

Risultati della modellazione Idrologico/Idraulica per i bacini dell'Ardivestra, Scuropasso e Versa

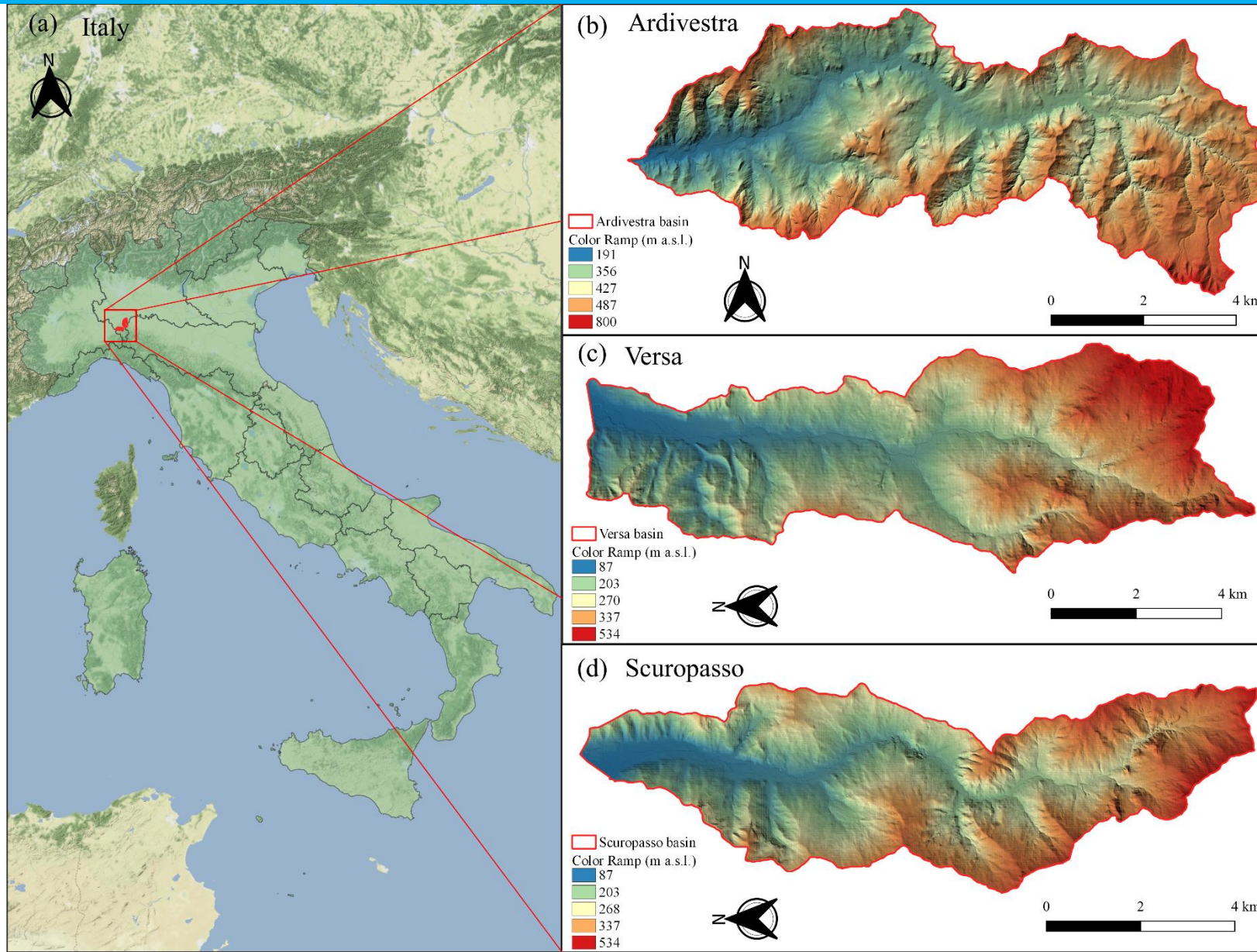
Giuseppe Barbero, Domenico Ferraro, Gabriella Petaccia



UNIVERSITÀ
DI PAVIA



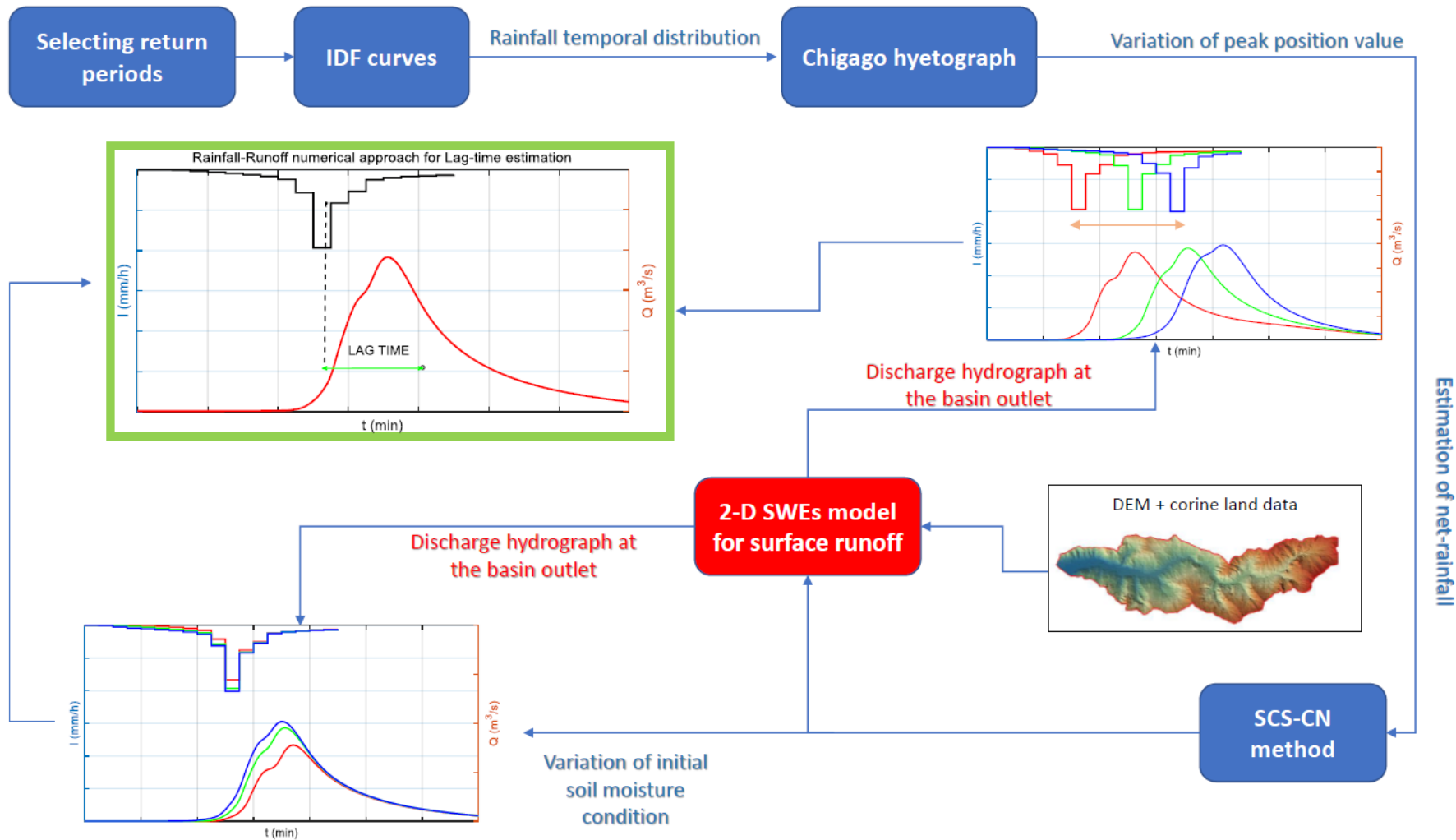
1. Inquadramento Area di Studio



2. Caratteristiche dei bacini considerati

Caratteristiche	Unità di misura	Ardivestra	Versa	Scuropasso
Area	[km ²]	47.32	55.38	36.84
Lunghezza asta principale	[km]	24.09	23.62	18.27
Lunghezza reticolo	[km]	198.38	265.44	163.57
pendenza	[-]	0.32	0.19	0.22
zmax	[m.a.s.l.]	797.18	665.92	532.61
zmean	[m.a.s.l.]	421.99	266.20	259.91
zmin	[m.a.s.l.]	190.97	71.31	84.87
Densità drenaggio	[m-1]	0.0042	0.0048	0.0044
n	[sm-1/3]	0.050	0.055	0.055
ip	[%]	0.25	0.68	1.68
Distanza baricentro-sez.chiusura	[km]	11.35	9.57	11.27

3. Modello Idrologico/idraulico



4. Definizione pioggia di progetto

Calcolo della linea segnatrice 1-24 ore

Località:
Coordinate:

Linea segnatrice
Tempo di ritorno (anni) **30**

Parametri ricavati da: <http://idro.arpalombardia.it>

A1 - Coefficiente pluviometrico orario 24,585
N - Coefficiente di scala 0,307
GEV - parametro alpha 0,278
GEV - parametro kappa -0,092
GEV - parametro epsilon 0,812

Evento pluviometrico
Durata dell'evento [ore]
Precipitazione cumulata [mm]

Formulazione analitica
$$h_T(D) = a_1 w_T D^n$$

$$w_T = \varepsilon + \frac{\alpha}{k} \left[1 - \left[\ln \left(\frac{T}{T-1} \right) \right]^k \right]$$

Bibliografia ARPA Lombardia:
<http://idro.arpalombardia.it/manual/1300.pdf>
http://idro.arpalombardia.it/manual/STRADA_report.pdf

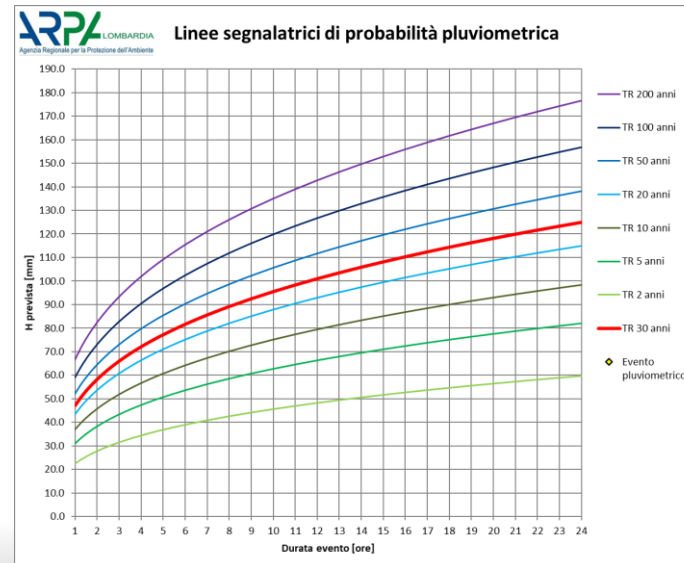
Tabella delle precipitazioni previste al variare delle durate e dei tempi di ritorno

Tr	2	5	10	20	50	100	200	30
wT	0.91563	1.25912	1.50707	1.76155	2.11699	2.40404	2.70898	1.91576254
Durata (ore)	TR 2 anni	TR 5 anni	TR 10 anni	TR 20 anni	TR 50 anni	TR 100 anni	TR 200 anni	TR 30 anni
0.25	11.3	15.5	18.5	21.7	26.0	29.6	33.3	23.5495111
0.5	15.9	21.9	26.2	30.6	36.8	41.8	47.1	33.3040379
0.75	19.5	26.8	32.1	37.5	45.1	51.2	57.7	40.7889496
1	22.5	31.0	37.1	43.3	52.0	59.1	66.6	47.0990221
1.25	24.1	33.2	39.7	46.4	55.7	63.3	71.3	50.4386279
1.5	25.5	35.1	42.0	49.0	58.9	66.9	75.4	53.3423208
1.75	26.7	36.8	44.0	51.4	61.8	70.2	79.1	55.9273924
2	27.8	38.3	45.8	53.6	64.4	73.1	82.4	58.26773
2.25	28.9	39.7	47.5	55.6	66.8	75.8	85.4	60.4132115
2.5	29.8	41.0	49.1	57.4	69.0	78.3	88.2	62.3992648
2.75	30.7	42.2	50.5	59.1	71.0	80.6	90.9	64.2520557
3	31.5	43.4	51.9	60.7	72.9	82.8	93.3	65.9915175
3.25	32.3	44.5	53.2	62.2	74.7	84.9	95.6	67.6332227
3.5	33.1	45.5	54.4	63.6	76.5	86.8	97.8	69.1895936
3.75	33.8	46.4	55.6	65.0	78.1	88.7	99.9	70.6707157
4	34.5	47.4	56.7	66.3	79.7	90.5	101.9	72.0849012
4.25	35.1	48.3	57.8	67.5	81.2	92.2	103.8	73.4390908
4.5	35.7	49.1	58.8	68.7	82.6	93.8	105.7	74.7391461
5	36.9	50.7	60.7	71.0	85.3	96.9	109.2	77.1961571
6	39.0	53.7	64.2	75.1	90.2	102.4	115.4	81.6402496
7	40.9	56.3	67.3	78.7	94.6	107.4	121.0	85.5966934
8	42.6	58.6	70.2	82.0	98.5	111.9	126.1	89.1785725
9	44.2	60.8	72.7	85.0	102.2	116.0	130.7	92.4622251
10	45.6	62.8	75.1	87.8	105.5	119.8	135.0	95.5018732
11	47.0	64.6	77.4	90.4	108.7	123.4	139.1	98.3375637
12	48.3	66.4	79.5	92.9	111.6	126.7	142.8	100.999804
13	49.5	68.0	81.4	95.2	114.4	129.9	146.4	103.512429
14	50.6	69.6	83.3	97.4	117.0	132.9	149.7	105.89445
15	51.7	71.1	85.1	99.5	119.5	135.7	152.9	108.161302
16	52.7	72.5	86.8	101.4	121.9	138.4	156.0	110.325708
17	53.7	73.9	88.4	103.4	124.2	141.0	158.9	112.398291
18	54.7	75.2	90.0	105.2	126.4	143.5	161.7	114.388022
19	55.6	76.4	91.5	106.9	128.5	145.9	164.5	116.302552
20	56.5	77.7	92.9	108.6	130.6	148.3	167.1	118.148469
21	57.3	78.8	94.3	110.3	132.5	150.5	169.6	119.931486
22	58.1	80.0	95.7	111.9	134.4	152.7	172.0	121.656594
23	58.9	81.1	97.0	113.4	136.3	154.8	174.4	123.328184
24	59.7	82.1	98.3	114.9	138.1	156.8	176.7	124.950138

