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Reassessment of flood risk for DMB project with high resolution 2D model

BASEMENT User Meeting 2023

Quentin Theiler / 26.01.23

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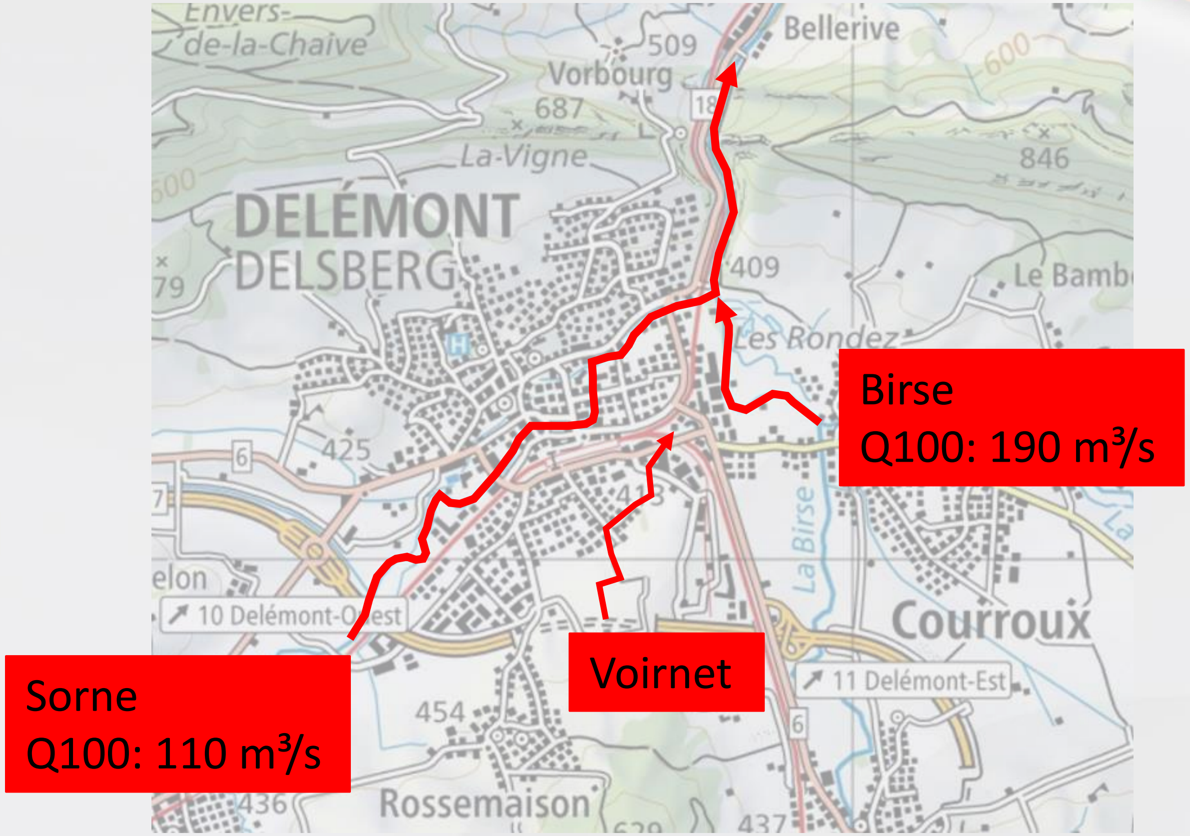
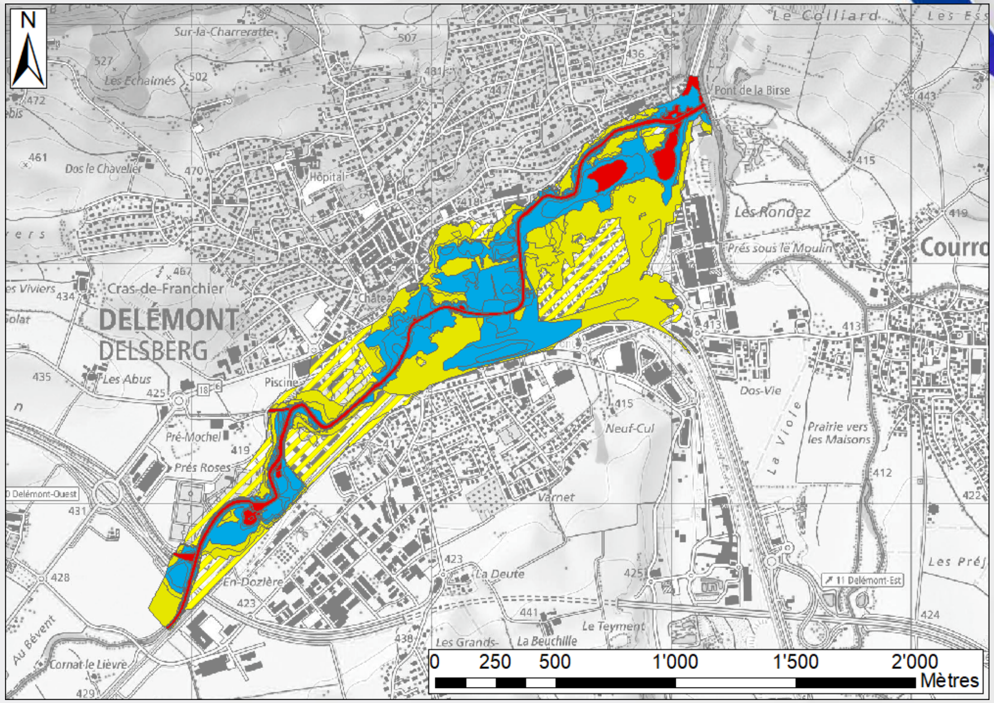
City of Delémont



