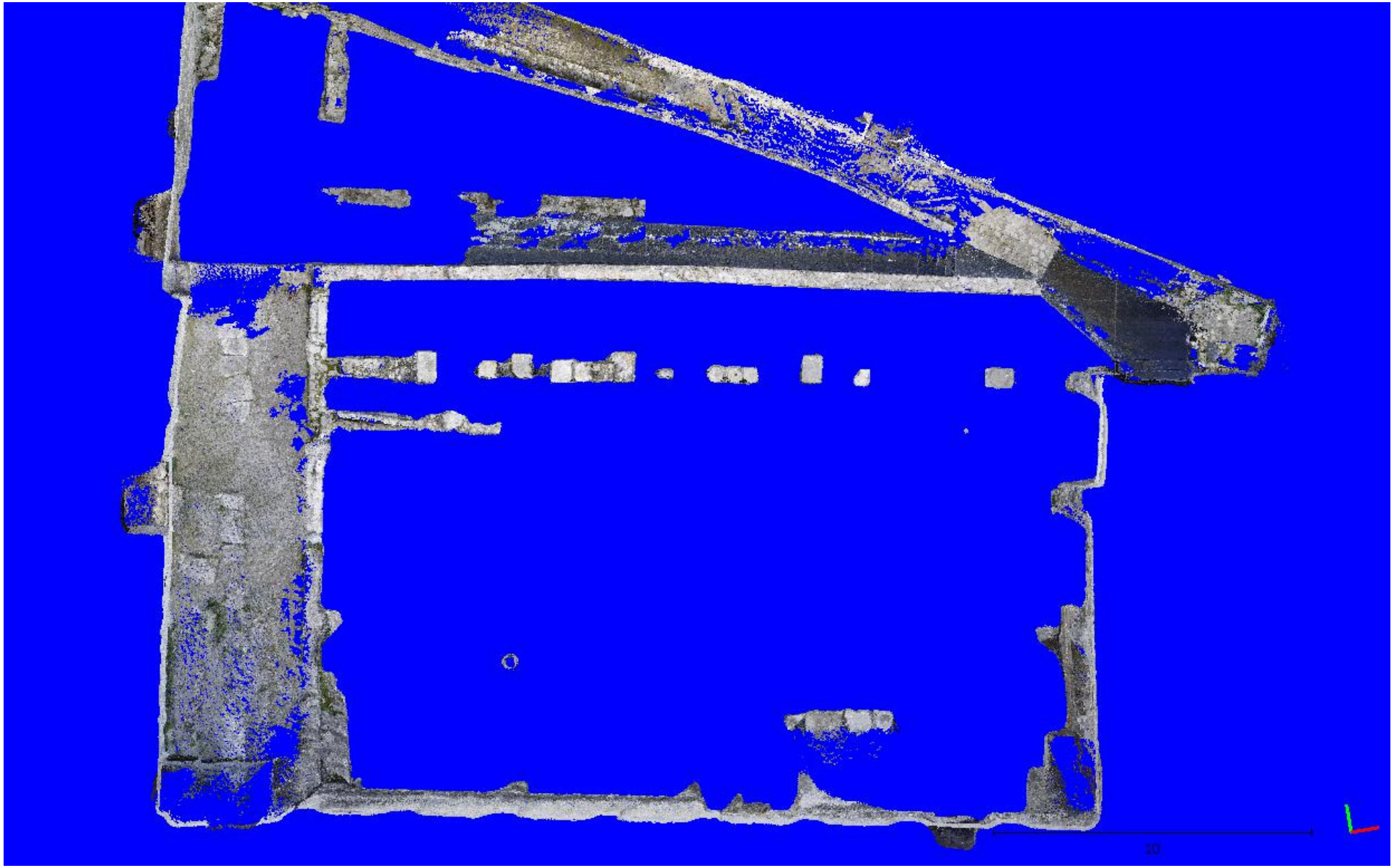
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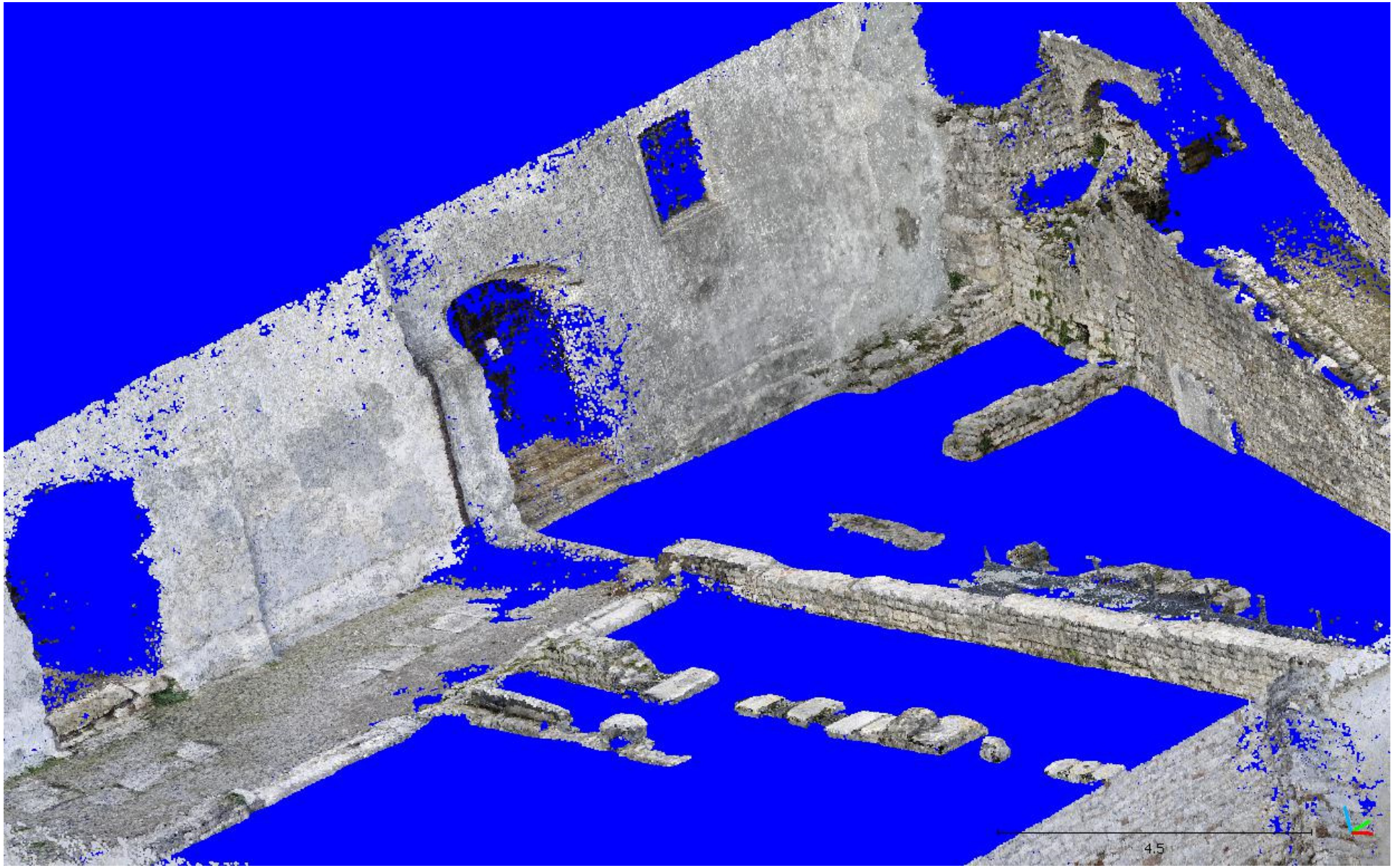

4.5

Coastal vulnerability index (CVI)

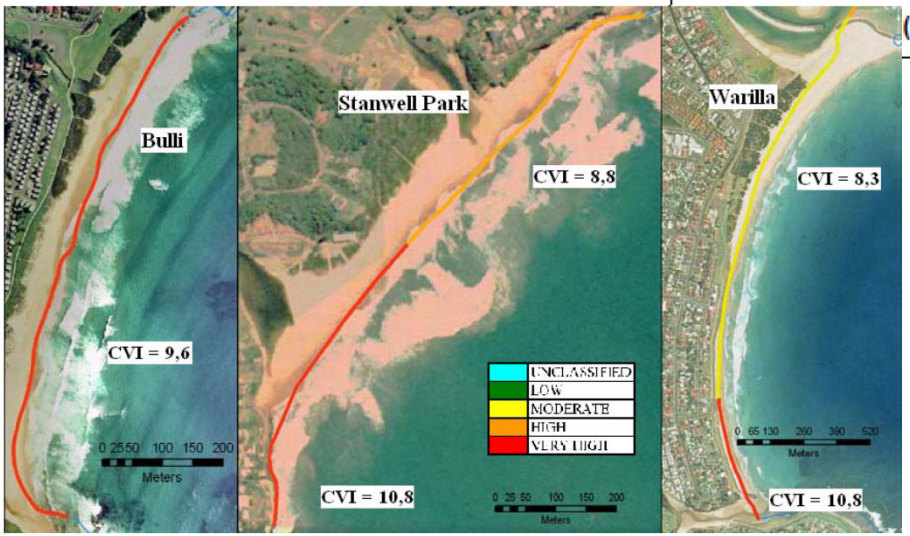
- USGS

$$CVI = \sqrt[2]{\frac{a \cdot b \cdot c \cdot d \cdot e \cdot f}{6}}$$

a = geomorphology;
b = shoreline change rates;
c = coastal slope;
d = relative sea level rate;
e =mean significant wave height;
f = mean tidal range.