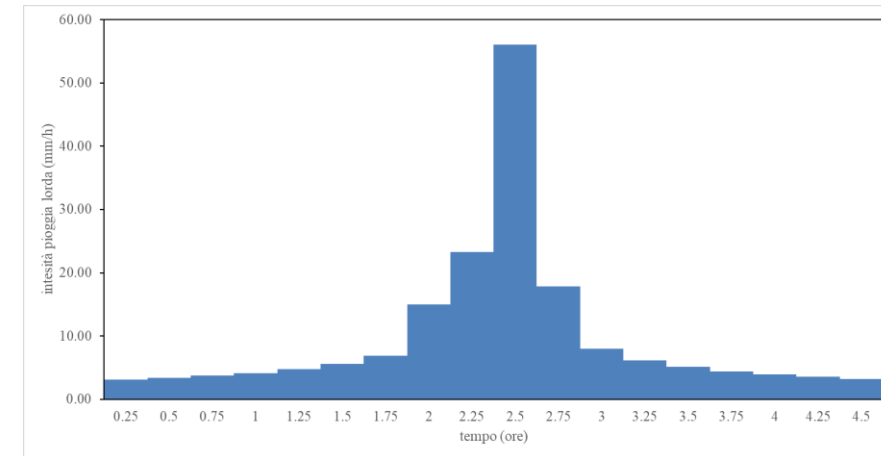
Scelta del tempo di Corrivazione

DATI MORFOMETRICI DEL BACINO IDROGRAFICO SOTTESO ALLA SEZIONE DI CHIUSURA CONSIDERATA		TEMPO DI CORRIVAZIONE t_c (ore)	
Superficie del Bacino	S = 47.99 Km ²	Giandotti	$t_c = \frac{4\sqrt{S} + 1.5L}{0.8\sqrt{H_m - H_0}} = 4.48$
Lunghezza percorso idraulico principa	L = 23.62 Km	Kirpich, Watt-Chow, Pezzoli	$t_c = 0.02221 \left(\frac{L}{\sqrt{P}} \right)^{0.8}$
Altitudine max percorso idraulico	Hmax = 688.20 m (s.l.m.)		
Altitudine min percorso idraulico	H0 = 66.87 m (s.l.m.)	<input checked="" type="radio"/> Giandotti	
Pendenza media percorso idraulico	P = 0.03 (m/m)	<input type="radio"/> Kirpich, Watt-Chow, Pezzoli...	
Altitudine max bacino	Hmax = 688.20 m (s.l.m.)		
Altitudine sezione considerata	H0 = 66.87 m (s.l.m.)		
Altitudine media bacino	Hm = 377.54 m (s.l.m.)		
Dislivello medio bacino	Hm - H0 = 310.67 m		

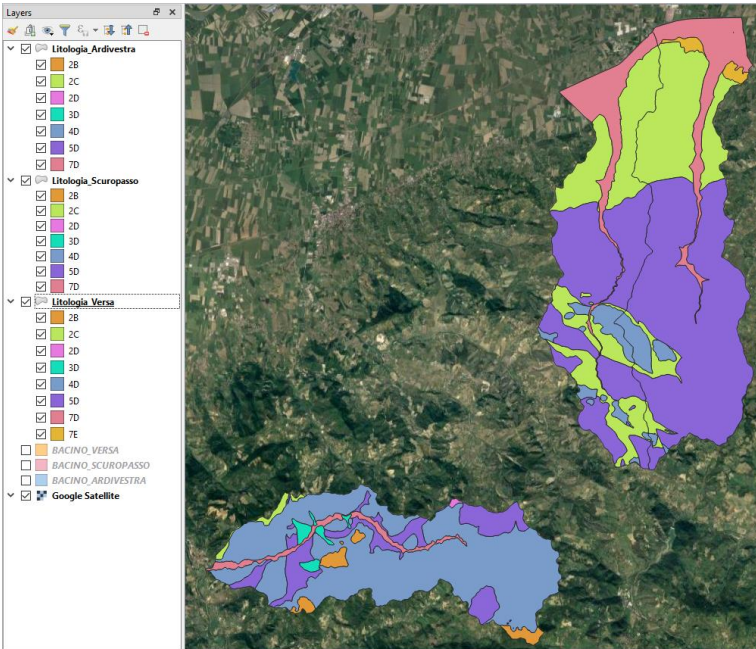
Curve di possibilità climatica



Ietogramma Chicago



4. Definizione pioggia di progetto

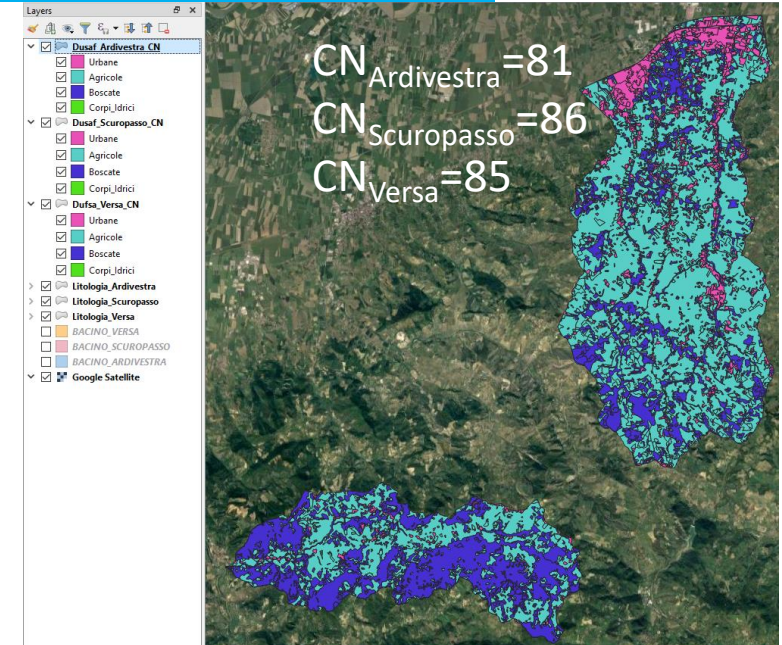


Il parametro CN

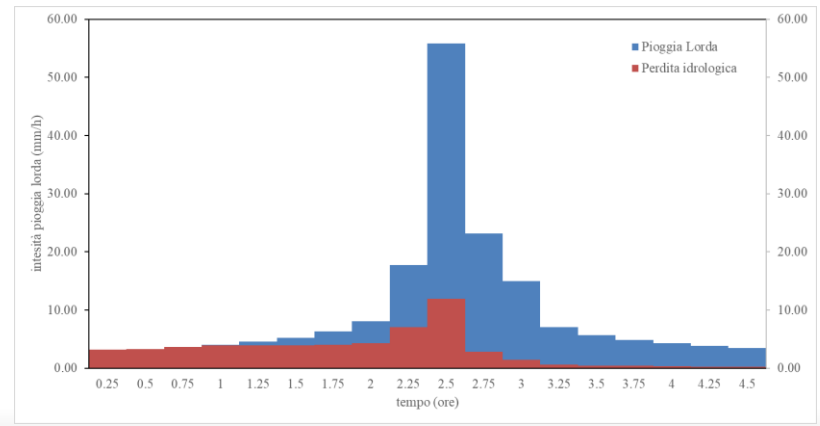
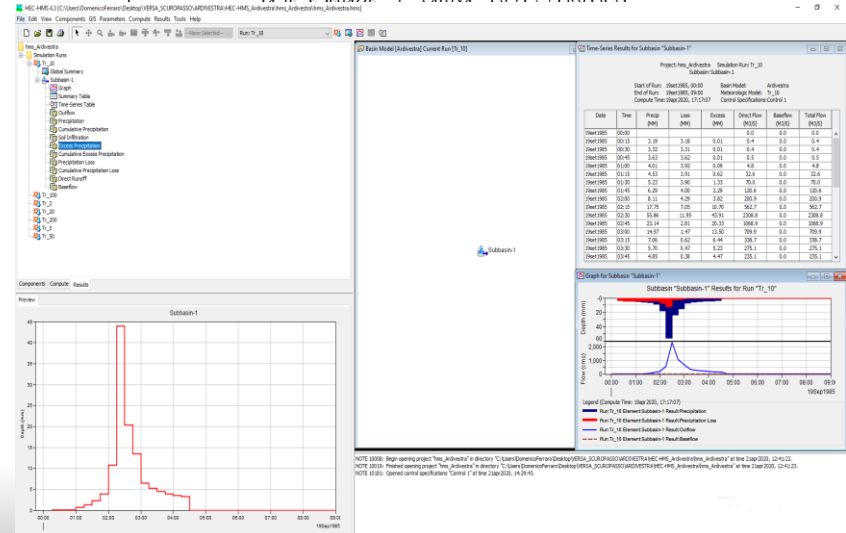
CN varia in funzione di 4 diverse classificazioni:

- 1- classificazione della possibilità di infiltrazione del suolo ('hydrologic soil group')
A, B, C e D (dove A indica i suoli a maggiore infiltrabilità e D quelli a minore infiltrabilità)
- 2- uso del suolo (colture disposte a file, pascoli, boschi, etc.), **trattamento della superficie** (solchi dritti, solchi a reggipoggio, solchi a reggipoggio e terrazzamenti)
- 3- **condizione di drenaggio** (cattiva, discreta, buona)
- 4- **condizioni iniziali di saturazione dei suoli.**

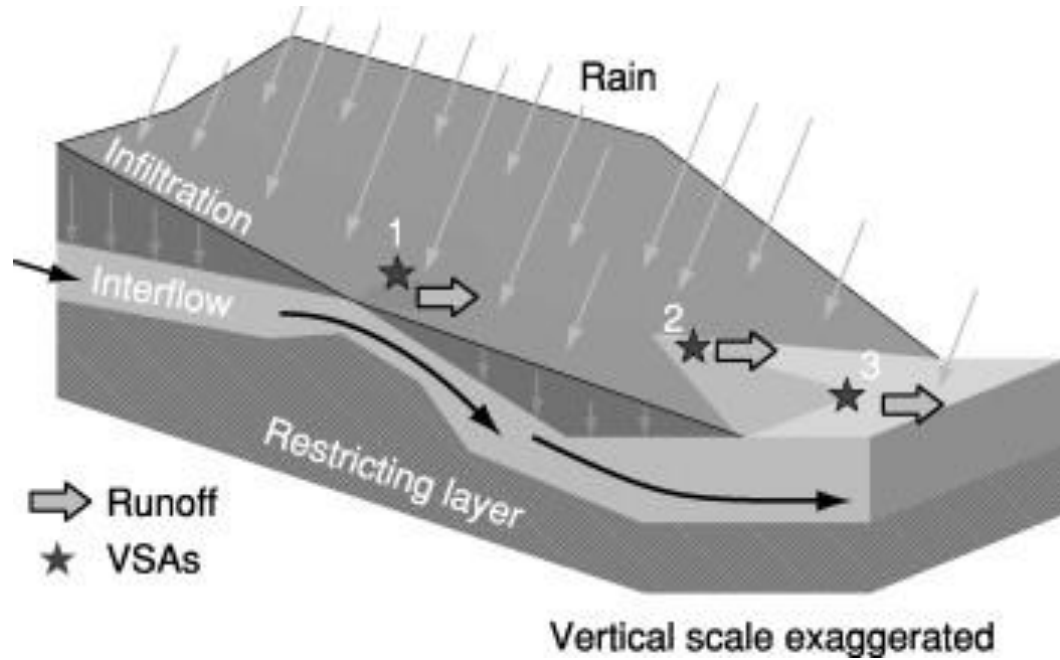
Uso del suolo	Tipo di copertura	Trattamento o pratica	Condizione idrologica	Classe del suolo			
				A	B	C	D
Maggesi		a solchi dritti	-	77	86	91	94
Colture a solchi	a solchi dritti	a solchi dritti	cattiva	72	81	88	91
		a solchi dritti	buona	67	78	85	89
		a reggipoggio	cattiva	70	79	84	88
		a reggipoggio	buona	65	75	82	86
		a re. e terrazze	cattiva	66	74	80	82
Grani piccoli	a solchi dritti	a re. e terrazze	buona	62	71	78	81
		a solchi dritti	cattiva	65	76	84	88
		a solchi dritti	buona	63	75	83	87
		a reggipoggio	cattiva	63	74	82	85
		a reggipoggio	buona	61	73	81	84
Legumi seminati folti o prati in rotazione	a re. e terrazze	a re. e terrazze	cattiva	61	72	79	82
		a re. e terrazze	buona	59	70	78	81
		a solchi dritti	cattiva	66	77	85	89
		a solchi dritti	buona	58	72	81	85
		a reggipoggio	cattiva	64	75	83	85
a reggipoggio	buona	55	69	78	83		
a re. e terrazze	cattiva	63	73	80	83		