Flood of 2007

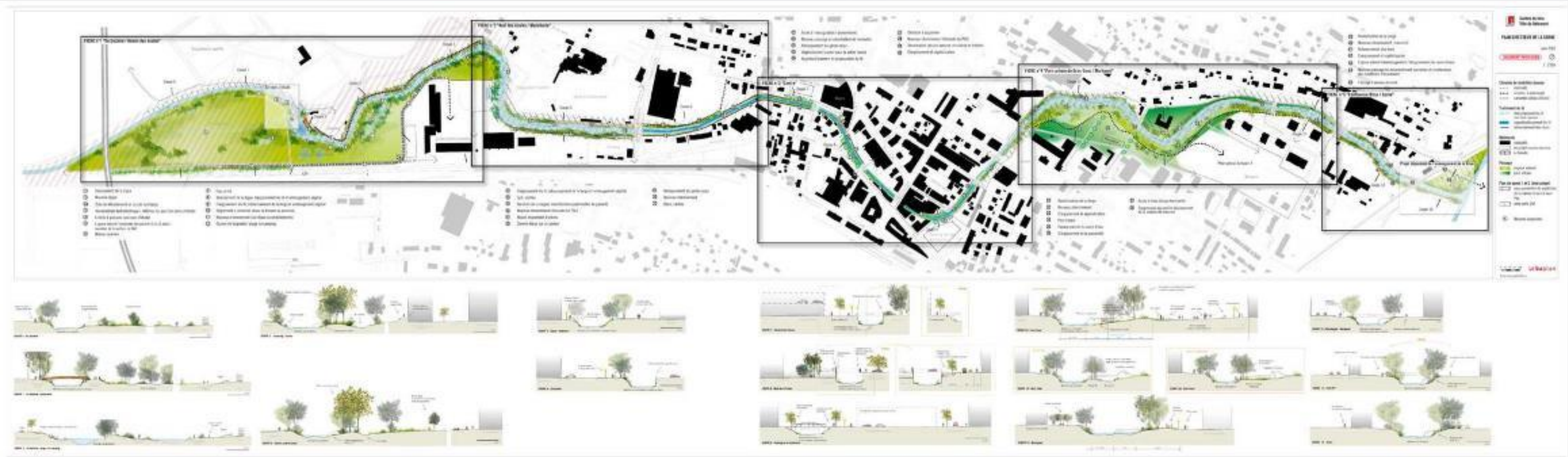
- Flood of August 2007
- Return period < 100 years
- Damages: > 10 millions CHF



«Delémont low tide»

Projet DMB

Actual damages: potential of 120 millions CHF
Budget: 15 millions CHF
Construction: 2012 - 2024