Coastal Vulnerability Index (CVI) analysis - application of 3D technology

	Very Low	Low	Moderate	High	Very high
Variable	**1**	**2**	**3**	**4**	**5**
Dune height (m)	> 30.1	20.1 - 30.0	10.1 - 20.0	5.1 - 10.0	0 - 5.0
Barrier types	Transgressive	Prograded	Stationary	Receded	Mainland beach
Beach types	Dissipative (D) Longshore bar trough (LBT)	Rhythmic bar beach (RBB)	Transverse bar rip (TBR)	Low tide terrace (LTT)	Reflective (R)
Relative sea-level change (mm/yr)	≤ -1.1 Land rising	-1.0 - 0.99	1.0 - 2.0 Eustatic rise	2.1 - 4.0	≥ 4.1 Land sinking
Shoreline erosion accretion (m/yr)	≥ +2.1 Accretion	1.0 – 2.0 Stable	-1.0 - +1.0 Erosion	-1.1 - -2.0 Erosion	≤ -2.1 Erosion
Mean tidal range (m)	≤ 0.99 Microtidal	1.0 – 1.9 Microtidal	2.0 – 4.0 Mesotidal	4.1 – 6.0 Mesotidal	≥ 6.1 Macrotidal
(m)	0 – 2.9	3.0 – 4.9	5.0 – 5.9	6.0 – 6.9	≥ 7.0

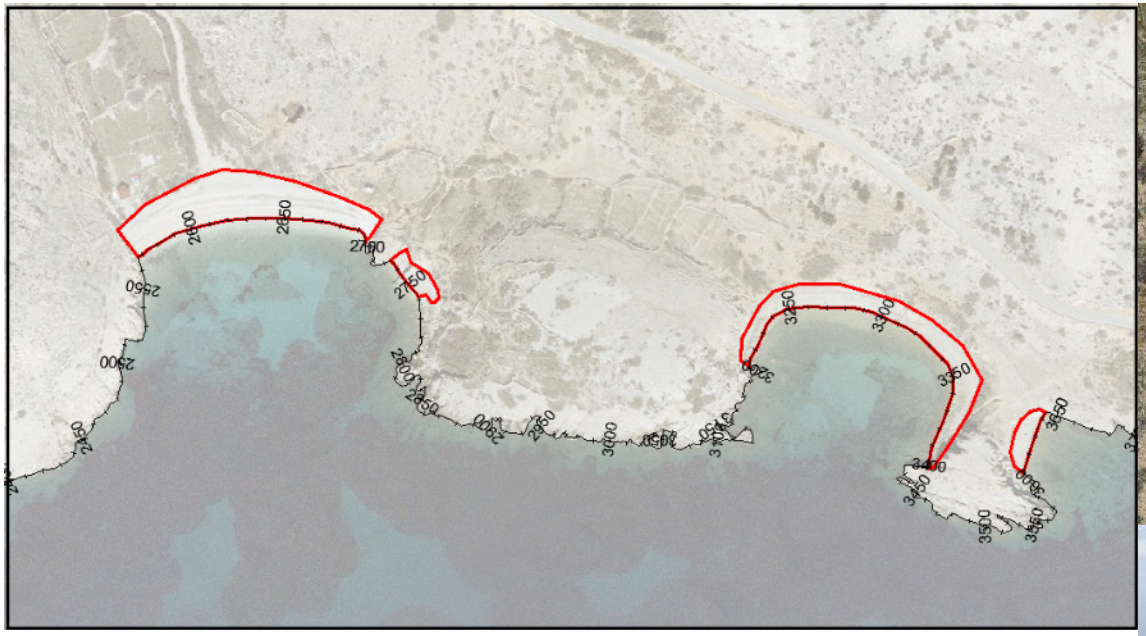


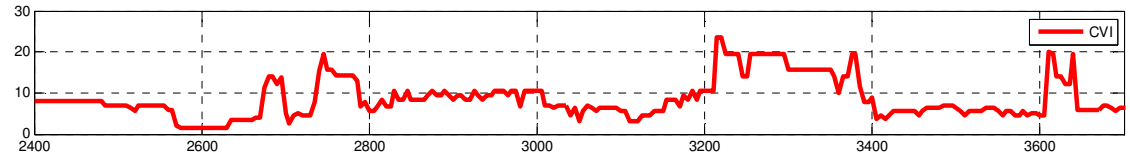
Coastal Vulnerability Index (CVI) analysis - application of 3D technology

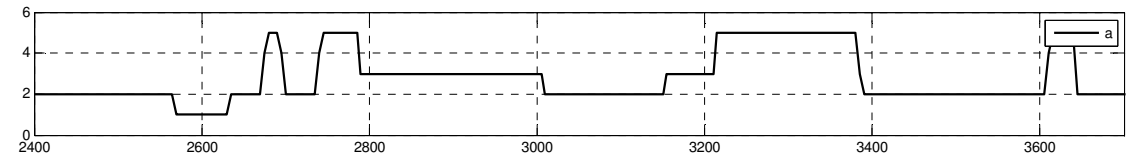
Table 2 shows the vulnerability categories, while Table 3 shows the vulnerability value associated to each variable and the estimated CVI values for each transect (a = Geomorphology, b = Coastal slope, c = Shoreline erosion/accretion rates, d = Emerged beach width, e = Dune width, f = Relative sea-level change, g = Mean significant wave height, h = Mean tide range, i = Width of vegetation behind the beach, l = Posidonia oceanica).

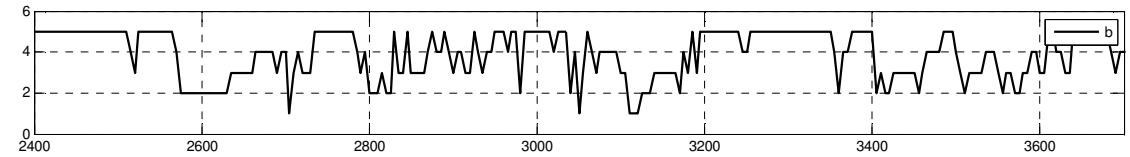
Table 3. Vulnerability value associated to each variable and CVI values for each transect.

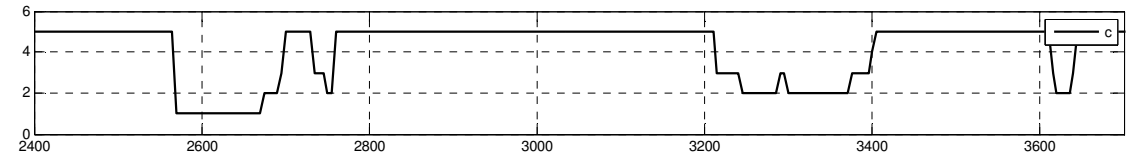
Transect	a	b	c	d	e	f	g	h	i	l	CVI Value	CVI Category
1	5	5	1	3	5	2	4	5	5	1	86.60	High
2	5	5	1	4	5	2	4	5	5	5	223.60	Very High
3	5	5	2	4	5	2	4	5	5	1	141.42	High
4	5	5	1	4	5	2	4	5	3	1	77.46	Moderate
5	5	5	1	3	4	2	4	5	5	1	77.46	Moderate
6	5	5	5	4	3	2	4	5	3	5	300.00	Very High
7	5	5	1	4	4	2	4	5	3	5	154.91	High
8	5	5	1	4	4	2	4	5	3	1	69.28	Moderate
9	5	5	4	4	5	2	4	5	2	1	126.49	High
10	5	5	2	4	4	2	4	5	3	1	97.98	High
11	5	5	2	4	4	2	4	5	2	1	80.00	Moderate
12	5	5	2	3	4	2	4	5	2	1	69.28	Moderate
13	5	5	3	3	3	2	4	5	2	1	73.48	Moderate
14	5	5	2	3	3	2	4	5	4	5	189.73	Very High
15	5	5	2	3	5	2	4	5	5	5	273.86	Very High
16	3	5	2	4	5	2	4	5	5	5	244.94	Very High
17	3	5	2	4	5	2	4	5	4	5	219.08	Very High
18	3	5	1	4	5	2	4	5	4	1	69.28	Moderate
19	3	5	2	3	5	2	4	5	4	1	84.85	Moderate
20	3	5	1	3	5	2	4	5	1	1	30.00	Low
21	3	5	2	3	5	2	4	5	4	1	84.85	Moderate
22	3	5	2	3	5	2	4	5	1	1	42.42	Low
23	3	5	1	3	5	2	4	5	5	1	67.08	Low
24	3	5	2	2	5	2	4	5	5	1	77.46	Moderate