Calcolo della pioggia netta con HEC-HMS



5. Modello Idraulico

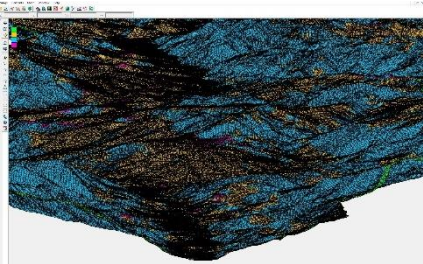


$$\frac{\partial U}{\partial t} + \frac{\partial F}{\partial x} + \frac{\partial G}{\partial y} = S$$

$$U = \begin{pmatrix} h \\ q_x \\ q_y \end{pmatrix}$$

$$F = \begin{pmatrix} q_x \\ \frac{q_x^2}{h} + \frac{gh^2}{2} \\ \frac{q_x \cdot q_y}{h} \end{pmatrix}$$

$$G = \begin{pmatrix} q_y \\ \frac{q_x \cdot q_y}{h} \\ \frac{q_y^2}{h} + \frac{gh^2}{2} \end{pmatrix}$$

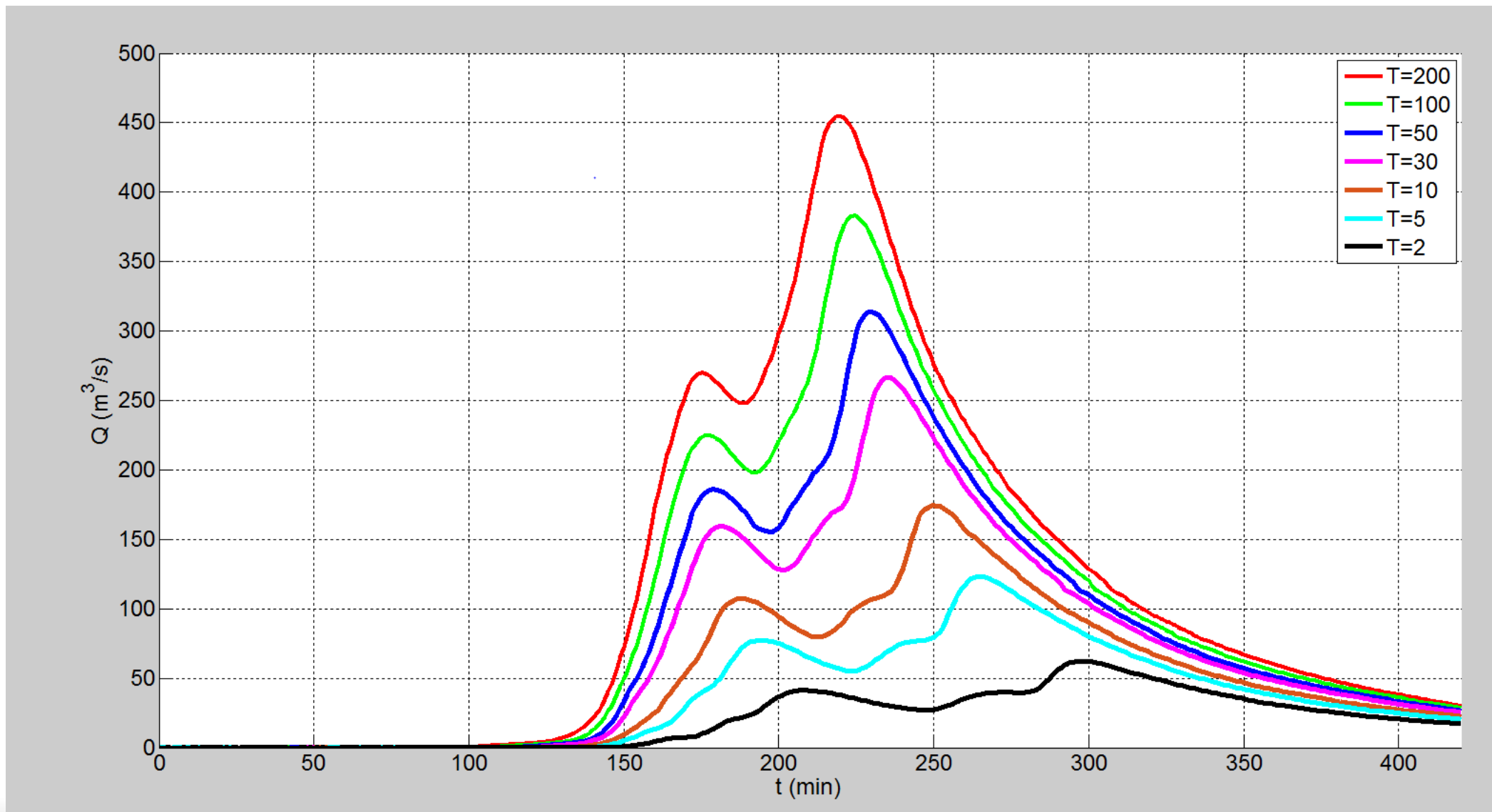


Griglia non strutturata Triangolare;
Dimensione lato 10 m;

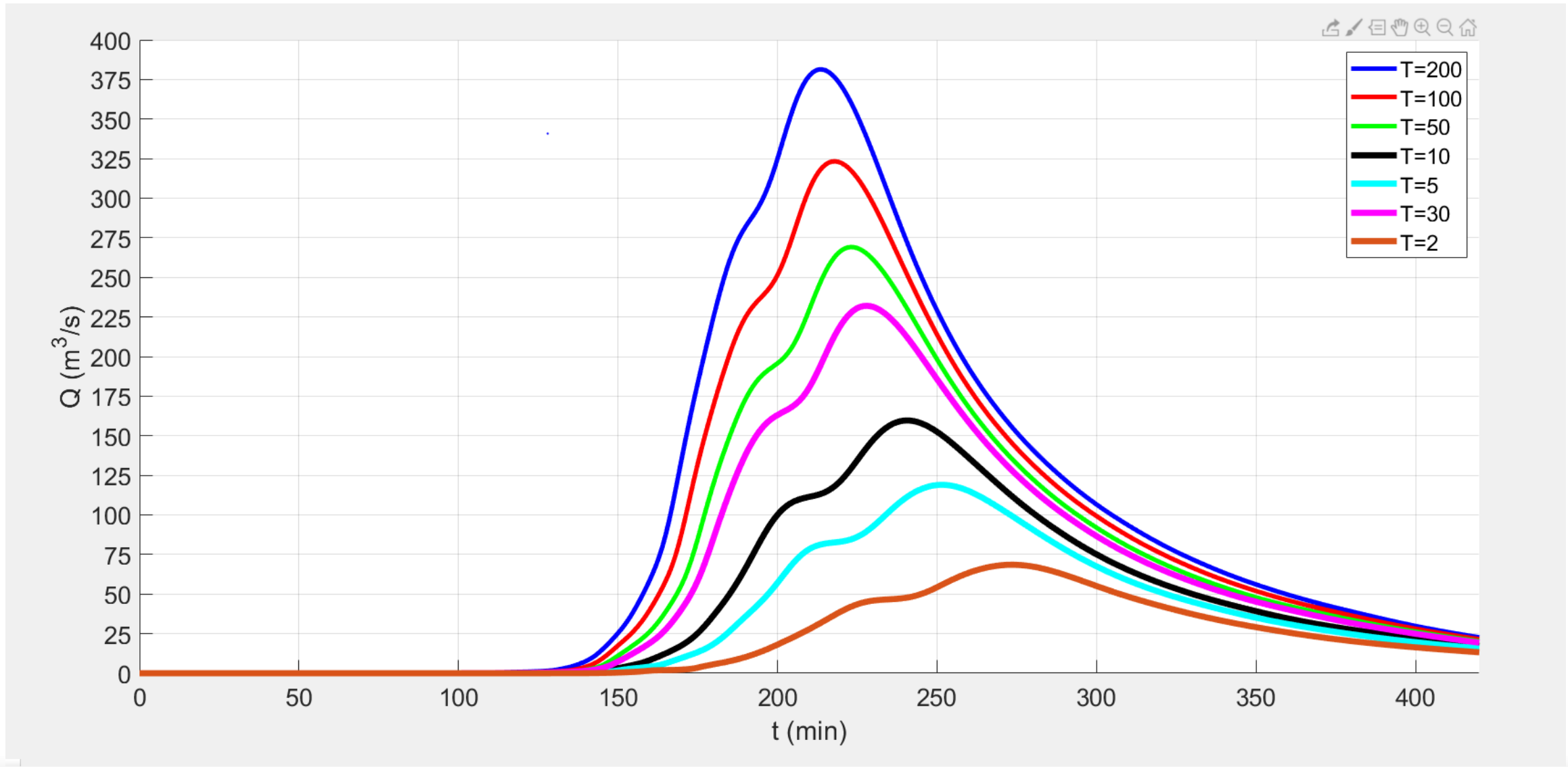
$$S = \begin{pmatrix} P \\ gh(S_{0x}^P - S_{fx}) \\ gh(S_{0y} - S_{fy}) \end{pmatrix}$$