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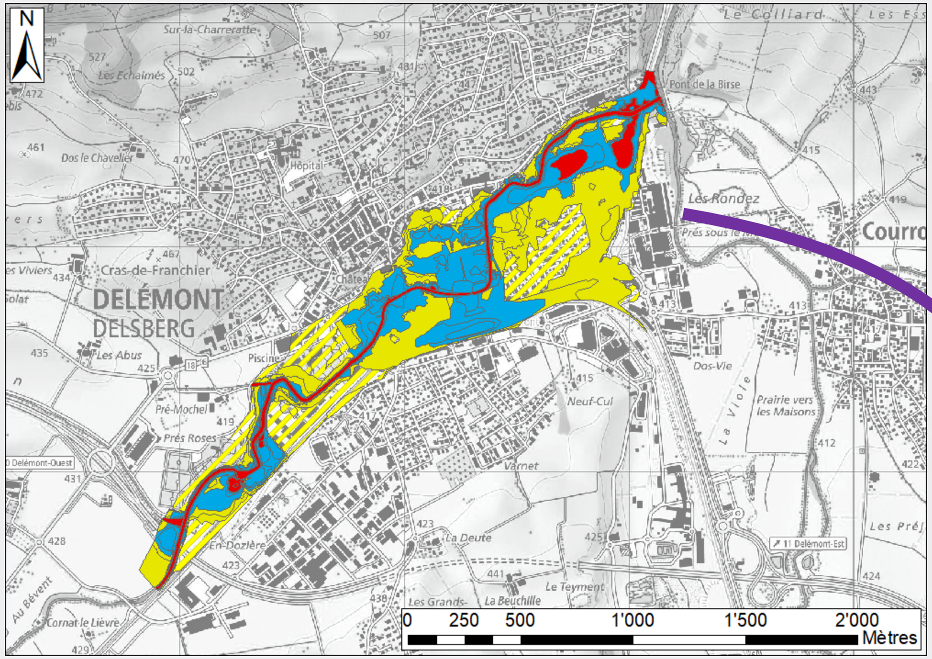
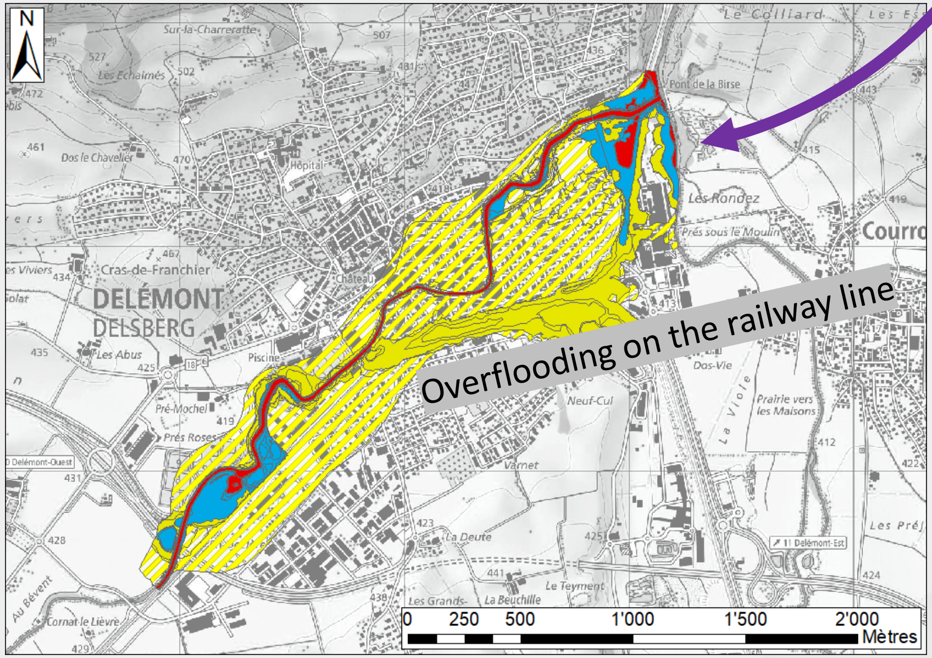
Projet DMB

Actual hazard map



Expected final hazard map



<u>Flood protection</u>

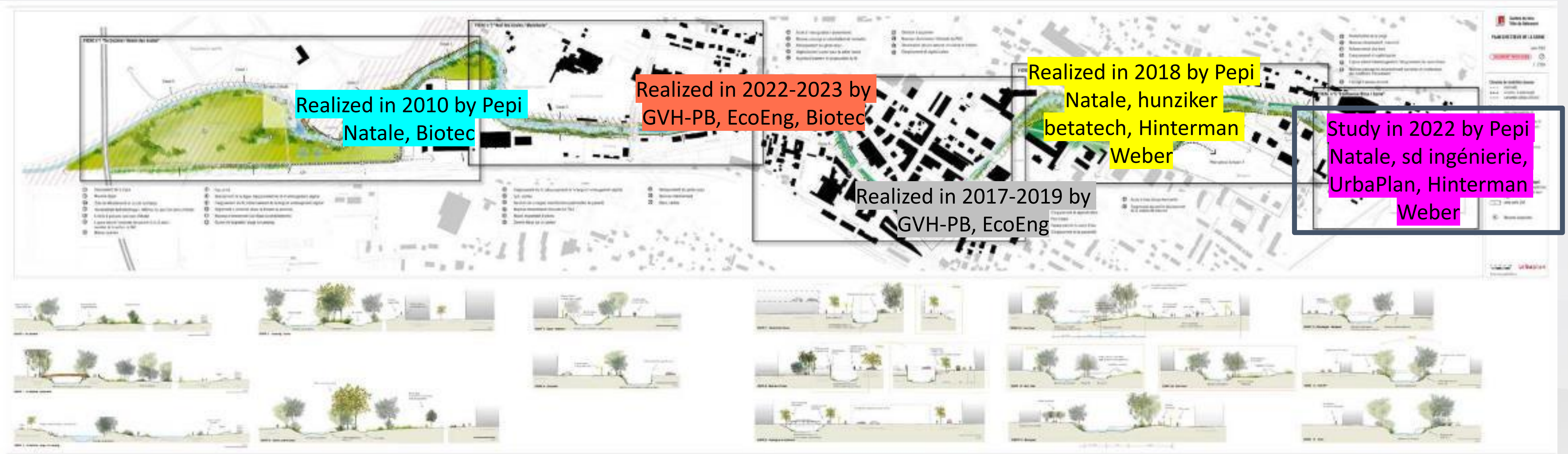
1. Enlargement if possible
2. Raising of walls / dikes
3. Deepening through the city
4. Overflow management