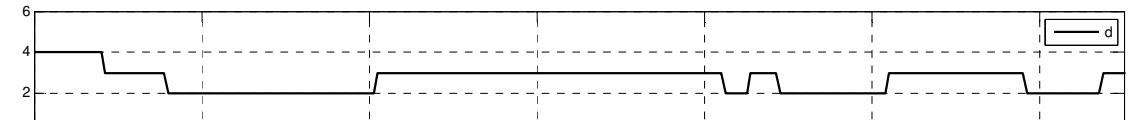



CVI
30
20
10
0
2400
2600
2800
3000
3200
3400
3600

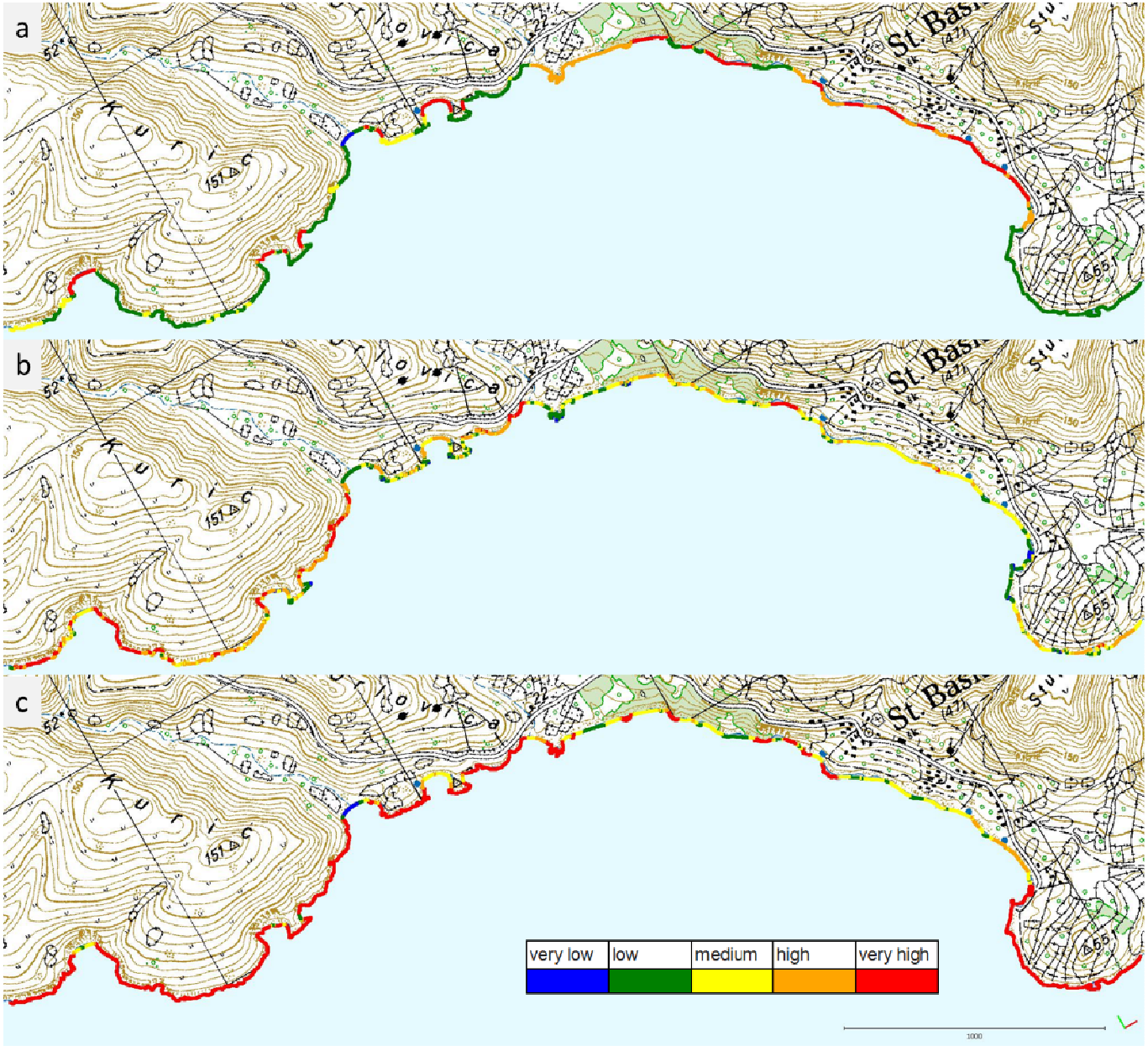

a
6
4
2
0
2400
2600
2800
3000
3200
3400
3600


b
6
4
2
0
2400
2600
2800
3000
3200
3400
3600

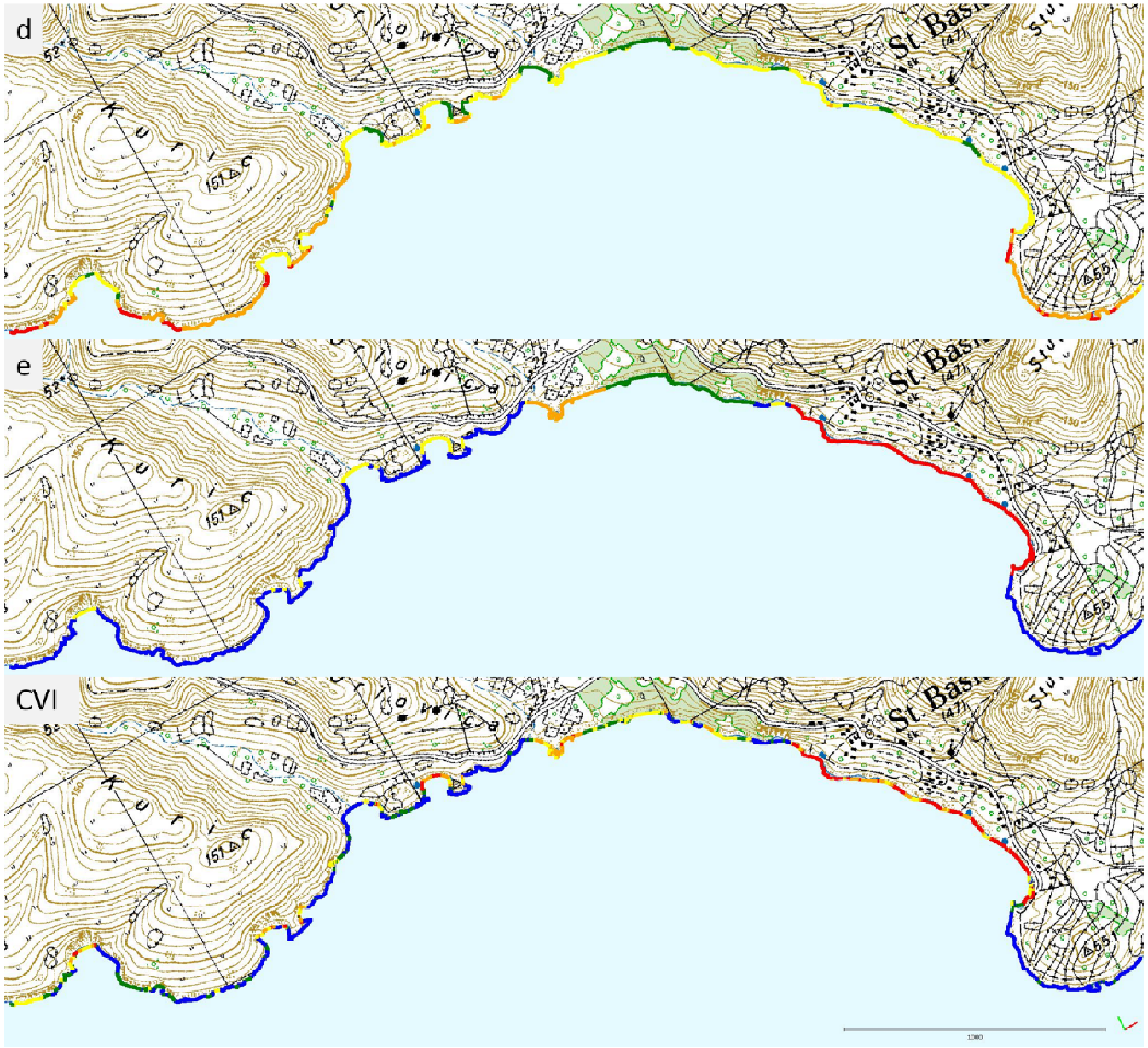

c
6
4
2
0
2400
2600
2800
3000
3200
3400
3600


d
6
4
2

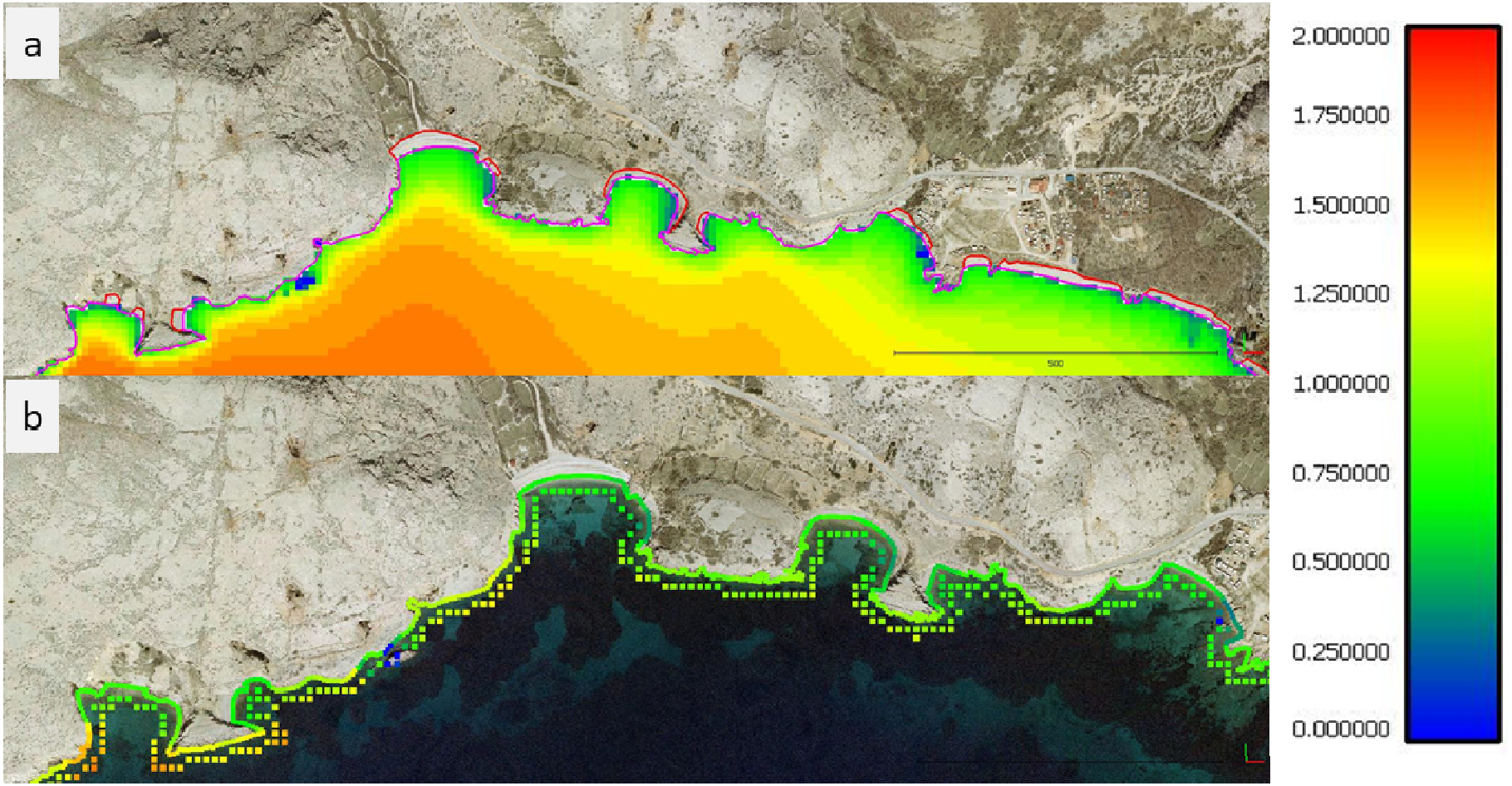
Coastal Vulnerability Index (CVI) analysis - application of 3D technology