$$P=R(x,y,t)-I(x,y,t)$$

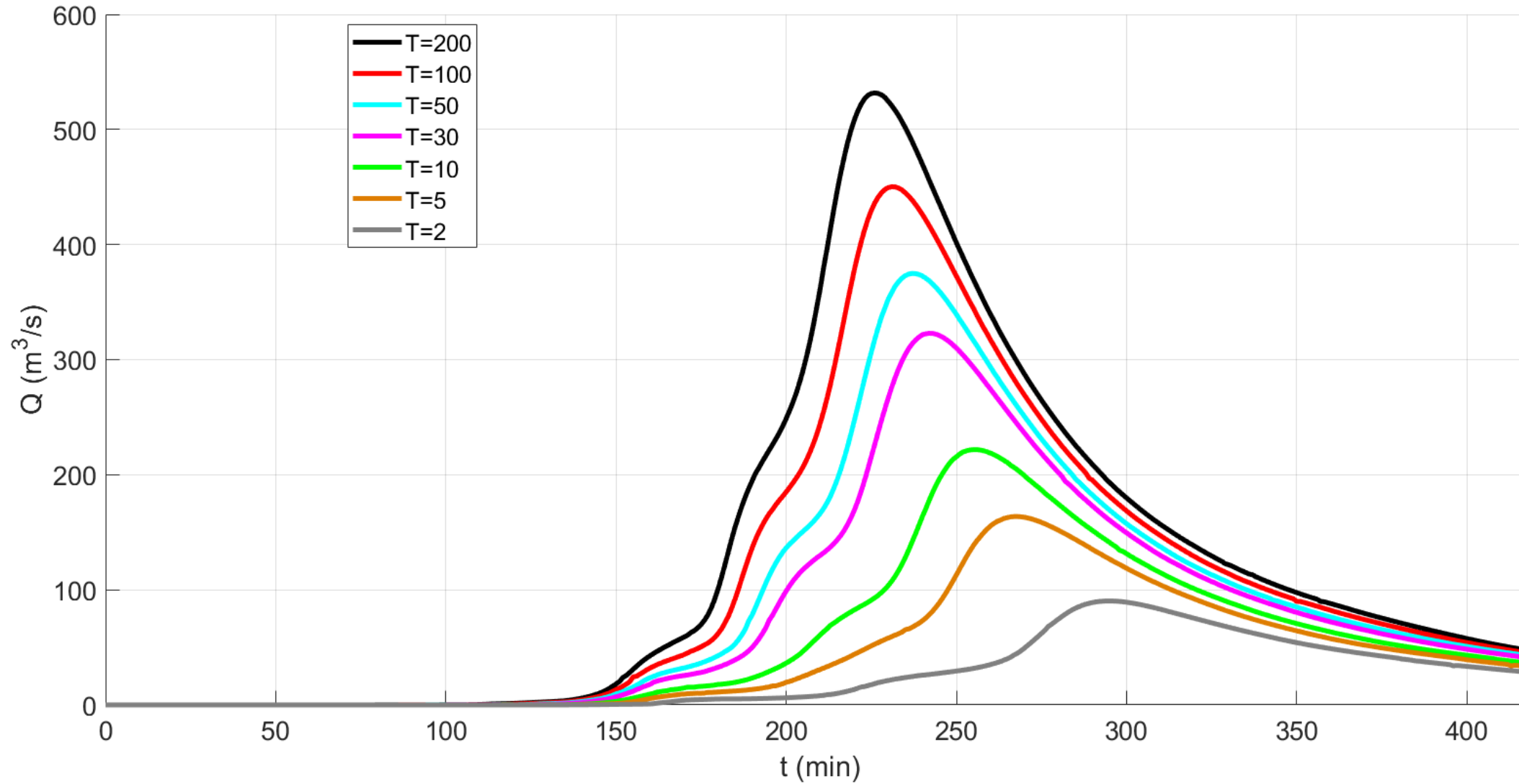
6. Idrogrammi delle portate -Ardivestra



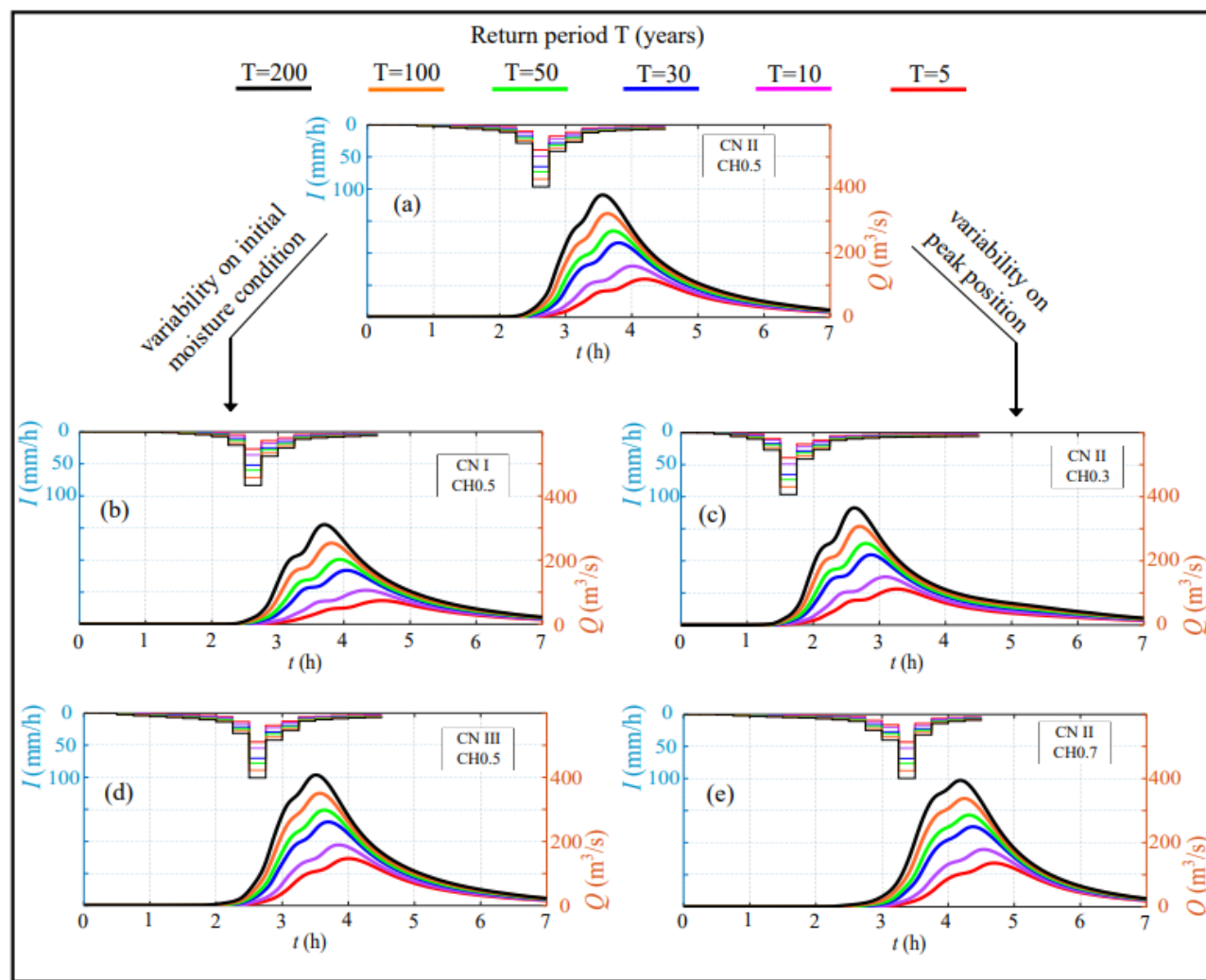
6. Idrogrammi delle portate -Scuropasso



6. Idrogrammi delle portate -Versa

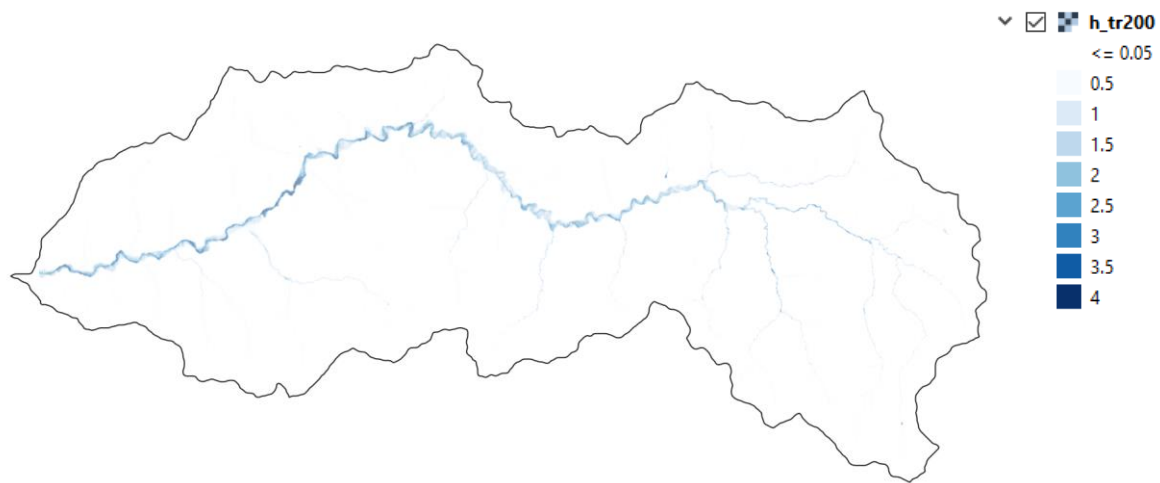


7. Variabilità del CN e della posizione del picco



8. Risultati per il bacino dell'Ardivestra Tr 200 anni

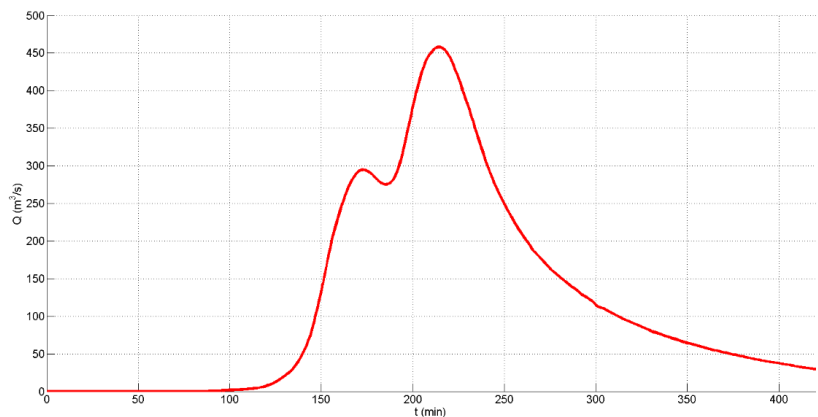
Mappa delle massime aree inondate per $h > 0.05$ m



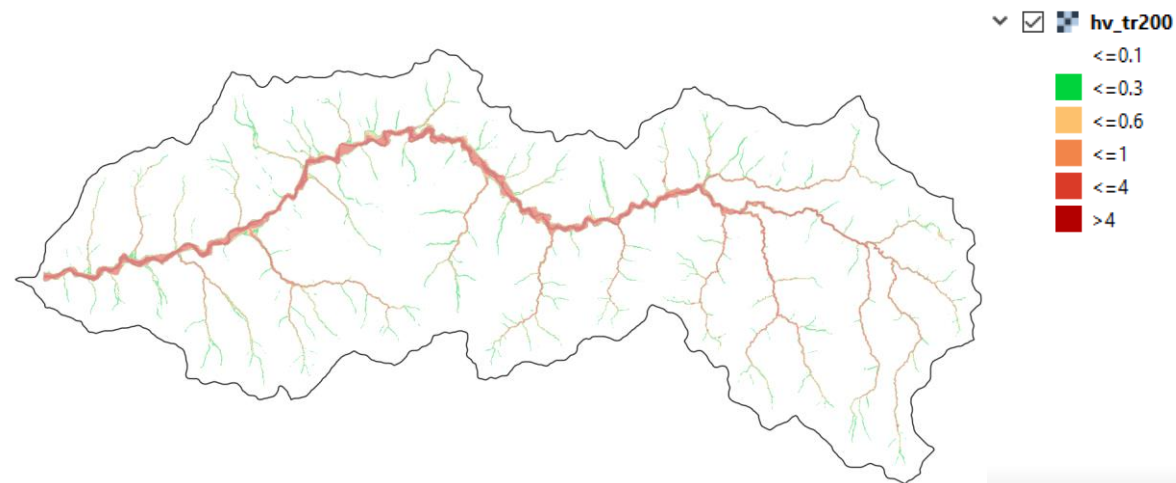
Mappa delle massime velocità (m/s)



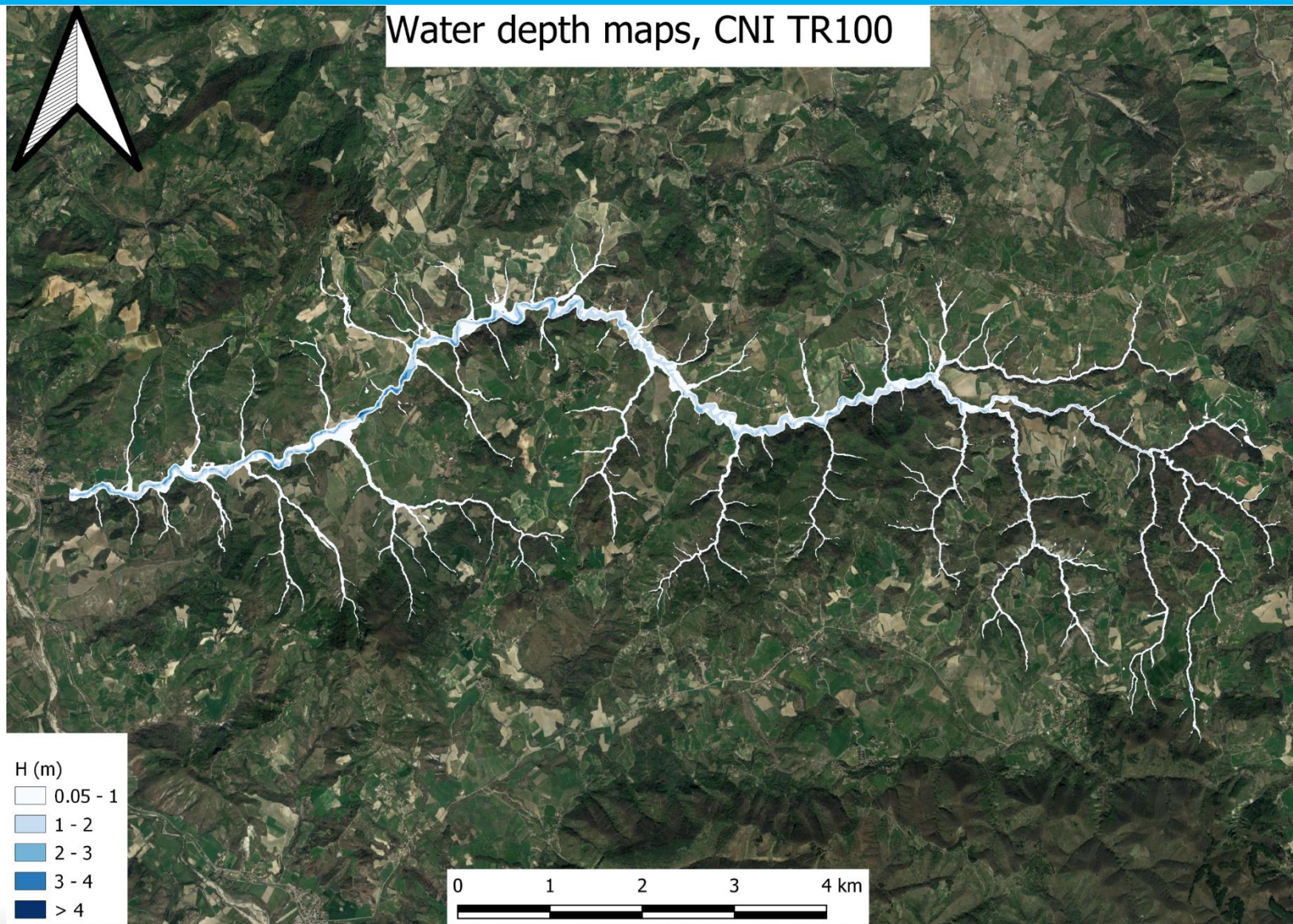
Idrogramma di piena per pioggia con $Tr=200$ anni