Projet DMB

<u>Challenges:</u>

- Collect all the data to have a quality control after the partial construction
- Create a real hazard map (state 2022 and final) and suggest optimization
- Integrate the surface runoff (stream Voirnet from the South of Delémont)

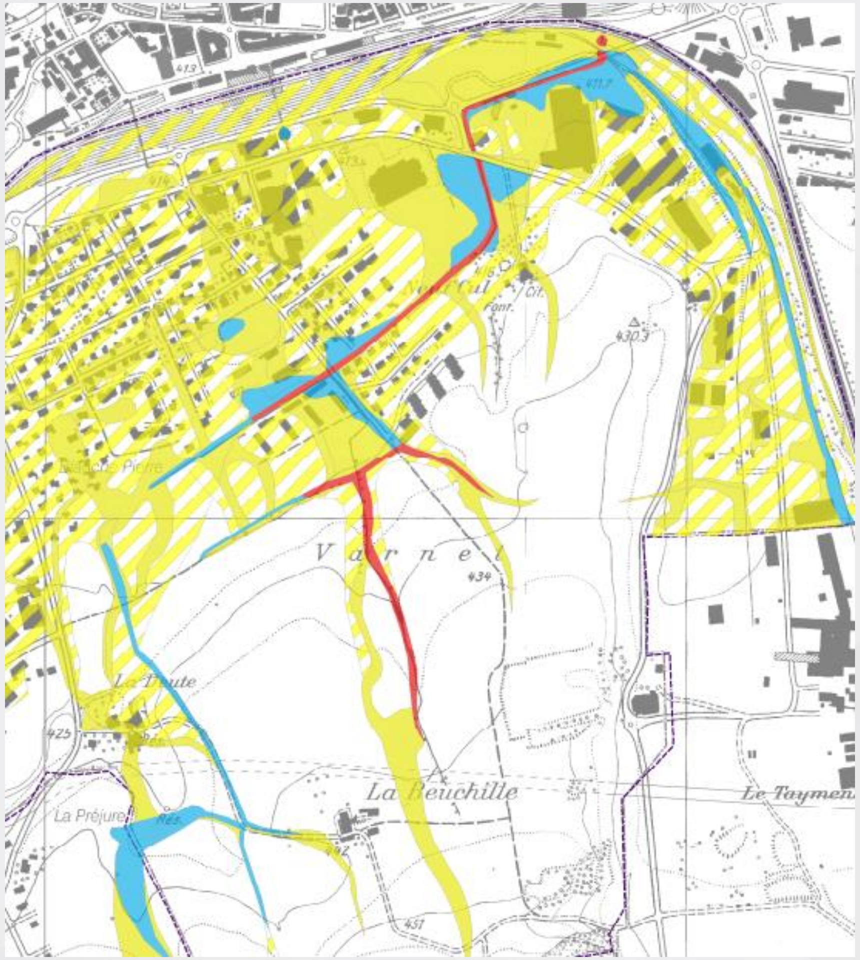
Global study by BG, Pepi Natale



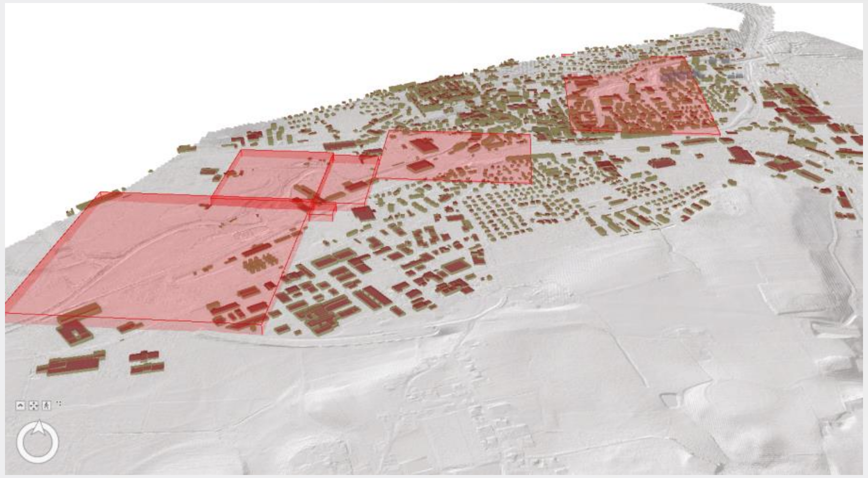
Extend DMB for the South of Delémont

Challenges:

- Collect all the data to have a quality control after the partial construction
- Create a real hazard map (state 2022 and final) and suggest optimization
- Integrate the surface runoff (stream Voirnet from the South of Delémont)



Drone flight → DEM → Mesh → initial 2D model



- Treatment of raw data (vegetation, building, etc.)
- Combining DEM
- Create a mesh with small resolution (up to 0.2m) and considering the wall effect of the buildings

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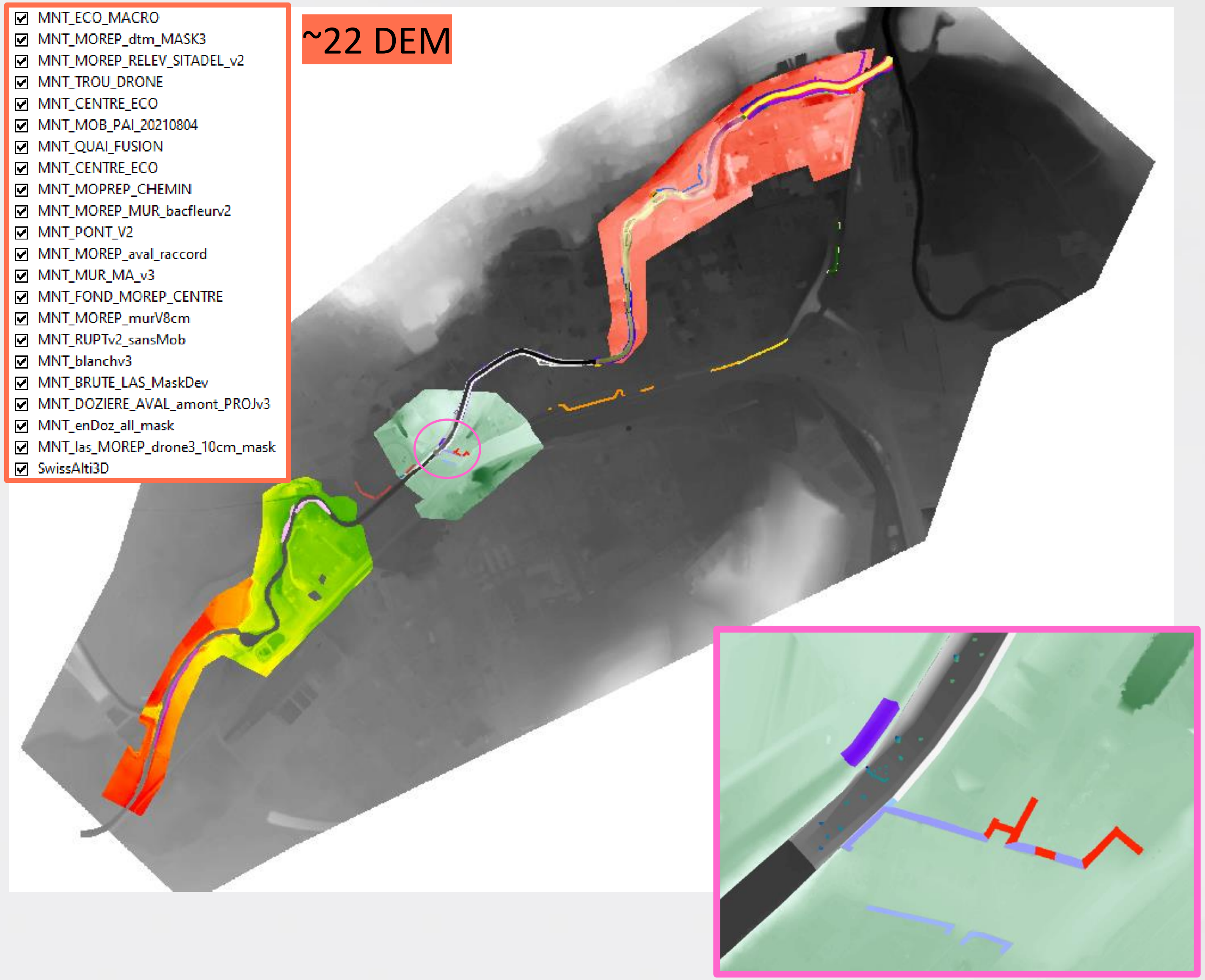
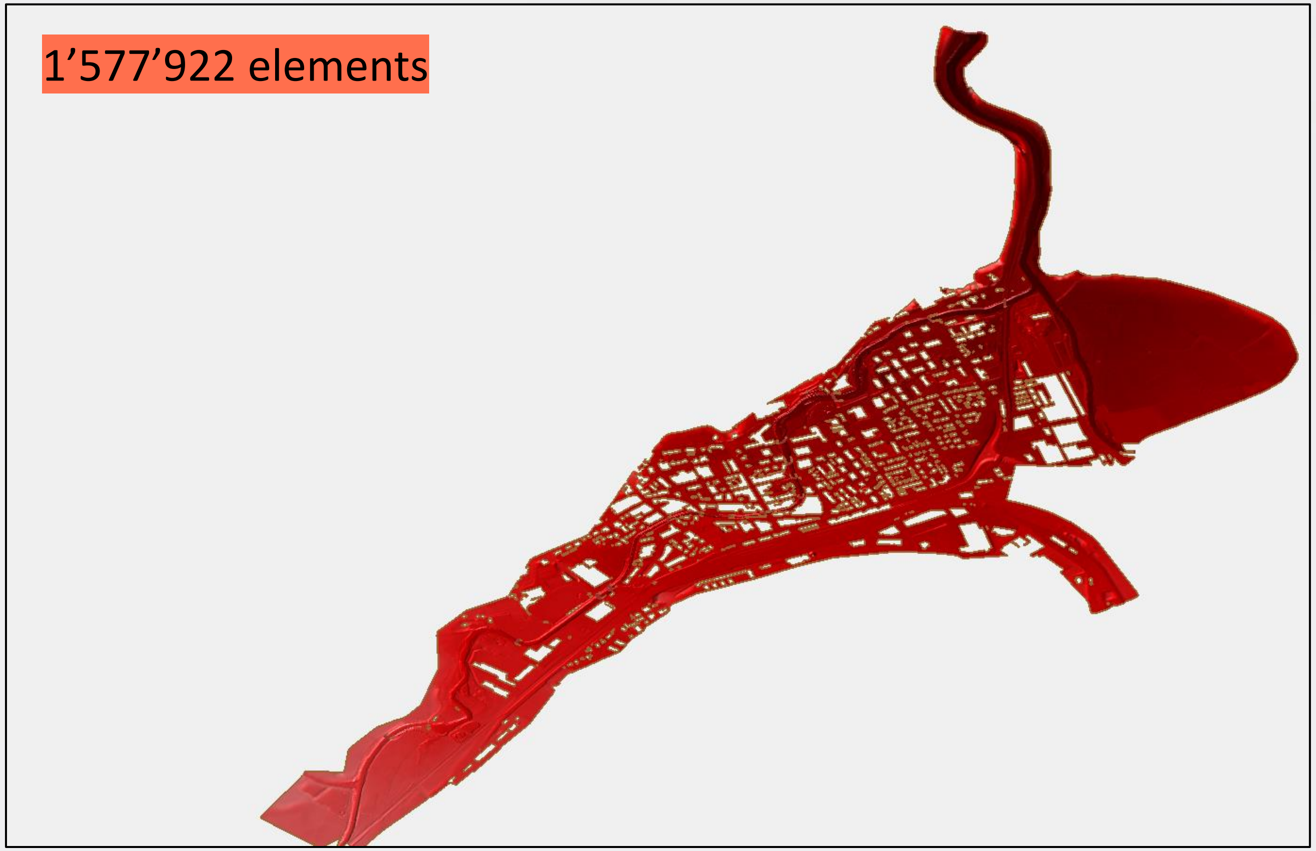
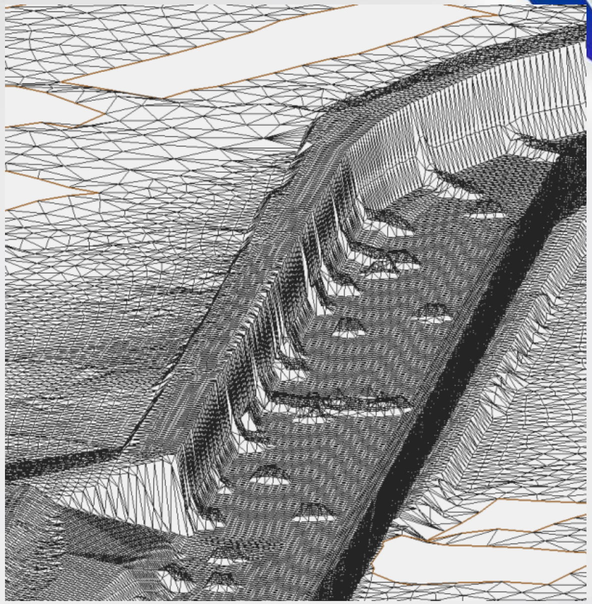
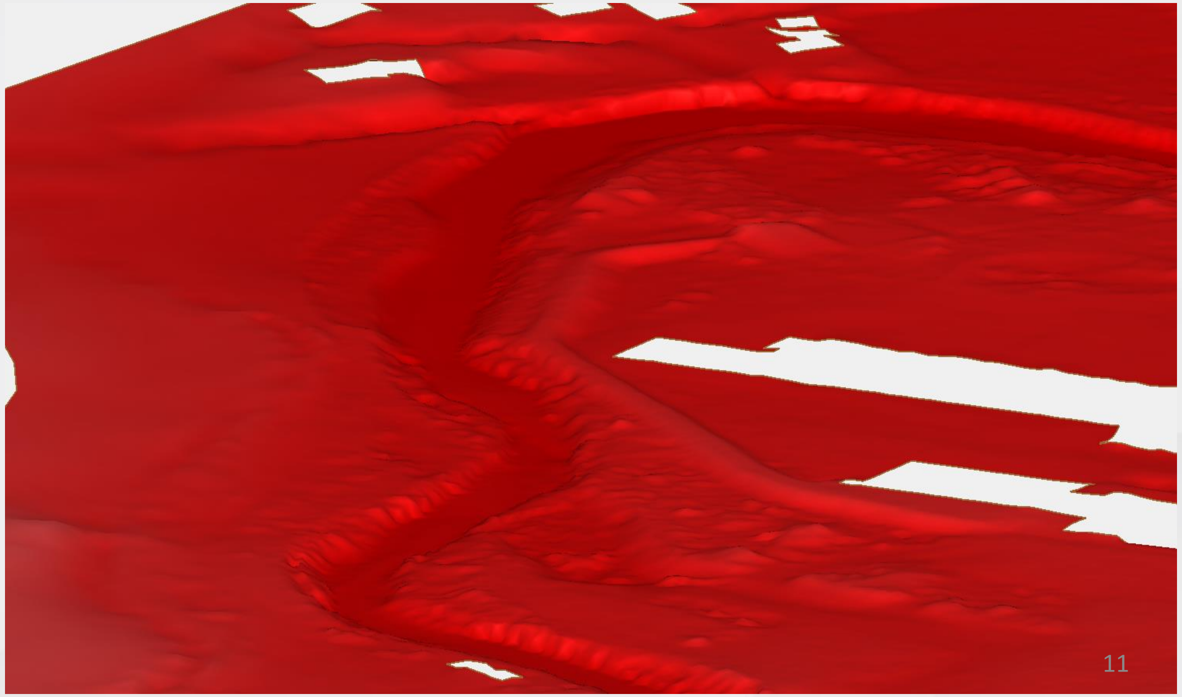
Drone flight → DEM → Mesh → initial 2D model