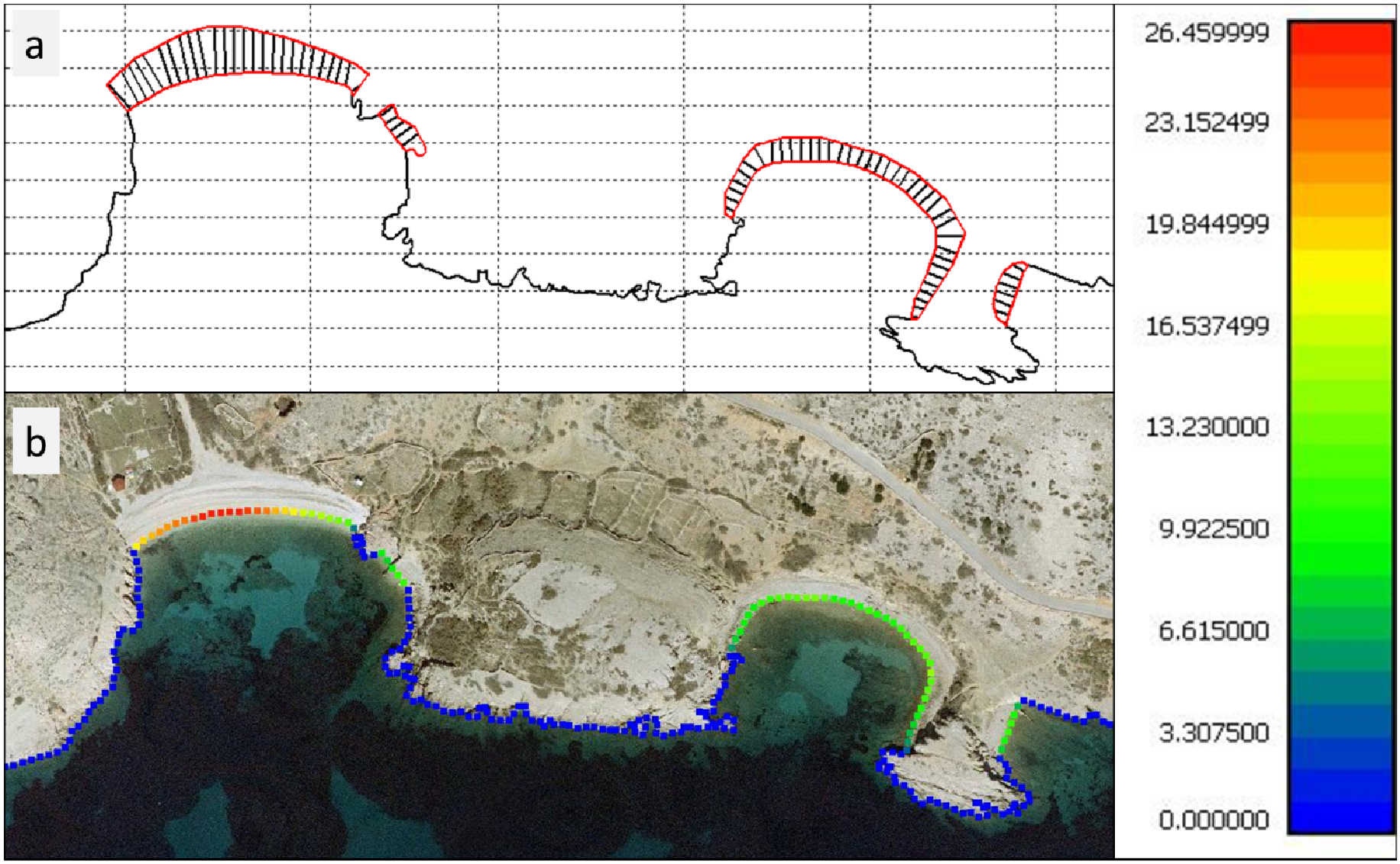
Coastal Vulnerability Index (CVI) analysis - application of 3D technology



Coastal Vulnerability Index (CVI) analysis - application of 3D technology



Coastal Vulnerability Index (CVI) analysis - application of 3D technology



Coastal vulnerability index (CVI)

- USGS

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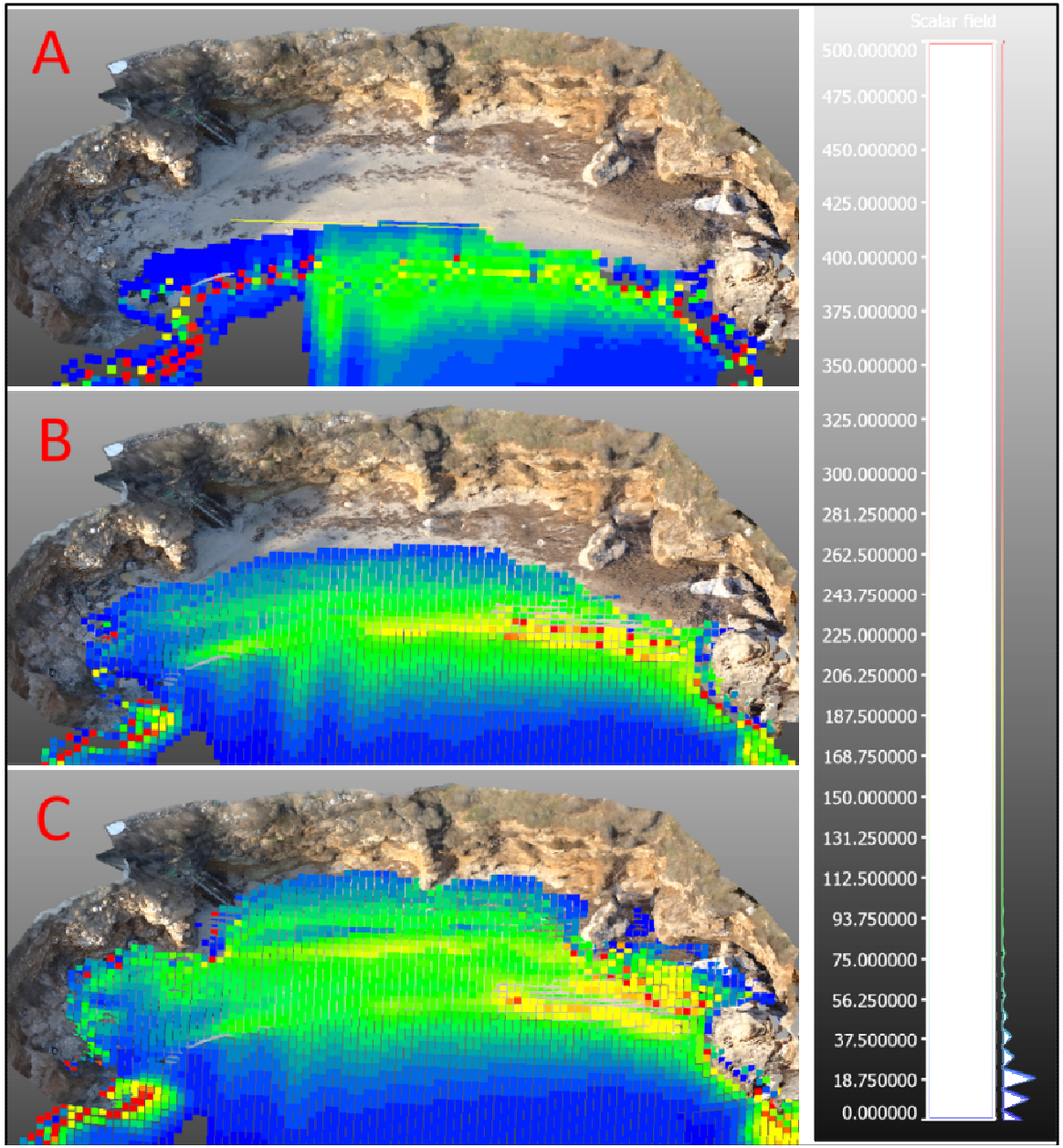
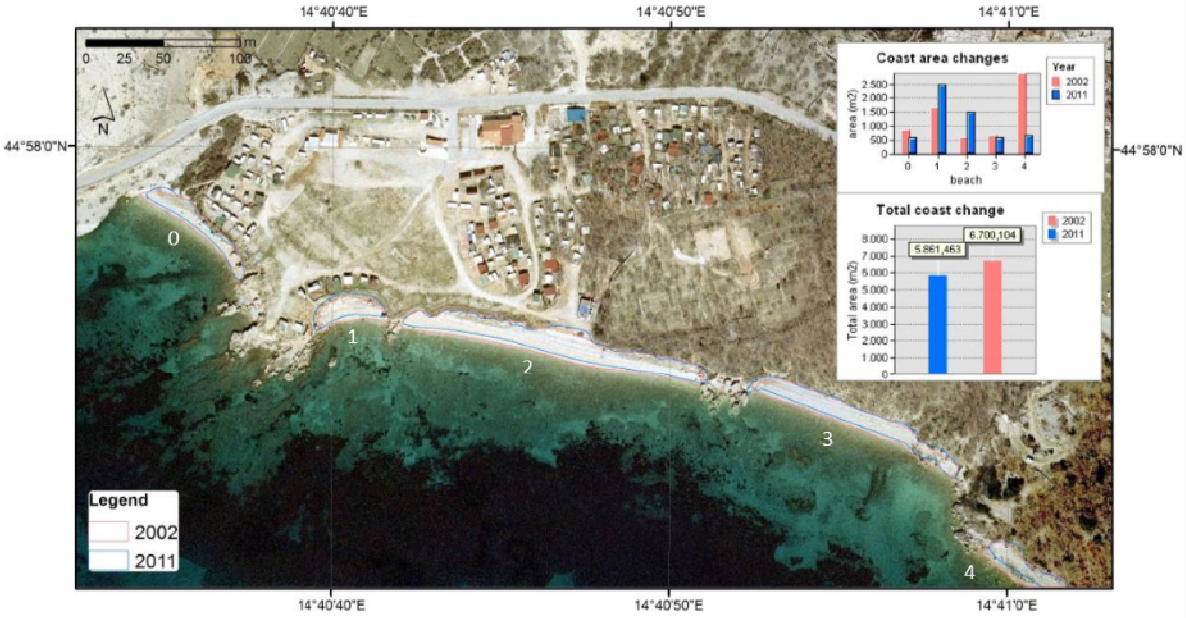
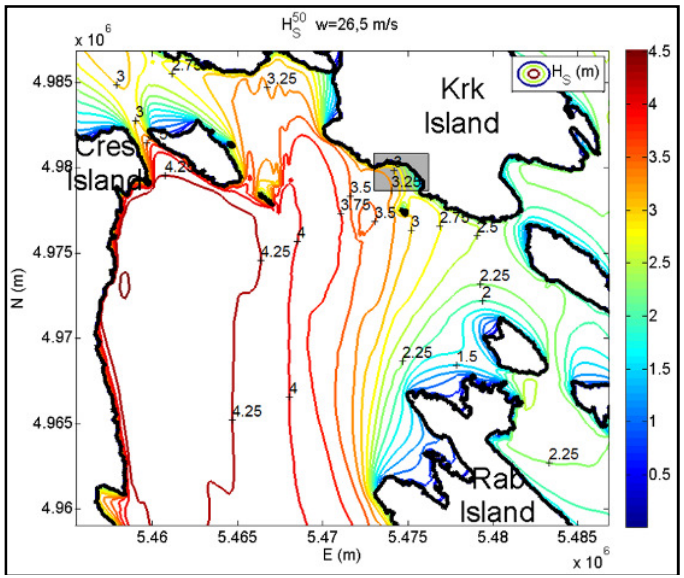
Coastal Vulnerability Index (CVI) analysis - application of 3D technology