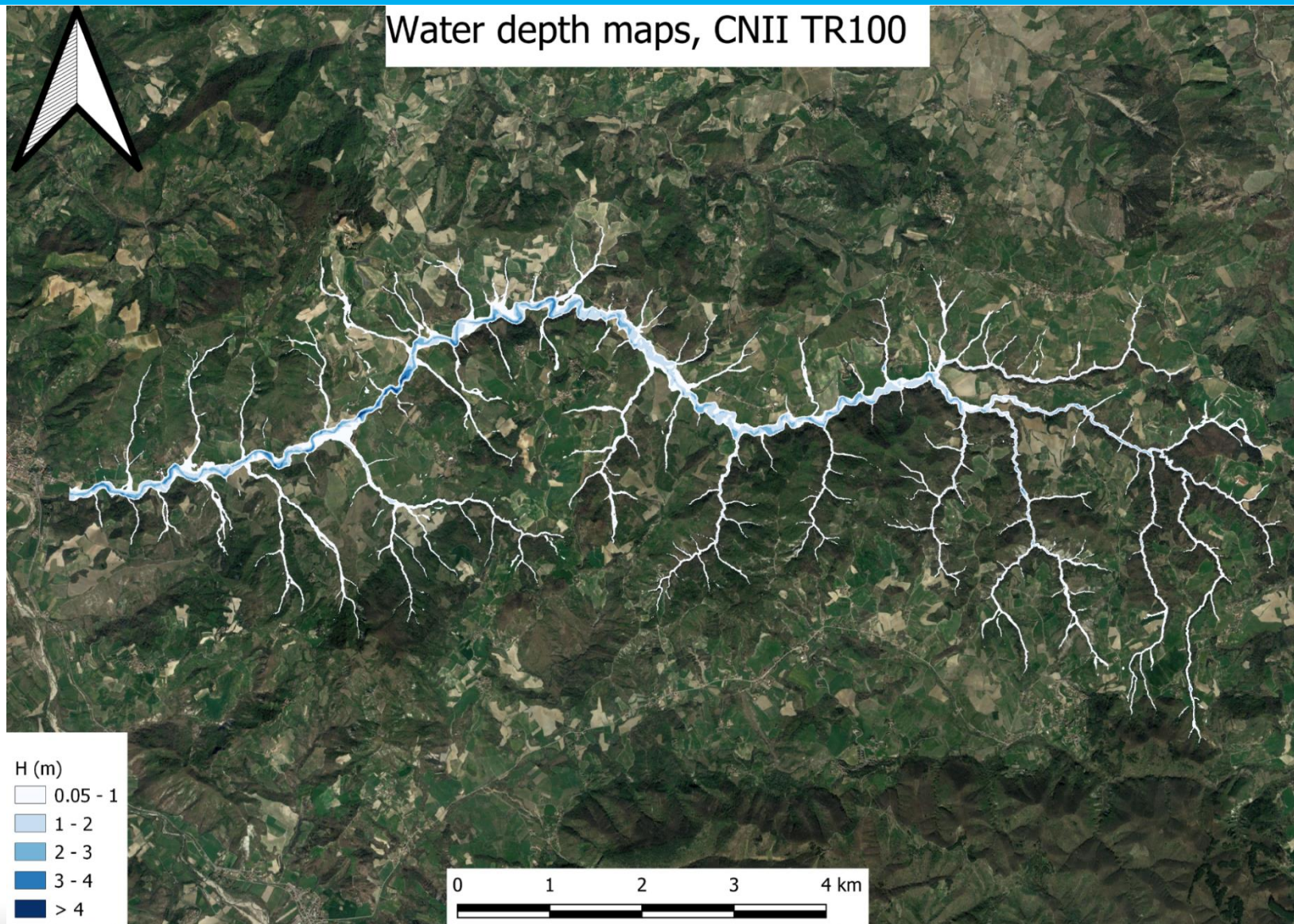
Mappa della pericolosità (m^2/s)



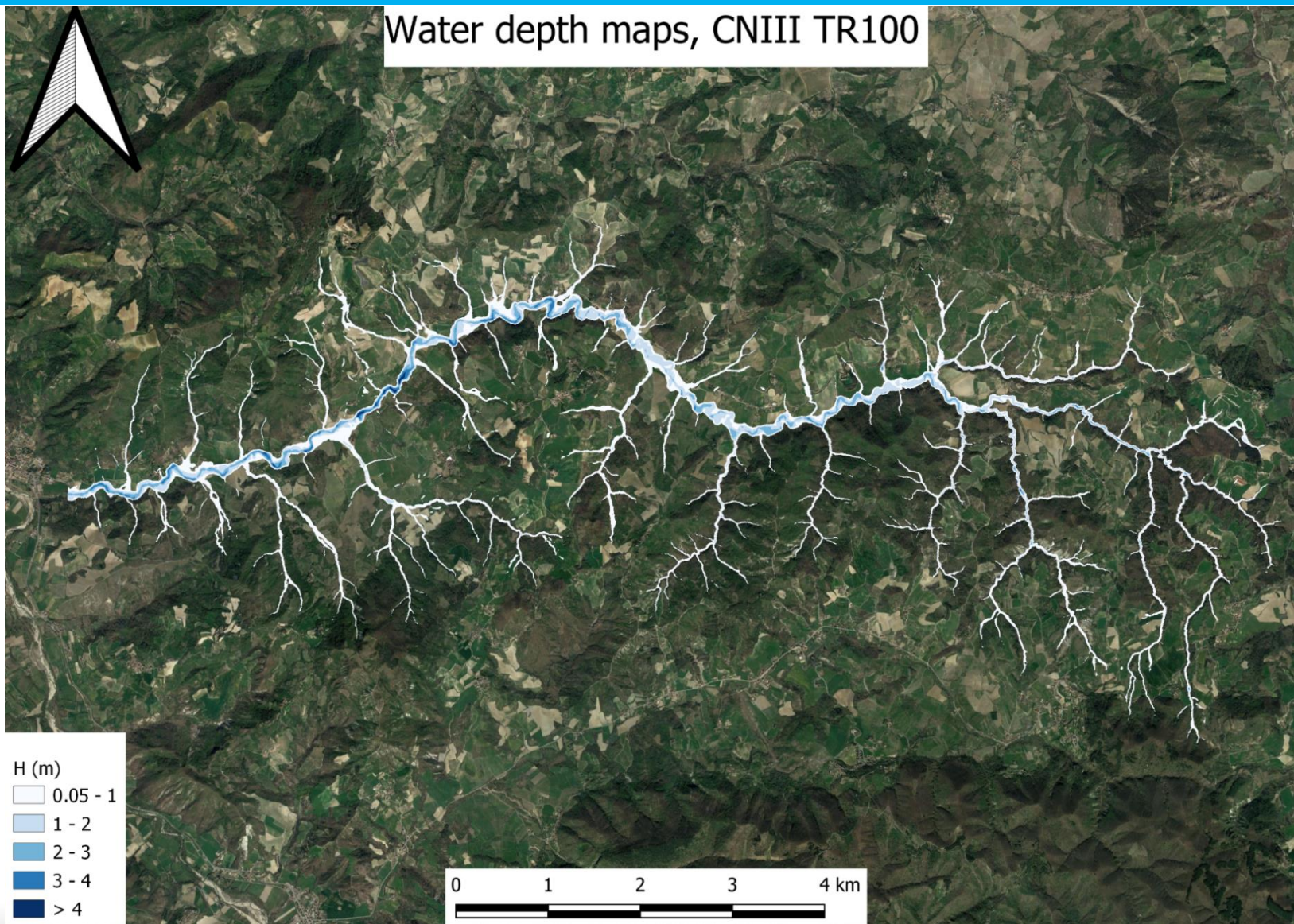
10. Mappe aree inondate Ardivestra-CN I, Tr 100 anni



10. Mappe aree inondate Ardivestra-CN II, Tr 100 anni

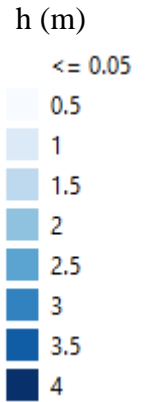


10. Mappe aree inondate Ardivestra-CN III, Tr 100 anni



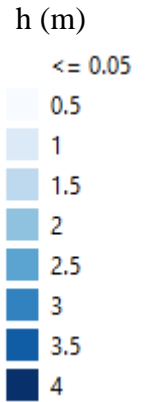
10. Mappa delle aree inondate con TR 5 anni

Case del Molino (Montesegale)



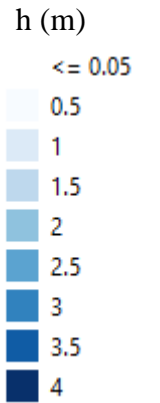
10. Mappa delle aree inondate con TR 30 anni

Case del Molino (Montesegale)