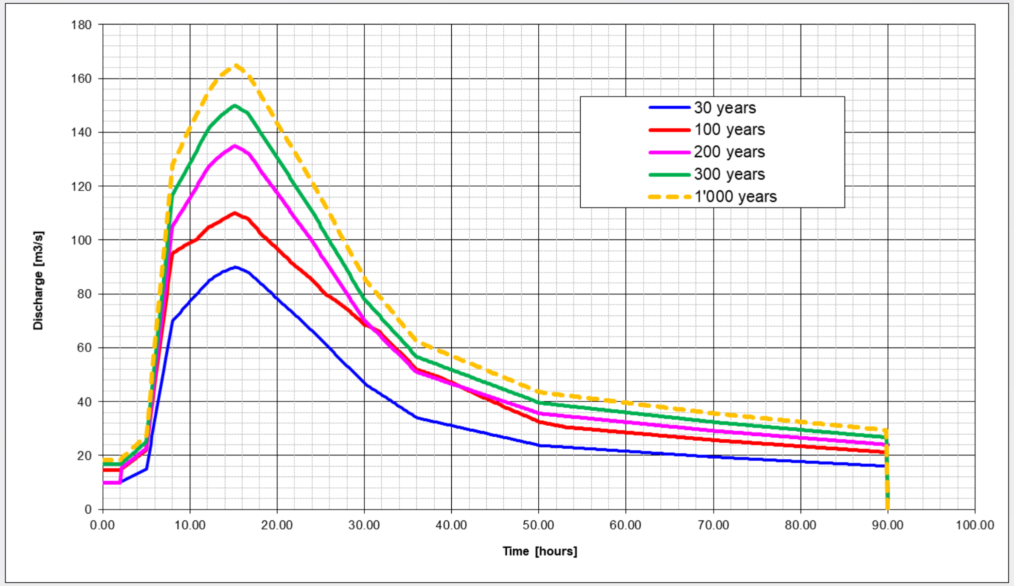
Drone flight → DEM → Mesh → initial 2D model