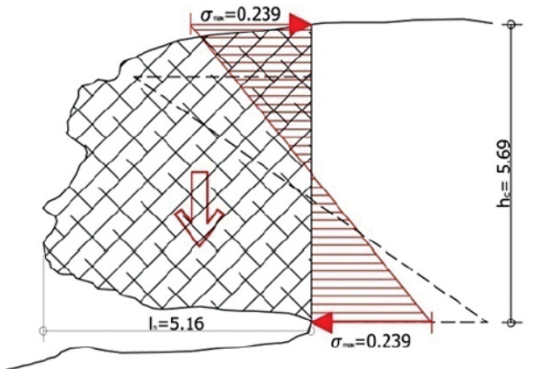


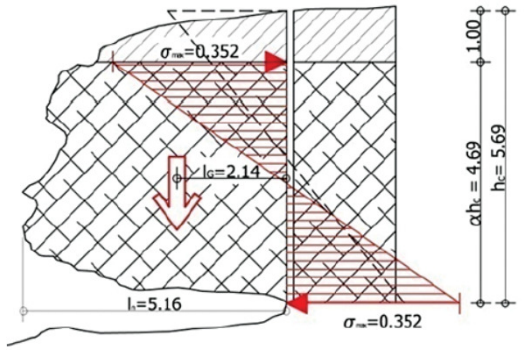
Djelovanje valova na obalu u slučaju povećanja morske razine

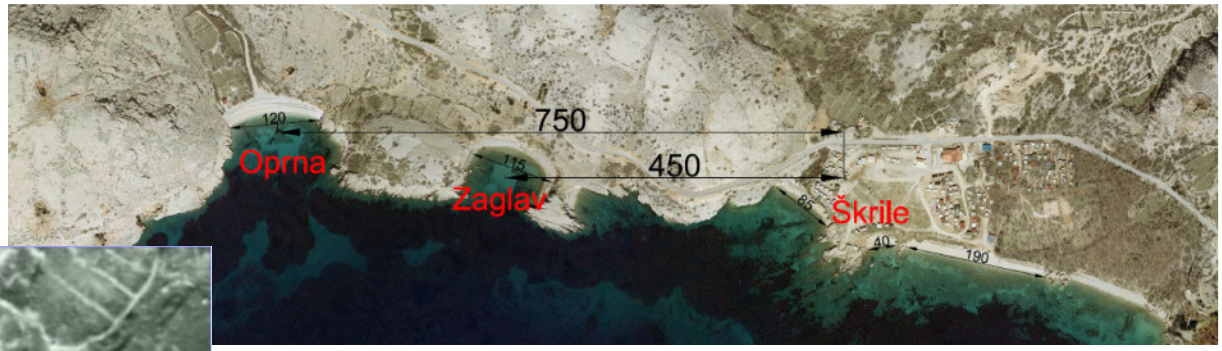
Coastal Vulnerability Index (CVI) analysis - application of 3D technology

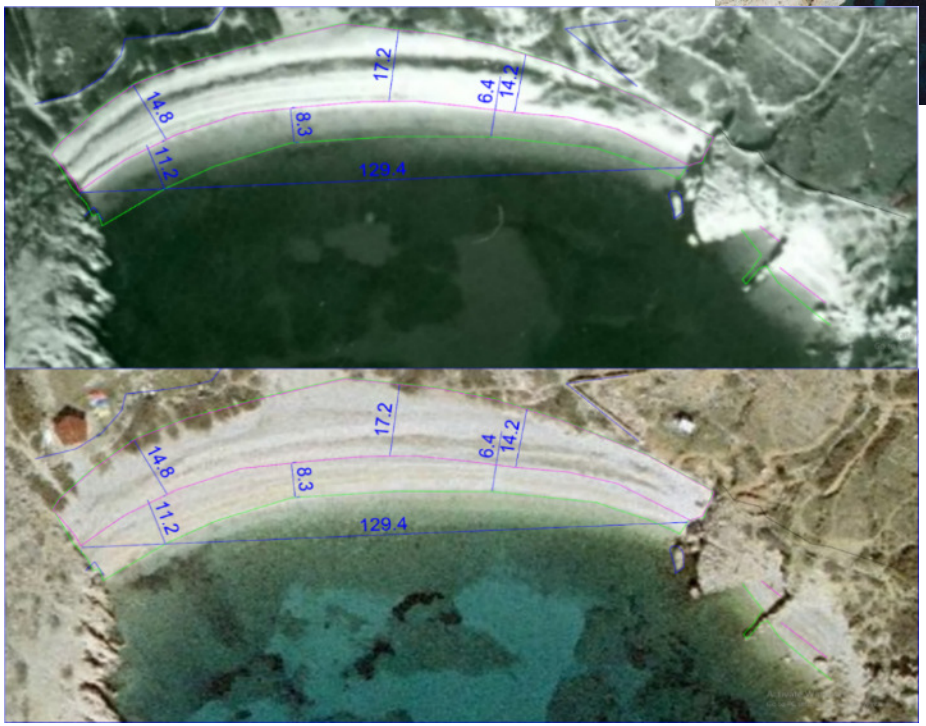




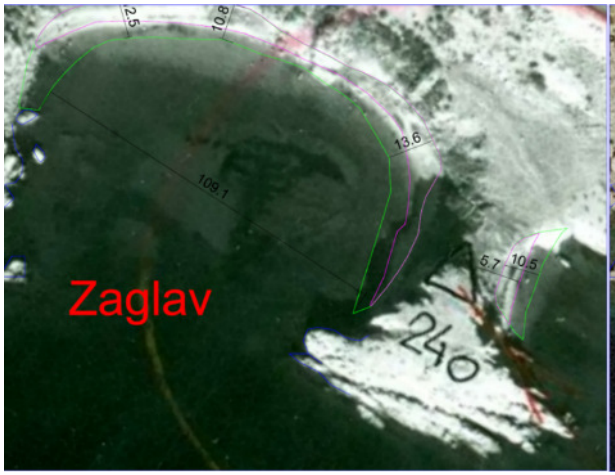




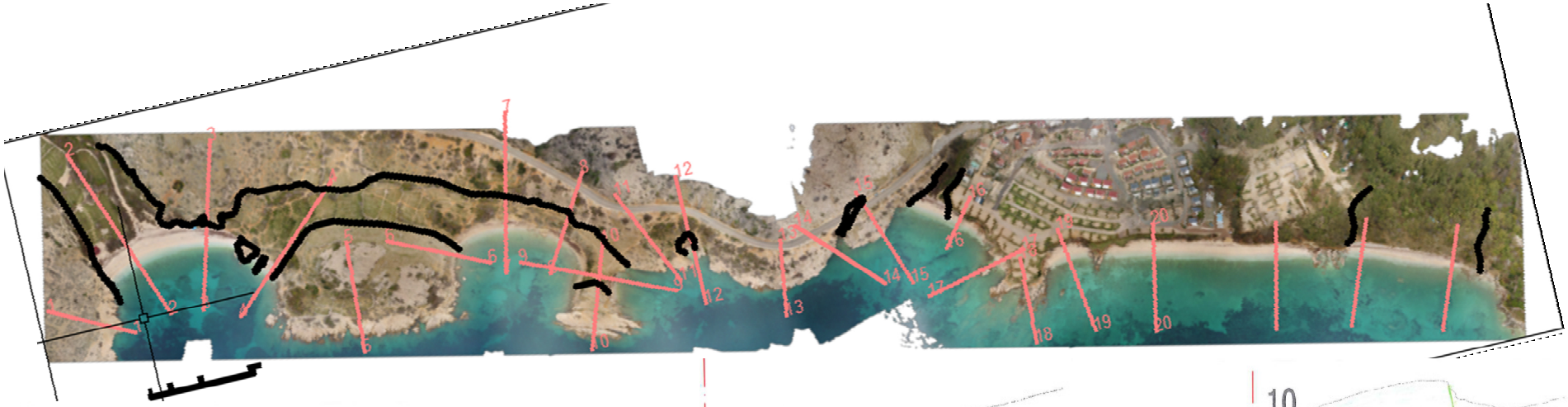

120
750
Oprna
115
450
Zaglav
85
Škrile
40
190

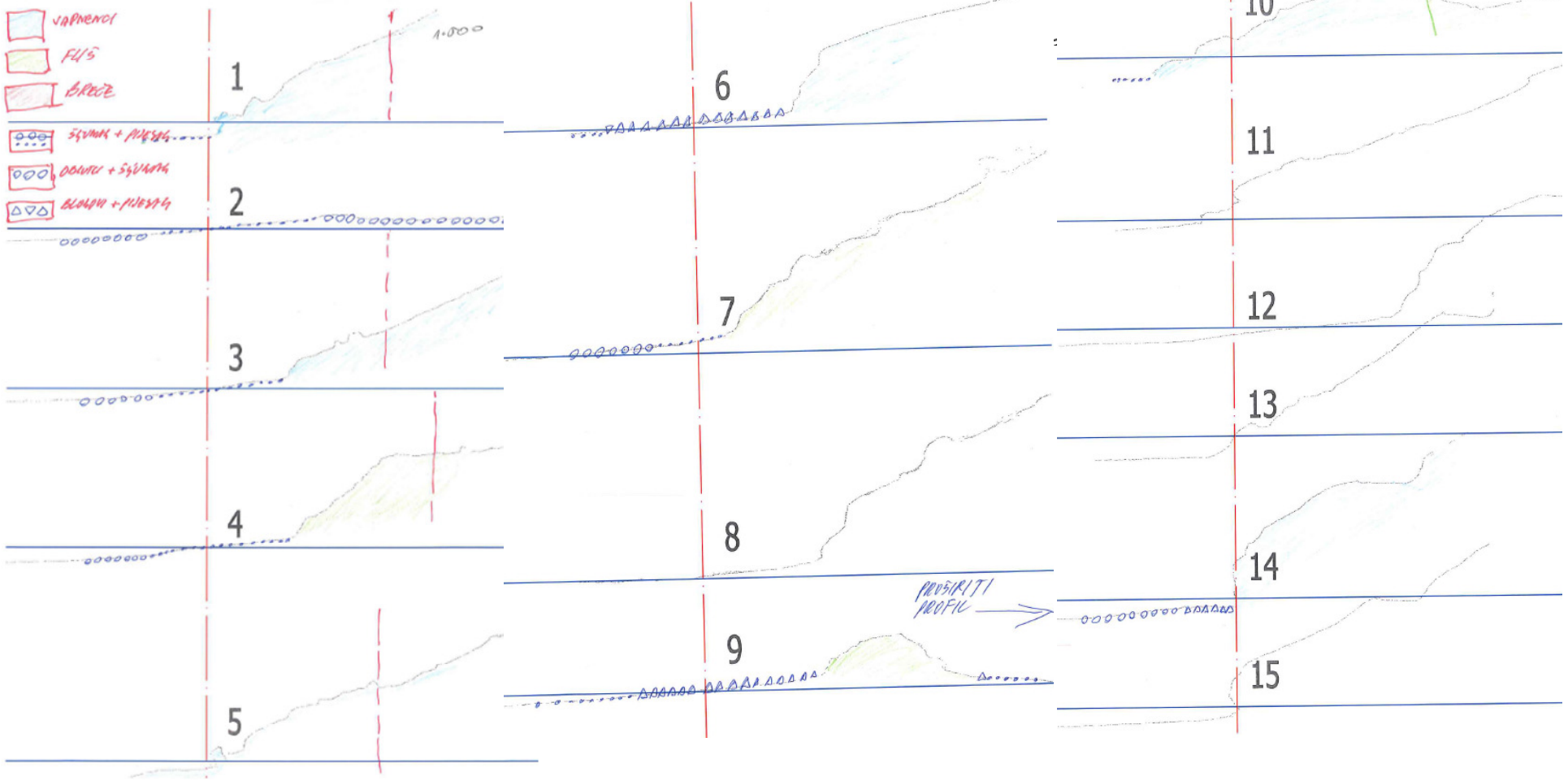

17.2
14.8
6.4
14.2
8.3
11.2
129.4

17.2
14.8
6.4
14.2
8.3
11.2
129.4


2.5
10.8
13.6
109.1
5.7
10.5
Zaglav
240


2.5
10.8
13.6
5.7
10.5
Zaglav




VAPNENCI
FLIŠ
BREČE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
PROŠIRITI PROFIL