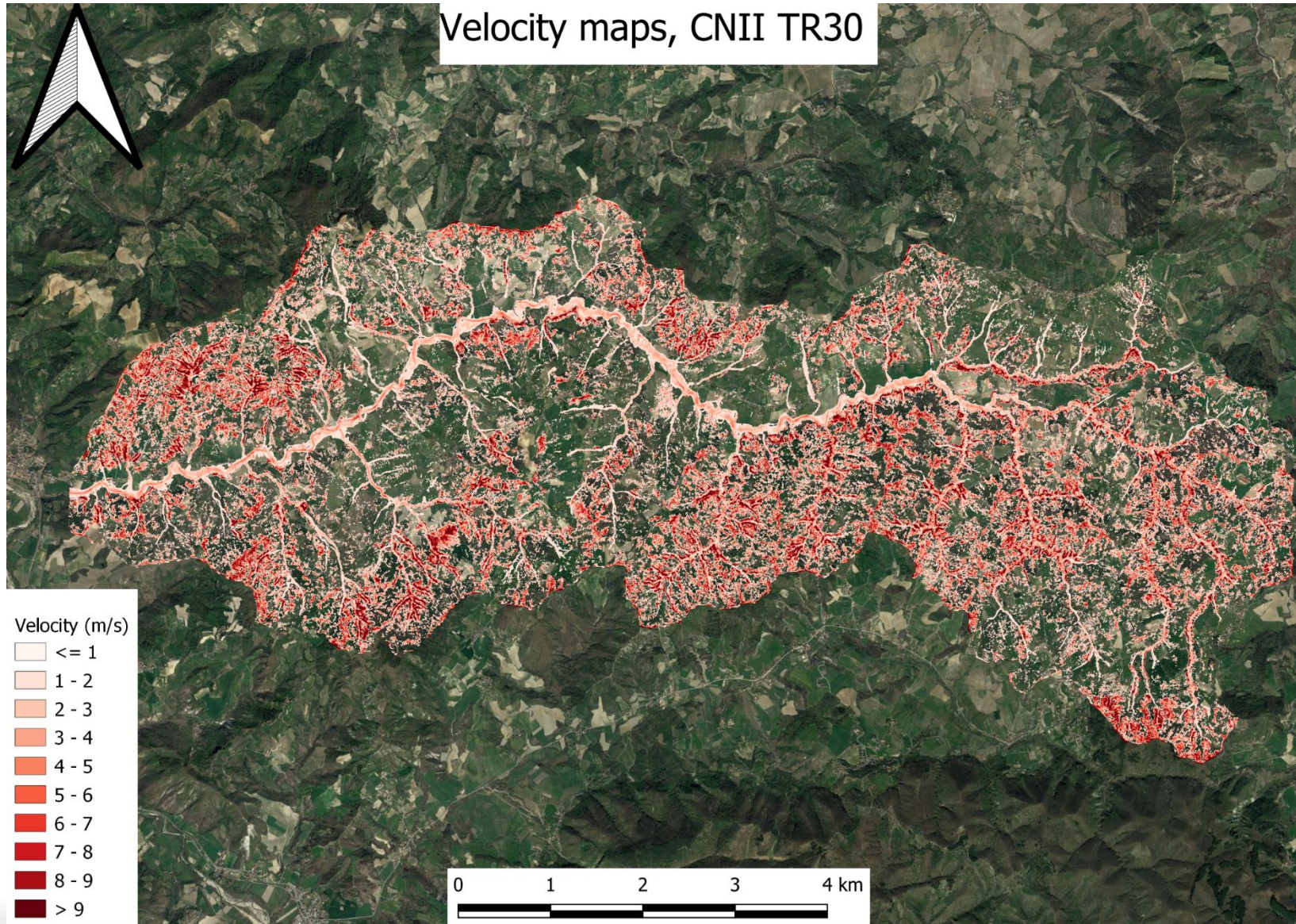


10. Mappa delle aree inondate con TR 200 anni

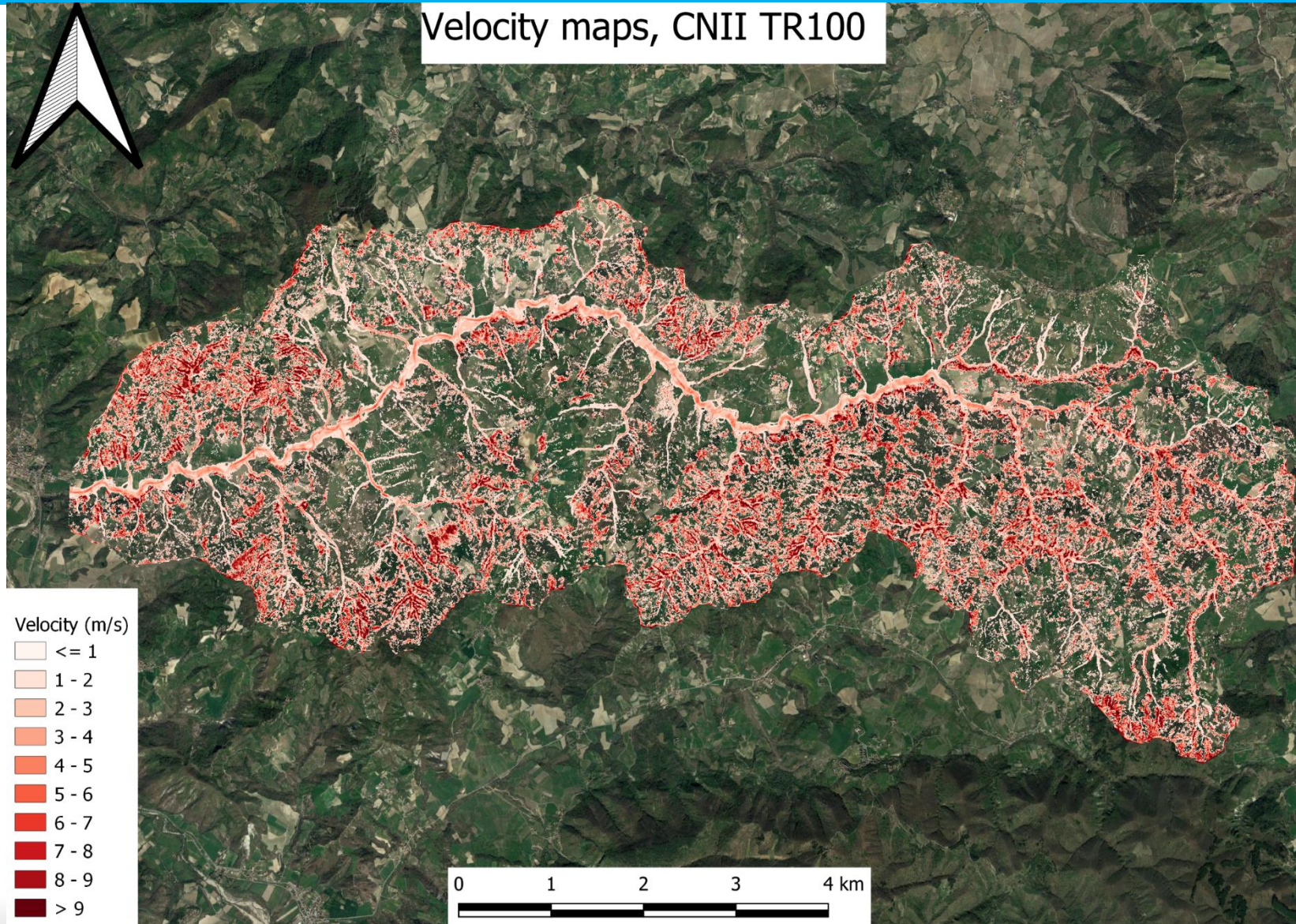
Case del Molino (Montesegeale)



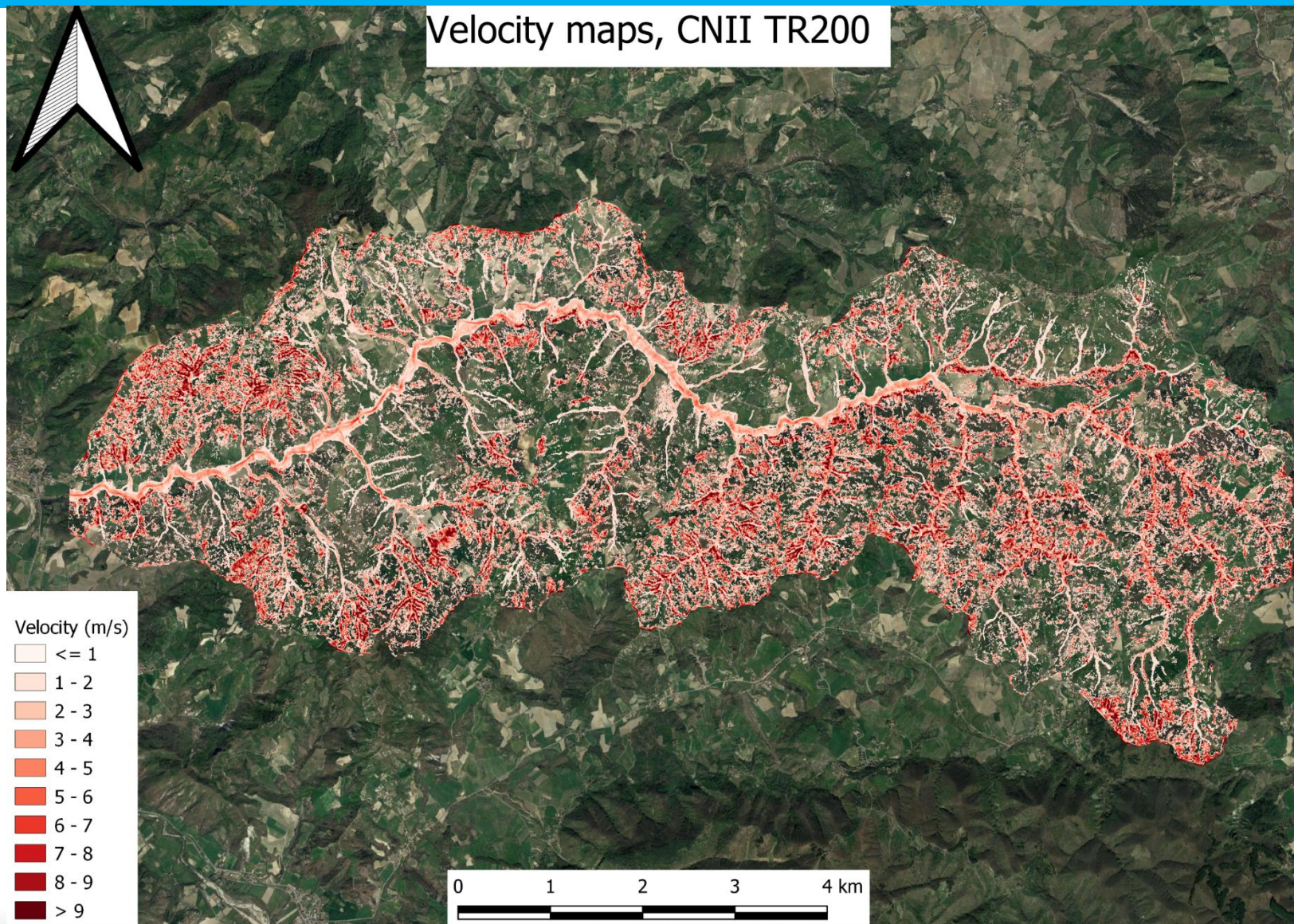
11. Mappe velocità- Ardivestra-CN II, Tr30 anni



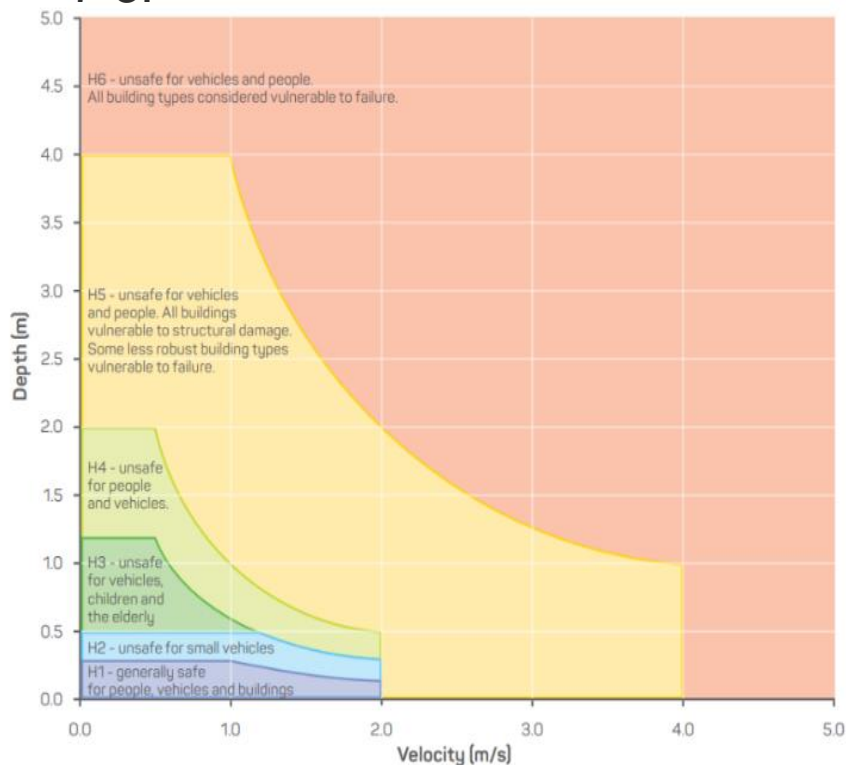
11. Mappe velocità- Ardivestra-CN II, Tr 100 anni



11. Mappe velocità- Ardivestra-CN II, Tr 200 anni



AIDR, 2017. Flood Hazard. Australian Disaster Resilience Handbook Collection. Guideline 7-3.



Australian Disaster Resilience Handbook Collection

The Australian Disaster Resilience Handbook Collection provides guidance on national principles and practices for disaster resilience.

The Handbook Collection:

- provides an authoritative, trusted and freely available source of knowledge about disaster resilience principles in Australia
- aligns national disaster resilience strategy and policy with practice, by guiding and supporting jurisdictions, agencies and other organisations and individuals in their implementation and adoption
- highlights and promotes the adoption of good practice in building disaster resilience in Australia
- builds interoperability between jurisdictions, agencies, the private sector, local businesses and community groups by promoting use of a common language and coordinated, nationally agreed principles.

The Handbook Collection is developed and reviewed by national consultative committees representing a range of state and territory agencies, governments, organisations and individuals involved in disaster resilience. The collection is sponsored by the Australian Government, Department of Home Affairs.

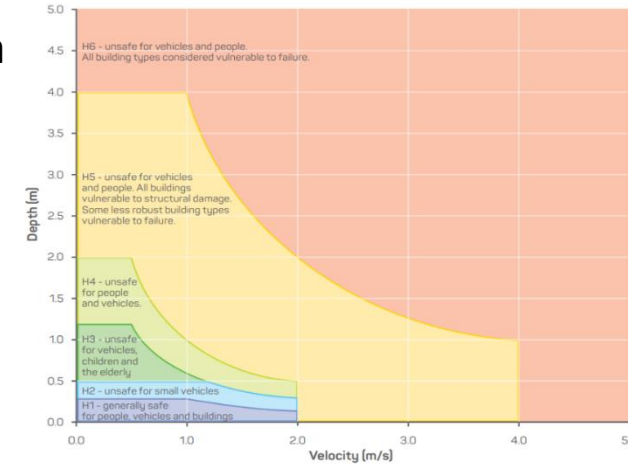
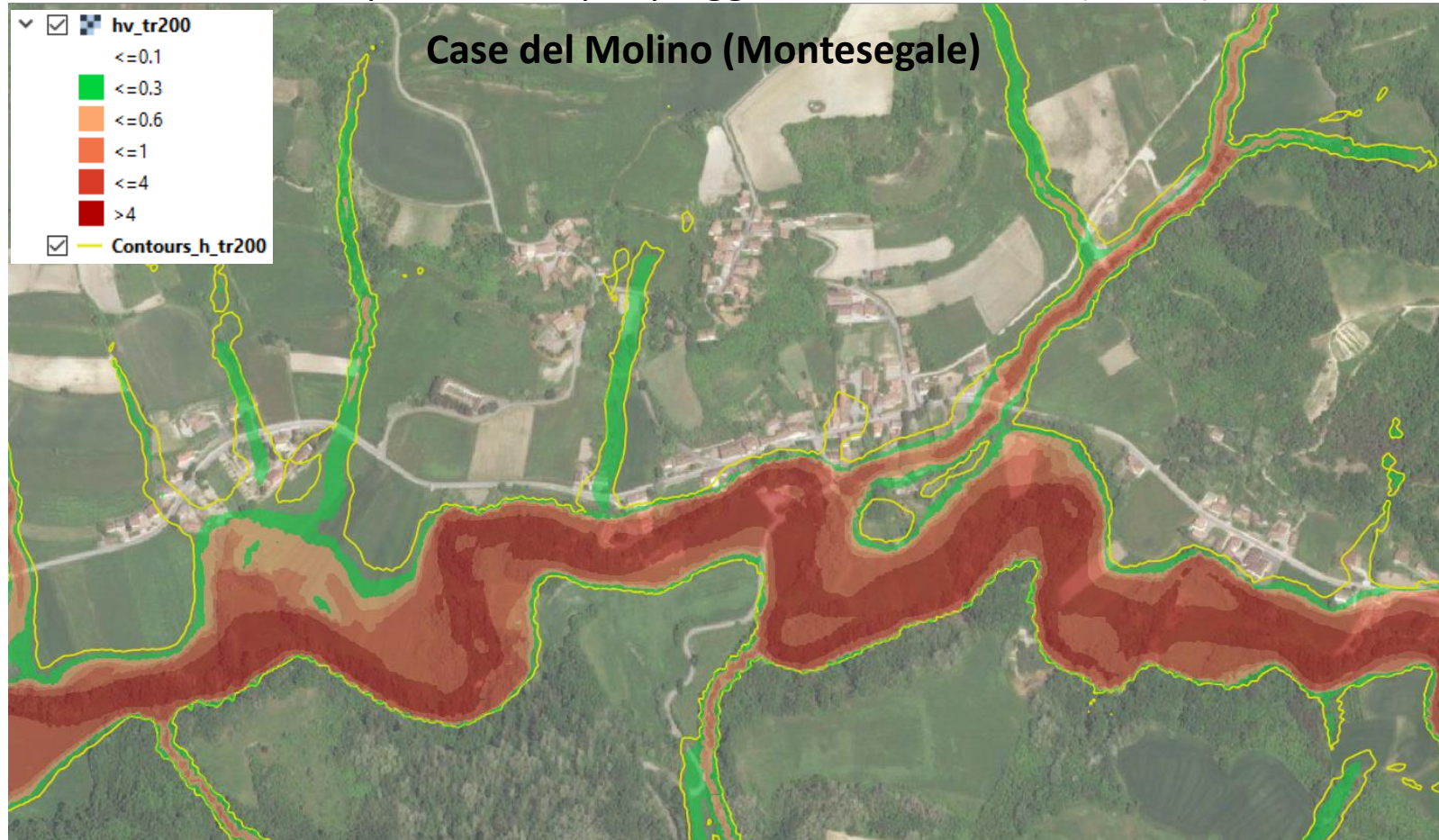
Access to the Handbook Collection and further details are available on the Australian Disaster Resilience Knowledge Hub (the 'Knowledge Hub'; <https://www.knowledge.aidr.org.au/handbooks>).