Coastal Vulnerability Index (CVI) analysis - application of 3D technology

Na plaži Sablićevo (Pećine, Rijeka) dolazi do odrona stjenske mase – opasnost za korisnike plaže

PEĆINE

FOTO ODRON NA PLAŽI SABLIĆEVO
Oprez! Odlomili se veliki komadi stijene

Pogledaj sve iz: Rijeka
Pogledaj sve vijesti

Autor: P. N.
Objavljeno: 1. prosinac 2018. u 14:13

Veliki komadi stijene pali su na plažu, na kojoj srećom u tom trenutku nije bilo nikoga

Na plaži Sablićevo na riječkim Pećinama došlo je do odrona, kako nam javlja jedan od čitatelja.

Veliki komadi stijene pali su na plažu, na kojoj srećom u tom trenutku nije bilo nikoga.

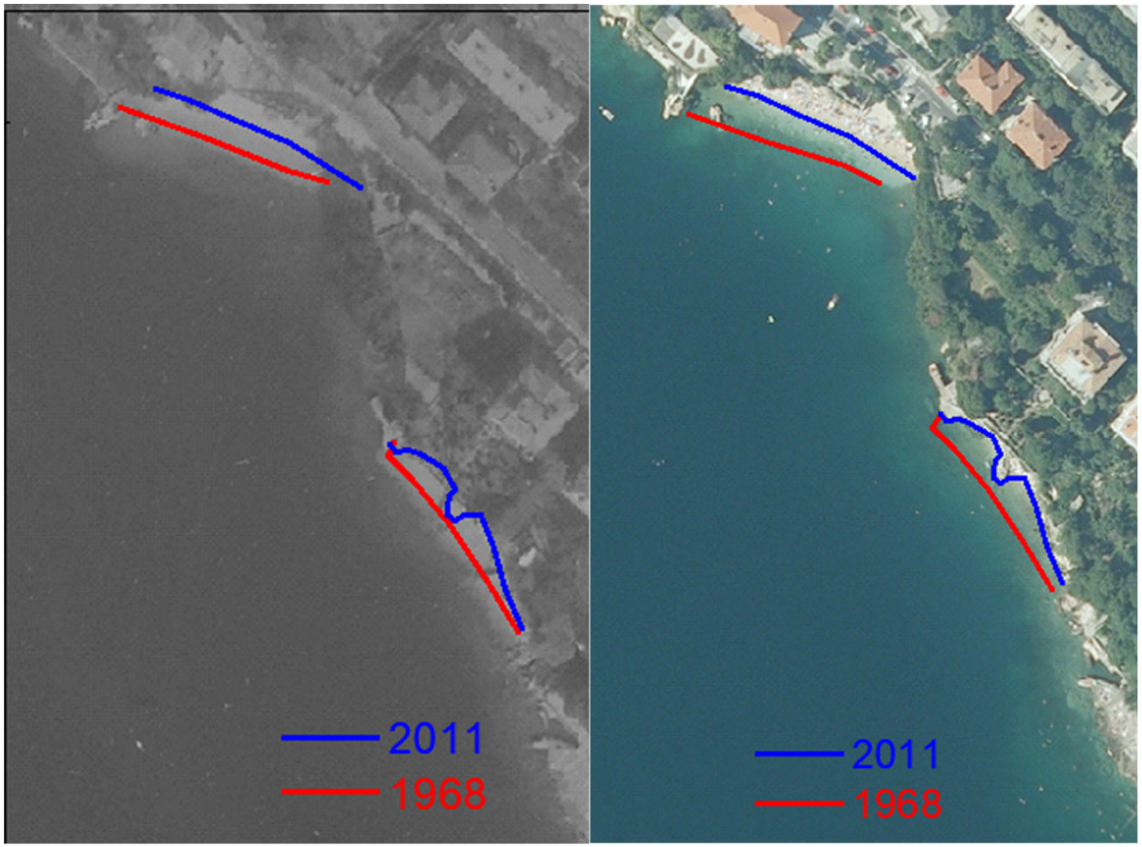
Riječka plaža Sablićevo na Pećinama uvrštena je proteklog ljeta na popis 40 najljepših hrvatskih plaža, prema izboru vodećega portala o Hrvatskoj na engleskom jeziku Croatia Week.

Foto Staša Sobolevski / Facebook

VEZANO
ČLANCI
› Vozači oprez: Ogromna stijena odronila se na Kupskoj magistrali i polomila stabla
› Hrvatska vojska pet dan pomaže u obrani od poplava, angažirano više od stotinu vojnika
› Dvoje mrtvih, tisuće evakuiranih zbog poplava i odrona u južnoj Kaliforniji

ČITATE KOMENTIRATE SVIĐA VAM SE
24 sata 7 dana
Preko noći zapalili "Otvoreni ormar", odjeću za siromašne: Ljudi, srce mi je puklo i ne mogu se više boriti
DESETLJEĆE OD VELIKE TRAGEDIJE Riječani se prisjećaju Simkea: 'Da se više nikad ne ponovi'
Hrvatska voditeljica oduševila obožavatelje objavom: "Jest da sam zaboravila hlače, al'..."
Isti dan kad i Mataničev, objavljen "alternativni" spot za EPK 2020, ali više nije dostupan na YouTubeu
AKO OVO NE URODI PLODOM... Ministar otkrio uvjete pod kojima će za dva mjeseca zatvoriti Mariščinu
ULJANIK IPAK IDE U STEČAJ? Ovo bi mogao biti kraj. Premijer Plenković odbio Debeljakovu ponudu za restrukturiranje
FAUSTO BUDICIN: Nitko sretniji od mene ako uđemo u Drugu HNL
Pretraži članke

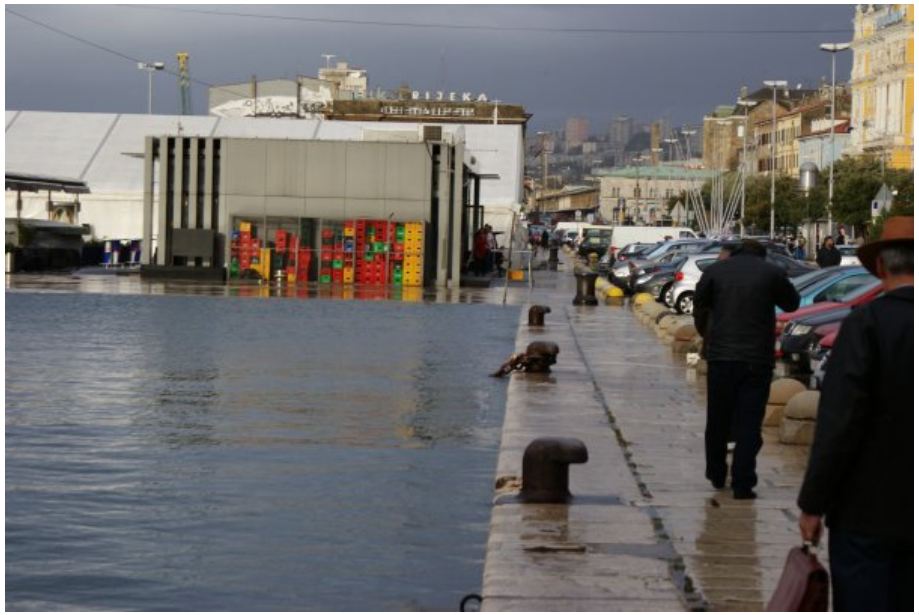
Coastal Vulnerability Index (CVI) analysis - application of 3D technology



Coastal Vulnerability Index (CVI) analysis - application of 3D technology

Coastal Vulnerability Index (CVI) analysis - application of 3D technology

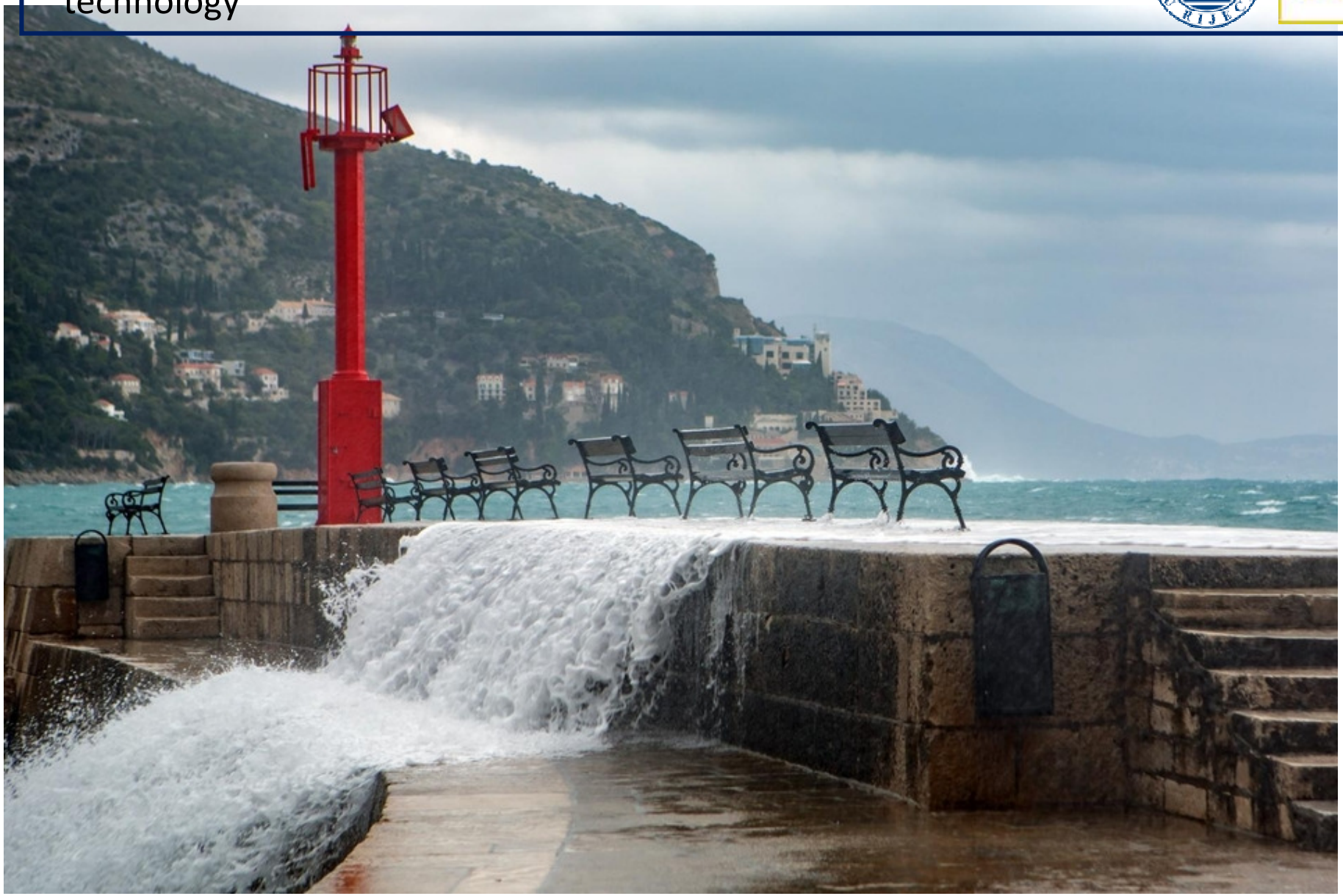
https://www.rtl.hr/vijesti-hr/novosti/svijet/3279873/europa-zbraja-posljedice-enormnih-poplava-u-italiji-8-mrtvih-jedna-zena-poginula-u-bujici-blata-u-vlastitoj-kuci/?galerija=2694477&slika=2898349



http://www.lokalpatrioti-rijeka.com/vijesti/98-foto-pogledajte-kako-bi-izgledala-rijeka-kad-bi-se-razina-mora-podignula-za-3-metra

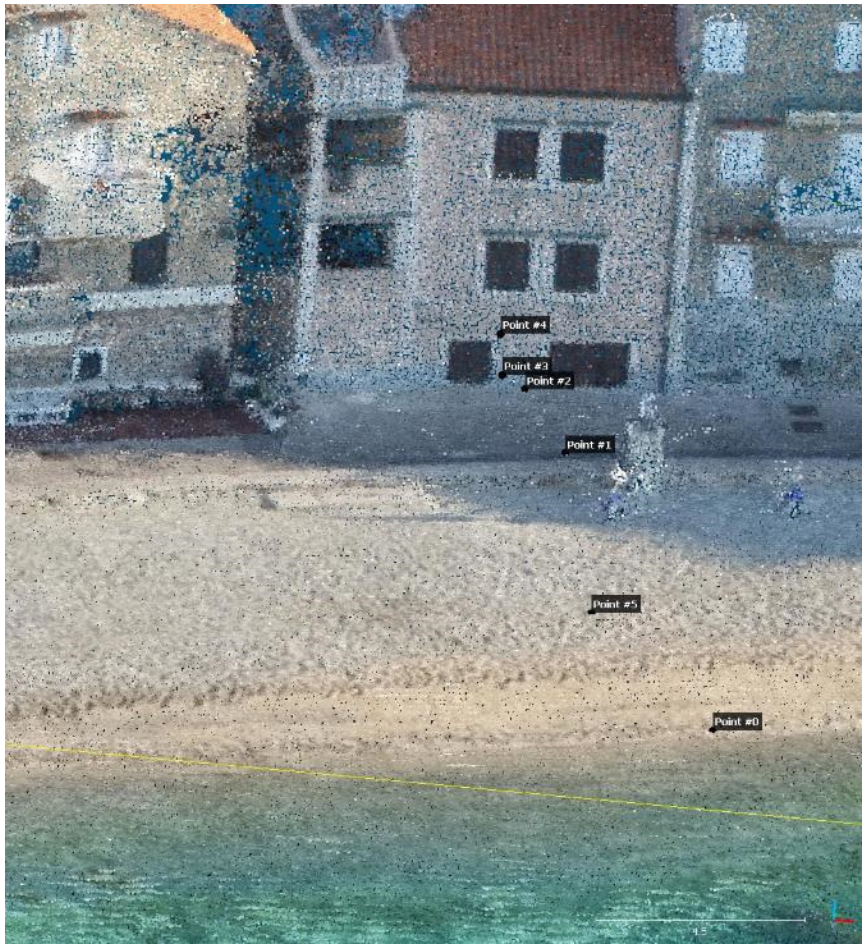
Coastal Vulnerability Index (CVI) analysis - application of 3D technology