- Handbook 1** Disaster Health
- Handbook 2** Community Recovery
- Toolkit 2-1 Community recovery checklists
- Toolkit 2-2 Further resources for community recovery
- Toolkit 2-3 Community recovery case studies
- Handbook 3** Managing Exercises
- Handbook 4** Evacuation Planning
- Handbook 5** Communicating with People with a Disability: National Guidelines for Emergency Managers
- Handbook 6** National Strategy for Disaster Resilience: Community Engagement Framework
- Handbook 7** Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia

Classi di pericolosità	Descrizione	Classificazione dei limiti
H1	Generally safe for vehicles, people and buildings	$hV \leq 0.3$
H2	Unsafe for small vehicles.	$hV \leq 0.6$
H3	Unsafe for vehicles, children and the elderly.	$hV \leq 0.6$
H4	Unsafe for vehicles and people.	$hV \leq 1$
H5	Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure.	$hV \leq 4$
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure	$hV > 4$

12. Mappa della pericolosità

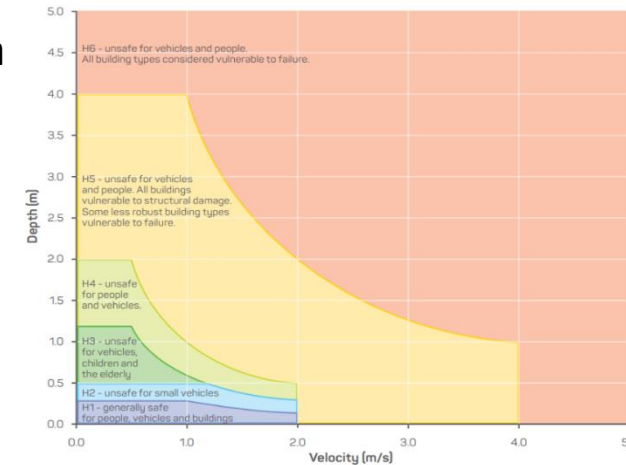
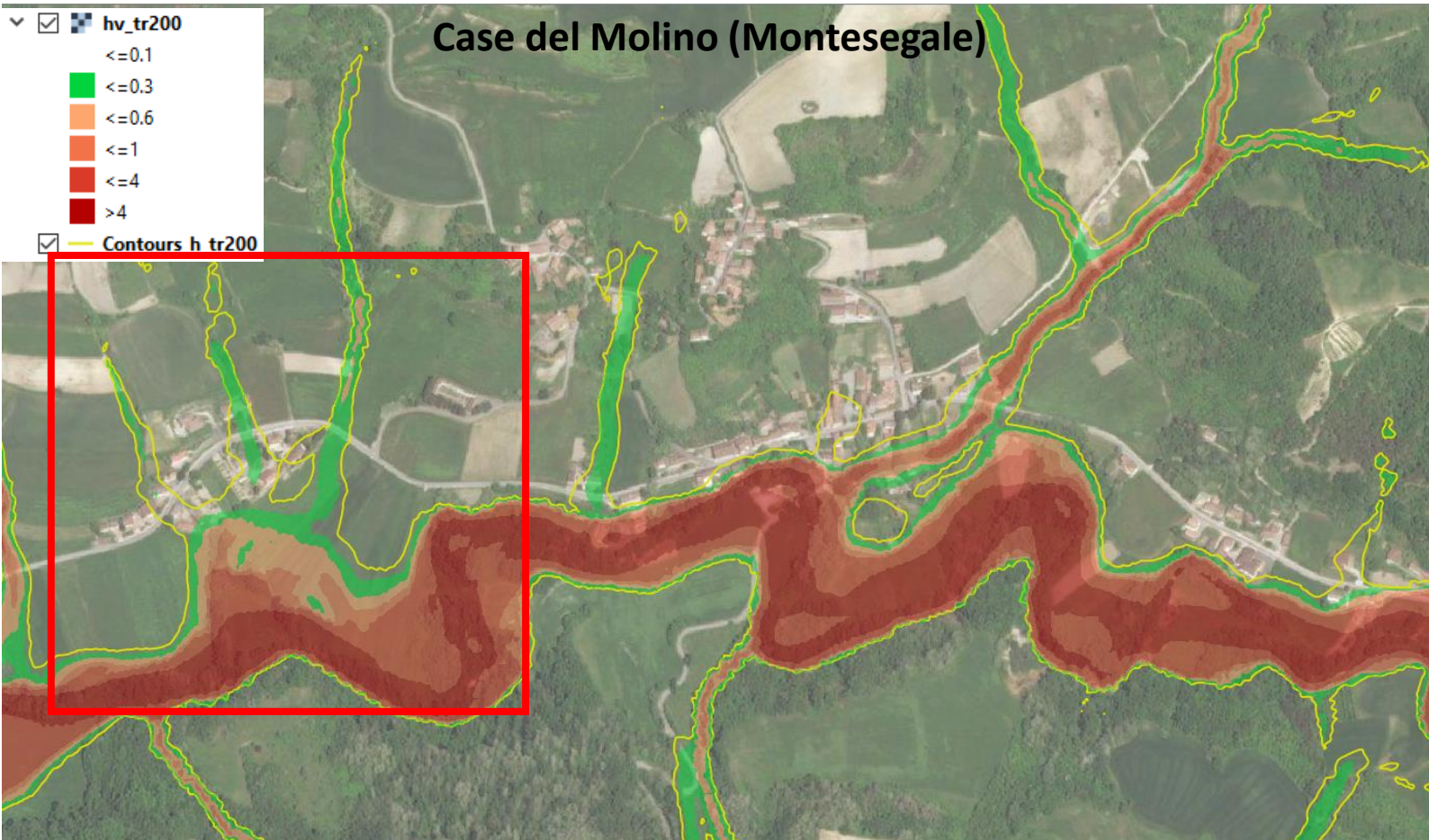
Confronto tra l'estensione delle aree inondate con $h > 0.05$ m e la mappa della pericolosità per pioggia con TR 200 anni (Raster)



Classi di pericolosità	Descrizione	Classificazione dei limiti
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12. Mappa della pericolosità

Confronto tra l'estensione delle aree inondate con $h > 0.05$ m e la mappa della pericolosità per pioggia con TR 200 anni (Raster)

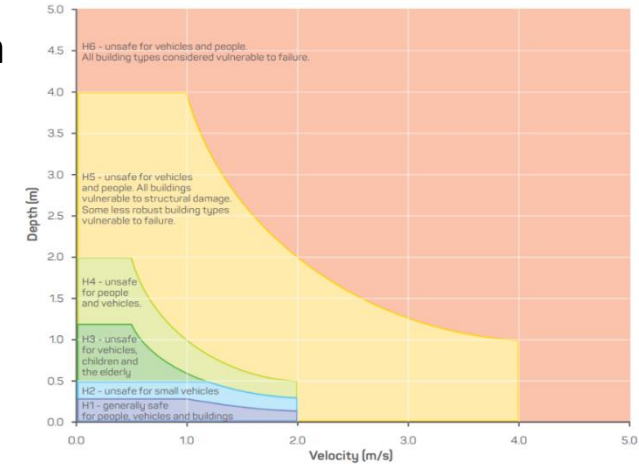
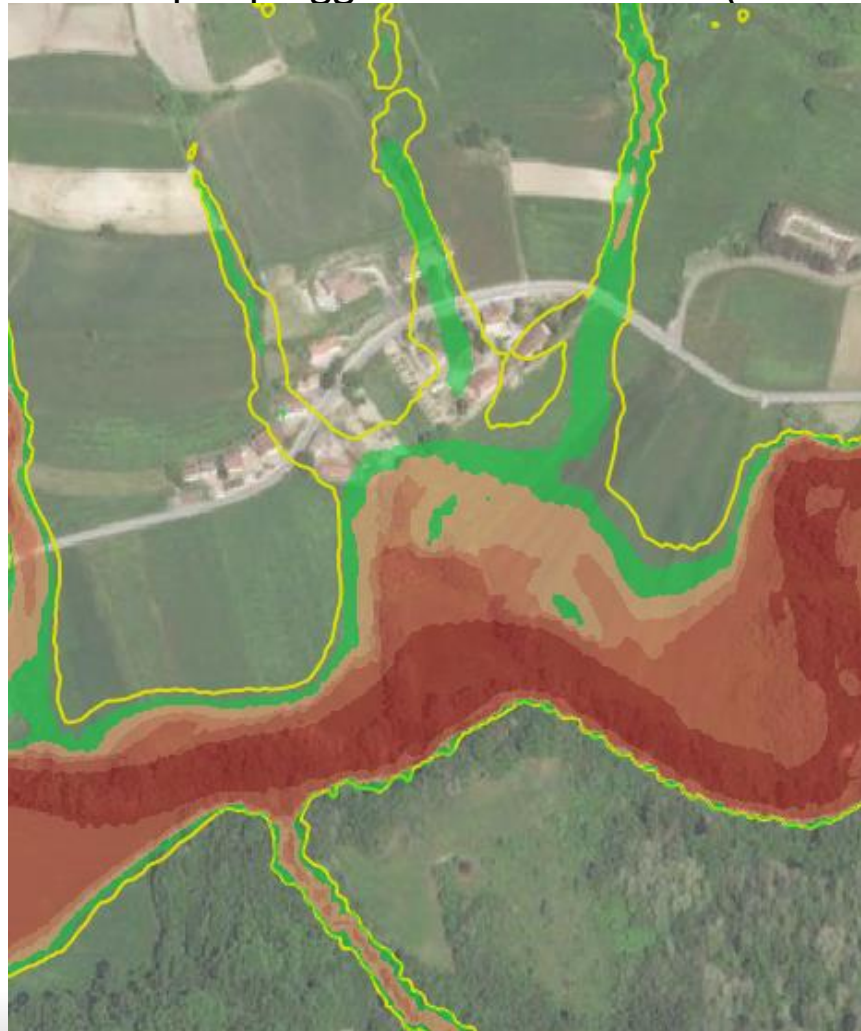


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H6	Unsafe for vehicles and people. All building types considered vulnerable to failure	$hV > 4$

12. Mappa della pericolosità

Confronto tra l'estensione delle aree inondate con $h > 0.05$ m e la mappa della pericolosità per pioggia con TR 200 anni (Raster)