Coastal Vulnerability Index (CVI) analysis - application of 3D technology

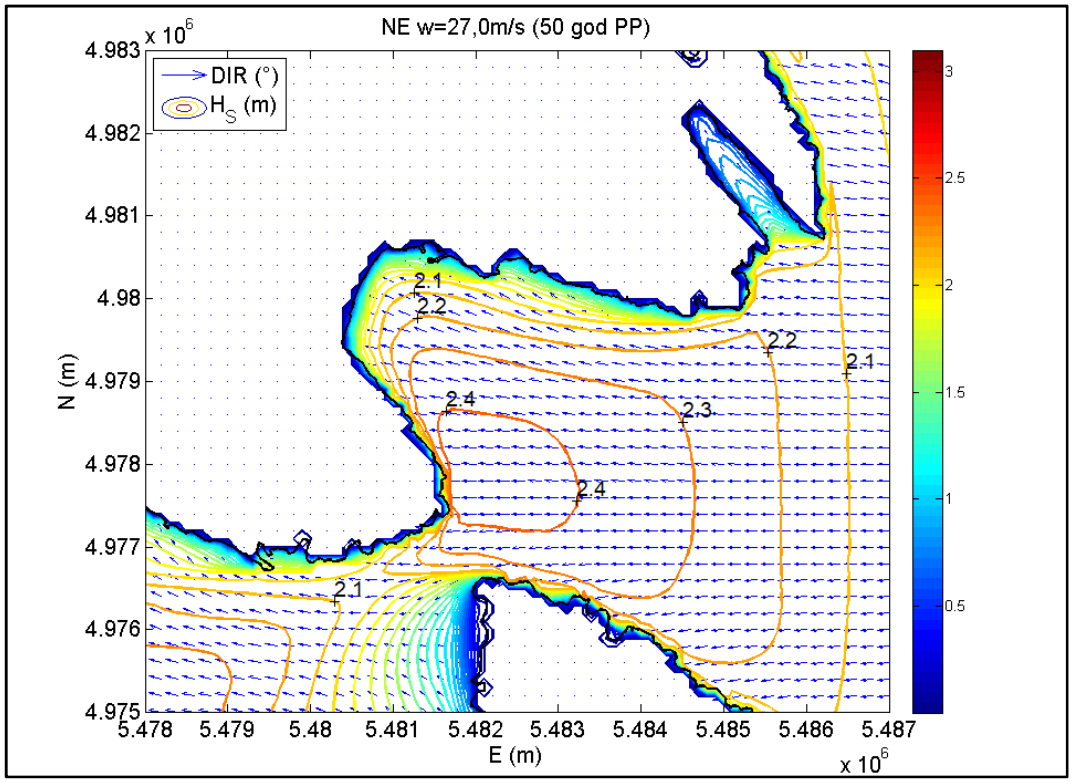


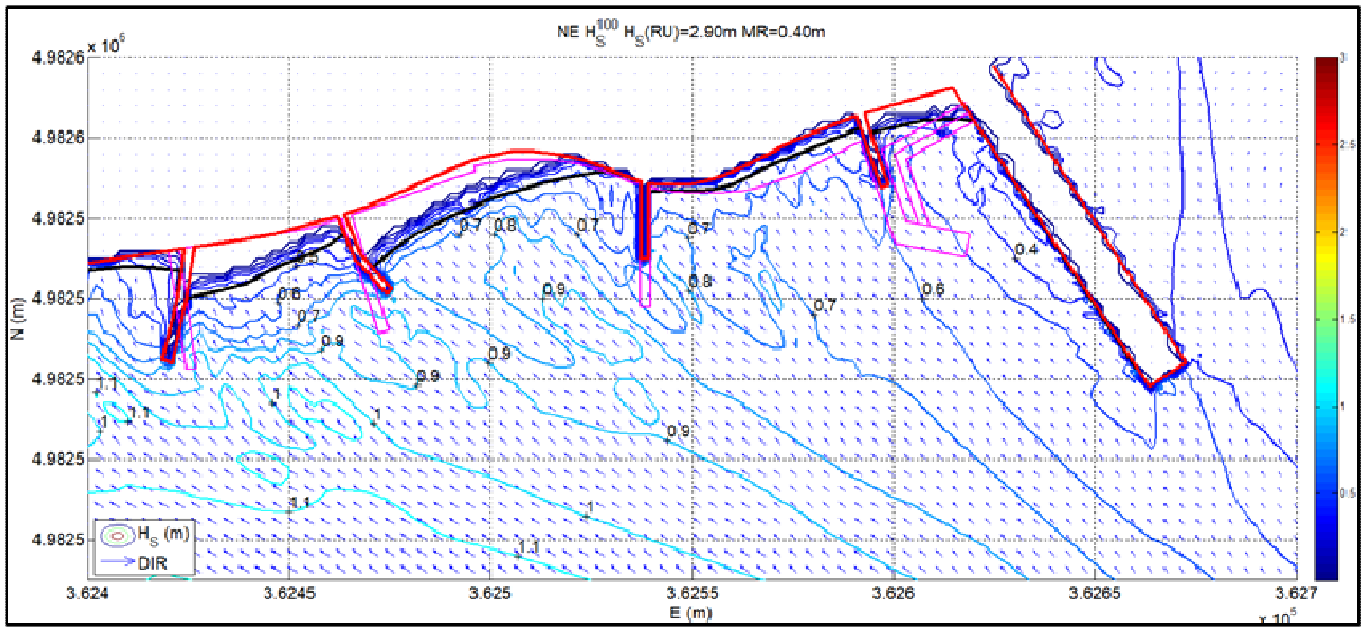
13/6/2017 – GF UniRi

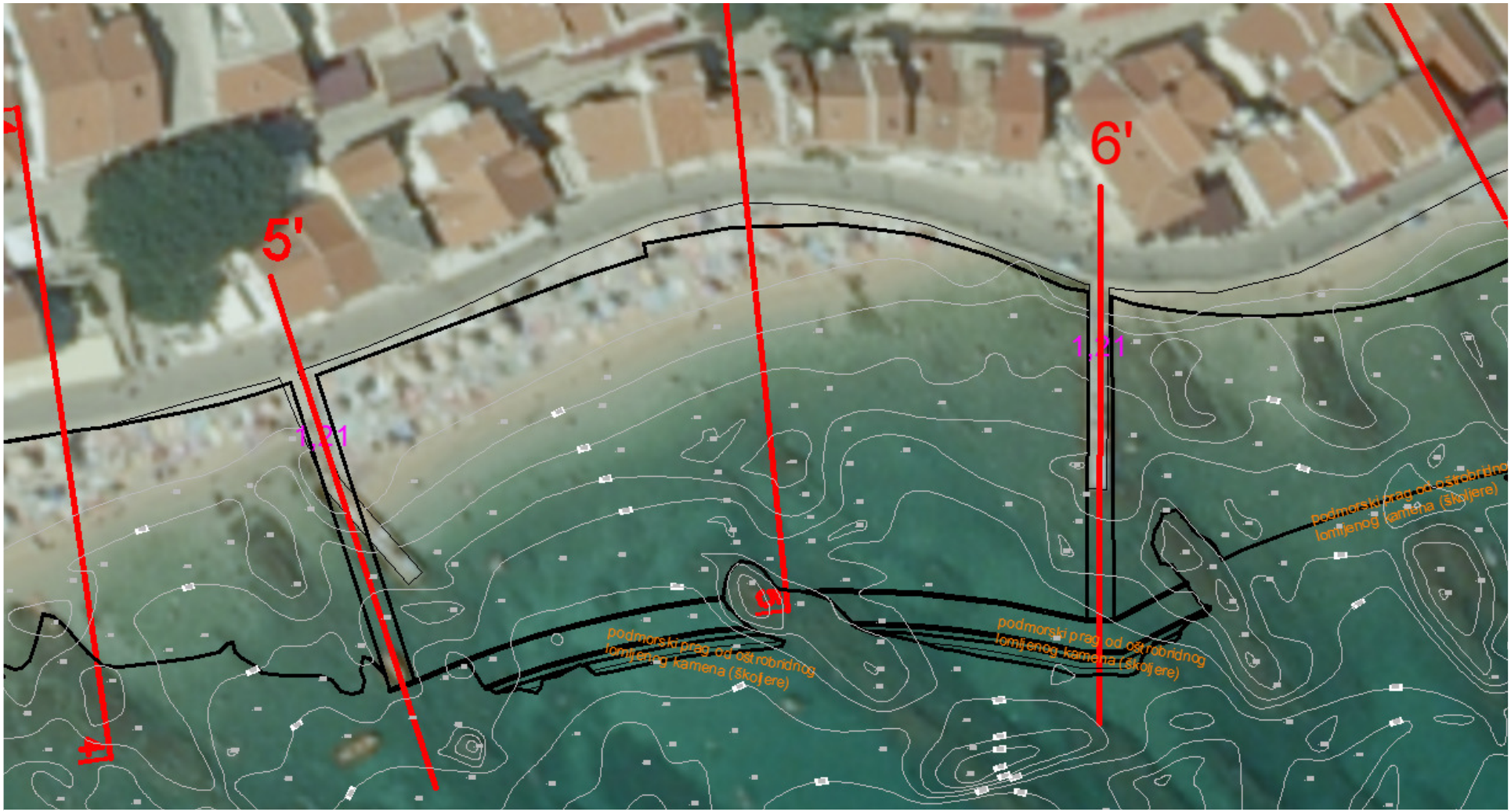

10



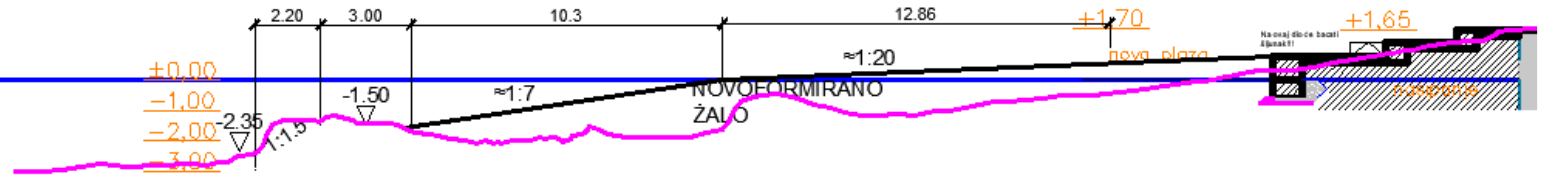
nr	X	Y	Z
0	1098.41	1442.92	-0.18
1	1093.83	1454.97	1.71
2	1092.59	1458.38	1.92
3	1092.07	1458.52	2.15
4	1091.97	1458.67	3.02
5	1095.24	1447.58	0.65


NE w=27,0m/s (50 god PP)
x 10^6
DIR (°)
H_S (m)
4.983
4.982
4.981
4.98
4.979
4.978
4.977
4.976
4.975
N (m)
5.478
5.479
5.48
5.481
5.482
5.483
5.484
5.485
5.486
5.487
E (m)
x 10^6
2.1
2.2
2.4
2.3
3
2.5
2
1.5
1
0.5


NE H_S^100 H_S(RU)=2.90m MR=0.40m
x 10^5
4.9826
4.9826
4.9825
4.9825
4.9825
4.9825
4.9825
N (m)
3.624
3.6245
3.625
3.6255
3.626
3.6265
3.627
E (m)
x 10^5
H_S (m)
DIR
0.7
0.8
0.9
1
1.1
0.6
0.4


5'
6'
1:1,5
1:1,5
podmorski prag od oštrobridnog lomljenog kamena (školjere)
podmorski prag od oštrobridnog lomljenog kamena (školjere)
podmorski prag od oštrobridnog lomljenog kamena (školjere)

PRESJEK 5–5

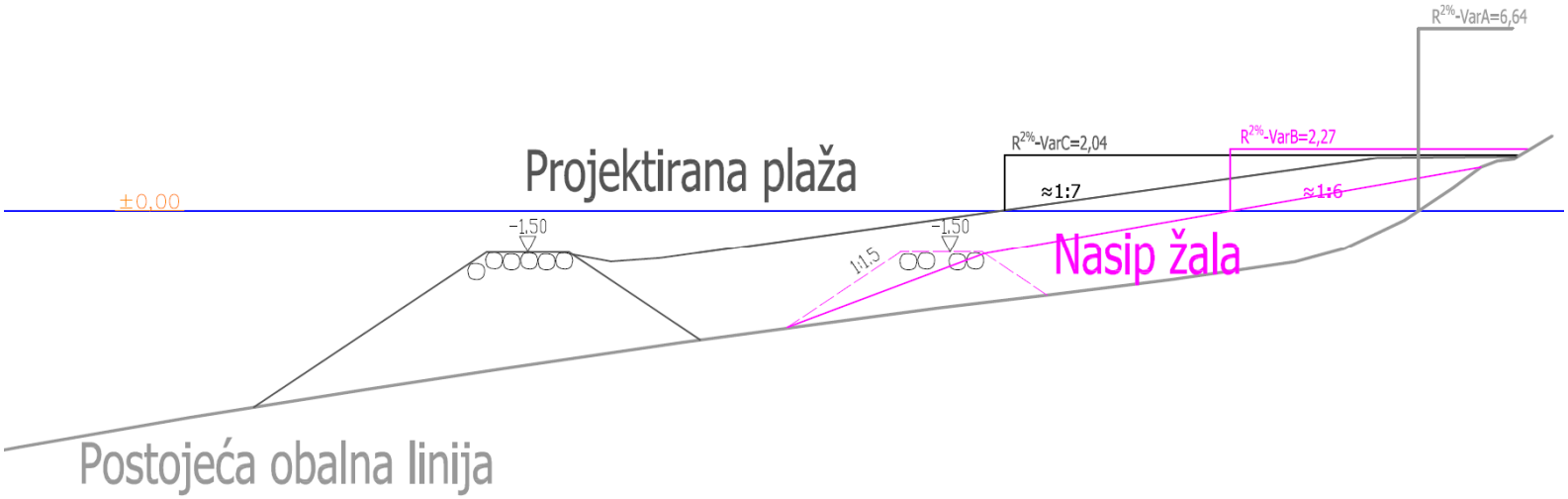

2.20
3.00
10.3
12.86
±0,00
−1,00
−2,00
−3,00
-2.35
1:1.5
-1.50
≈1:7
≈1:20
NOVOFORMIRANO ŽALO
+1,70
nova plaža
+1,65
postojeće

Uzdizanje valova (wave runup)

Uspoređene su visine uzdizanja valova za tri analizirane varijante prema klasičnoj Huntovoj (1955) formuli i prema recentnoj Poate (2016) formuli za jugo 50 godišnjeg povratnog perioda (HS=2,7m)
U tablici 1 prikazan je proračun uspinjanja valova.

Hunt		H_o	T_o	L_o	ΔH	ΔL	$tg\beta$	R
$R = \tan\beta \sqrt{H_o L_o}$	Var A	2.7	4.1	26.2236	3.75	2.5	1.50	12.62
	Var B	2.7	4.1	26.2236	1	5.7	0.18	1.48
	Var C	2.7	4.1	26.2236	1	7.1	0.14	1.19

Poate		H_o	T_o	L_o	ΔH	ΔL	$tg\beta$	C	R
$R_{2\%} = C \tan\beta^{0.5} T_p H_s$	Var A	2.7	4.1	26.2236	3.75	2.5	1.50	0.49	6.64
	Var B	2.7	4.1	26.2236	1	5.7	0.18	0.49	2.27
	Var C	2.7	4.1	26.2236	1	7.1	0.14	0.49	2.04



Coastal Vulnerability Index (CVI) analysis - application of 3D technology

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Thank you for your attention