- hv_tr200**
- ≤ 0.1
- ≤ 0.3
- ≤ 0.6
- ≤ 1
- ≤ 4
- > 4
- Contours_h_tr200**

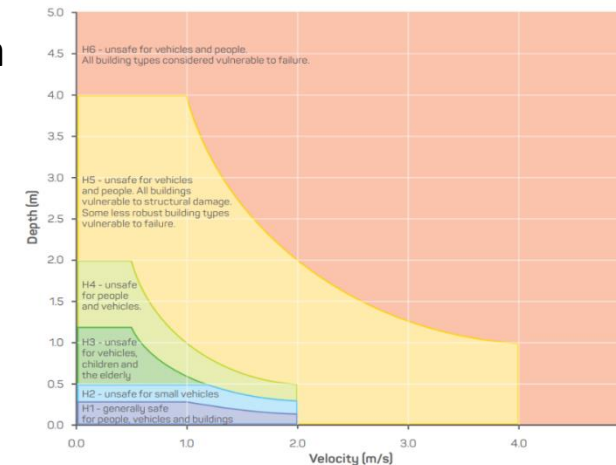
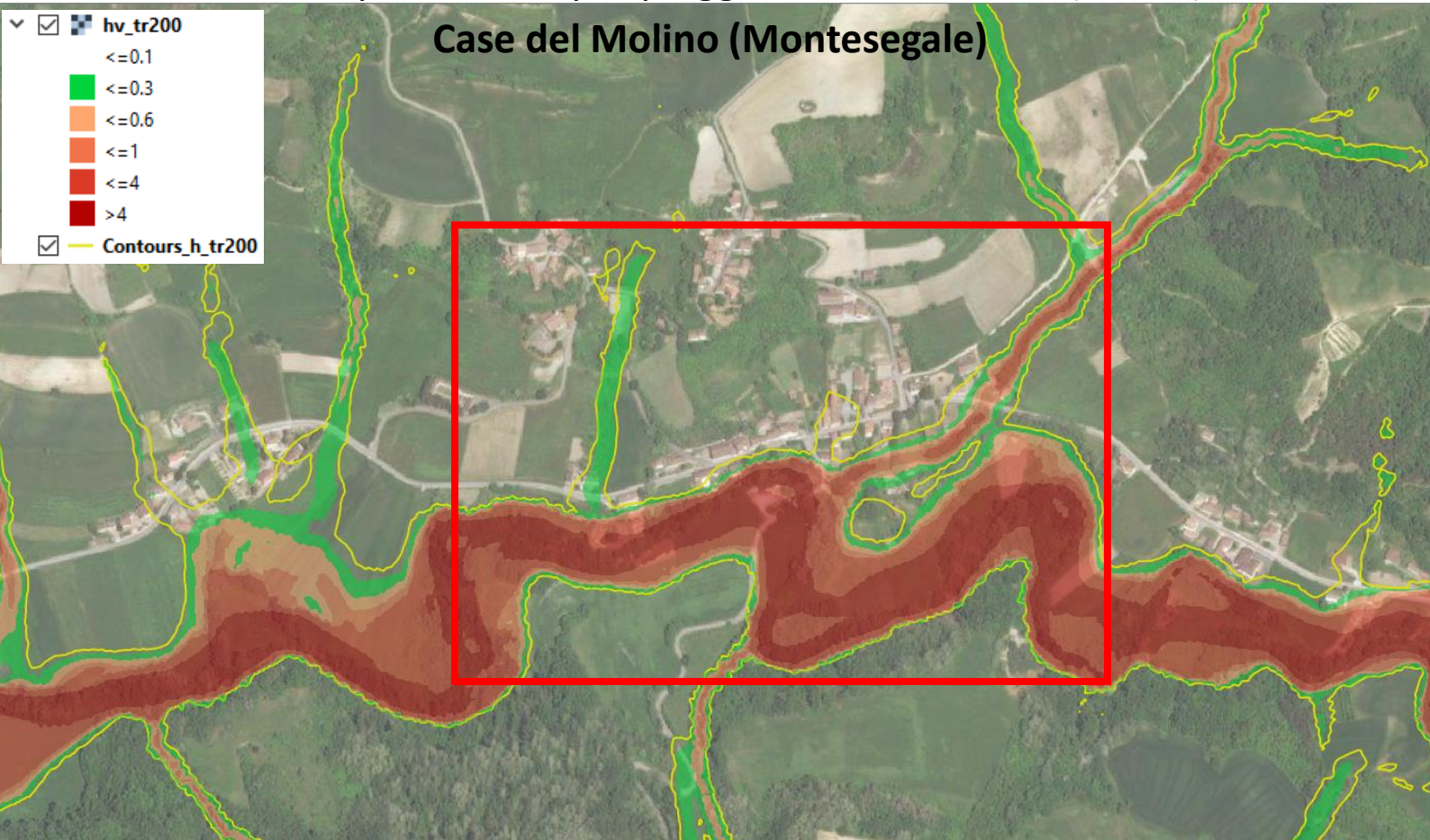


Classi di pericolosità	Descrizione	Classificazione dei limiti
H1	Generally safe for vehicles, people and buildings	$hV \leq 0.3$
H2	Unsafe for small vehicles.	$hV \leq 0.6$
H3	Unsafe for vehicles, children and the elderly.	$hV \leq 0.6$
H4	Unsafe for vehicles and people.	$hV \leq 1$
H5	Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure.	$hV \leq 4$
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure	$hV > 4$

12. Mappa della pericolosità

Confronto tra l'estensione delle aree inondate con $h > 0.05$ m e la mappa della pericolosità per pioggia con TR 200 anni (Raster)

Case del Molino (Montesegale)

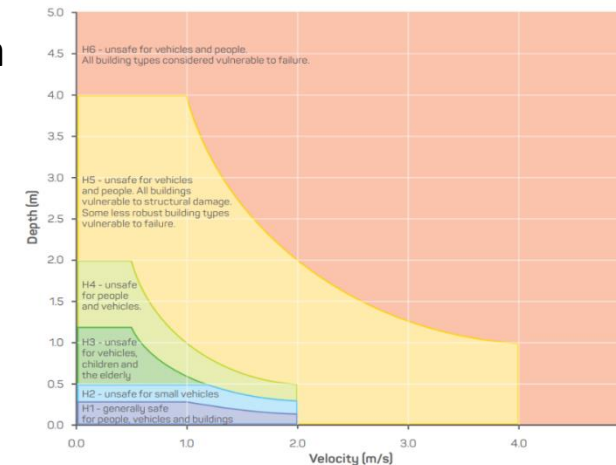
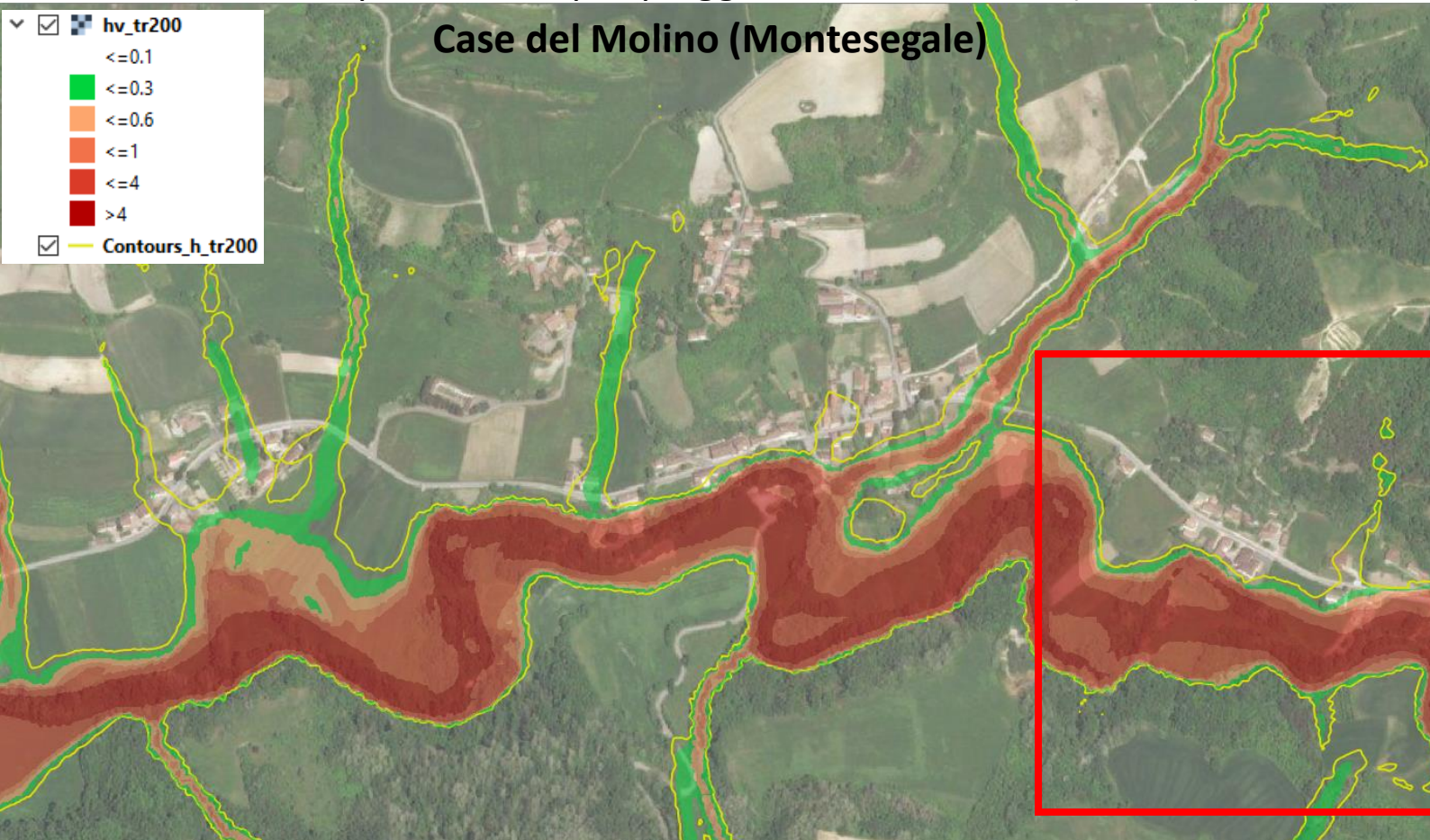


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12. Mappa della pericolosità

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Case del Molino (Montesegale)

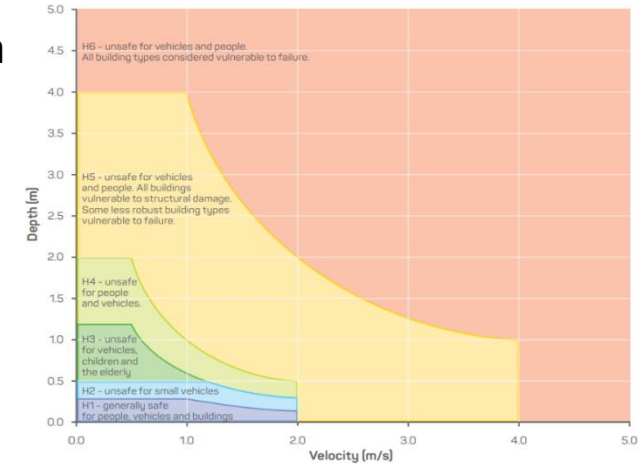
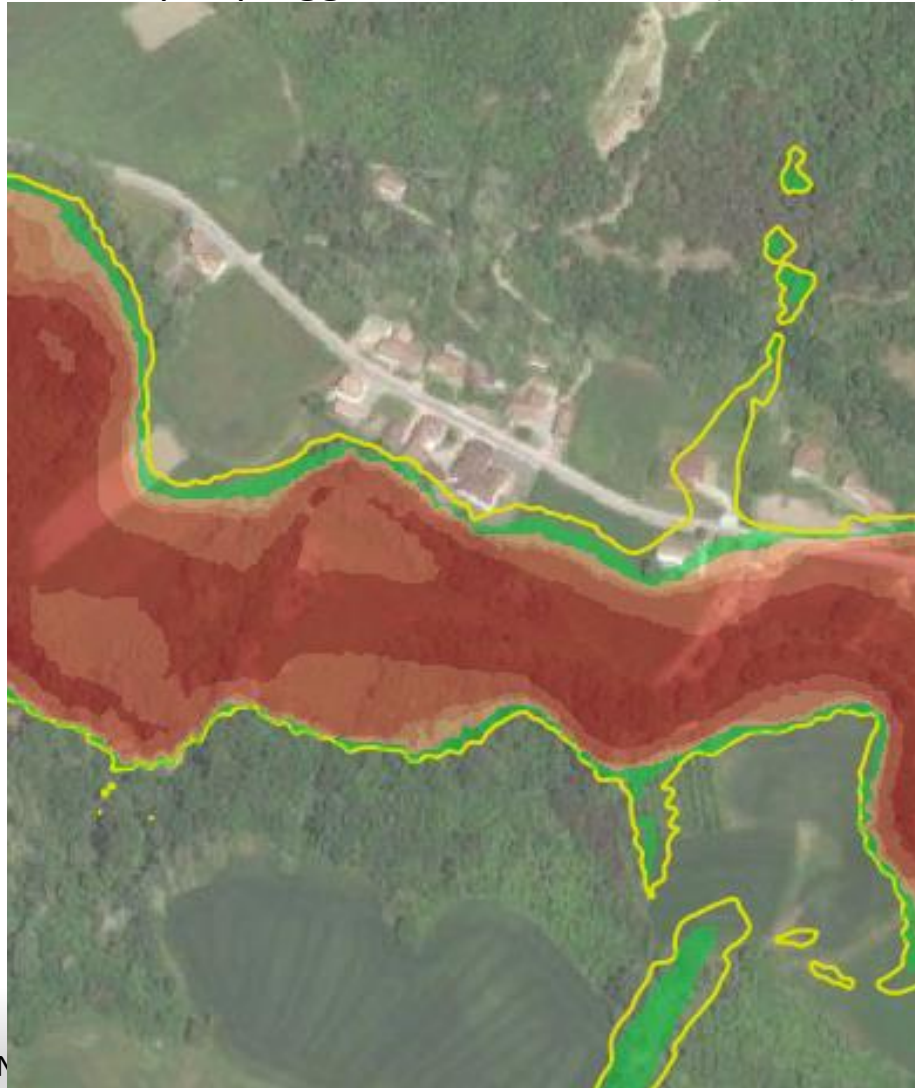


Classi di pericolosità	Descrizione	Classificazione dei limiti
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12. Mappa della pericolosità

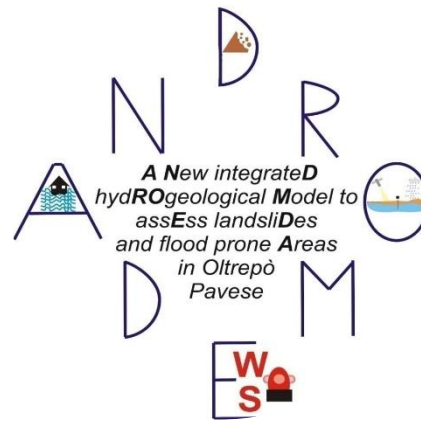
Confronto tra l'estensione delle aree inondate con $h > 0.05$ m e la mappa della pericolosità per pioggia con TR 200 anni (Raster)

- hv_tr200
- ≤ 0.1
- ≤ 0.3
- ≤ 0.6
- ≤ 1
- ≤ 4
- > 4
- Contours_h_tr200



Classi di pericolosità	Descrizione	Classificazione dei limiti
H1	Generally safe for vehicles, people and buildings	$hV \leq 0.3$
H2	Unsafe for small vehicles.	$hV \leq 0.6$
H3	Unsafe for vehicles, children and the elderly.	$hV \leq 0.6$
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