Boundary conditions



- 2 inflows (Sorne, Birse)
- 3 outflows (river, road, path)
- 16 bridges (h-q relation)
- 1 lateral weir calibrated with physical model (LCH)
- 9 materials index
- Nonstationary flood of 90hours
- model.json = 436 lines of text
- 1 week of calculation with Basement v3.2.0

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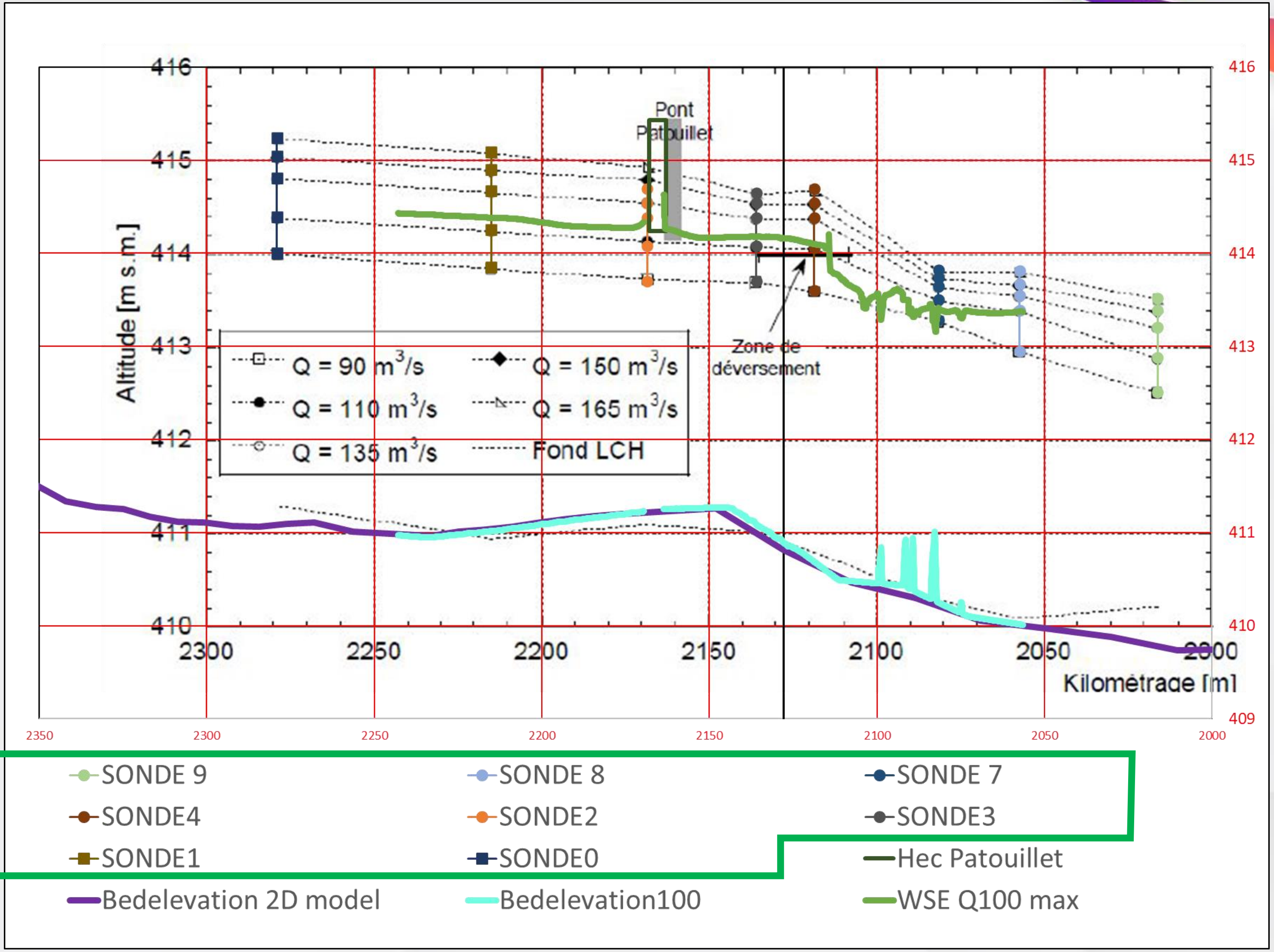
Boundary conditions: weir

sensors



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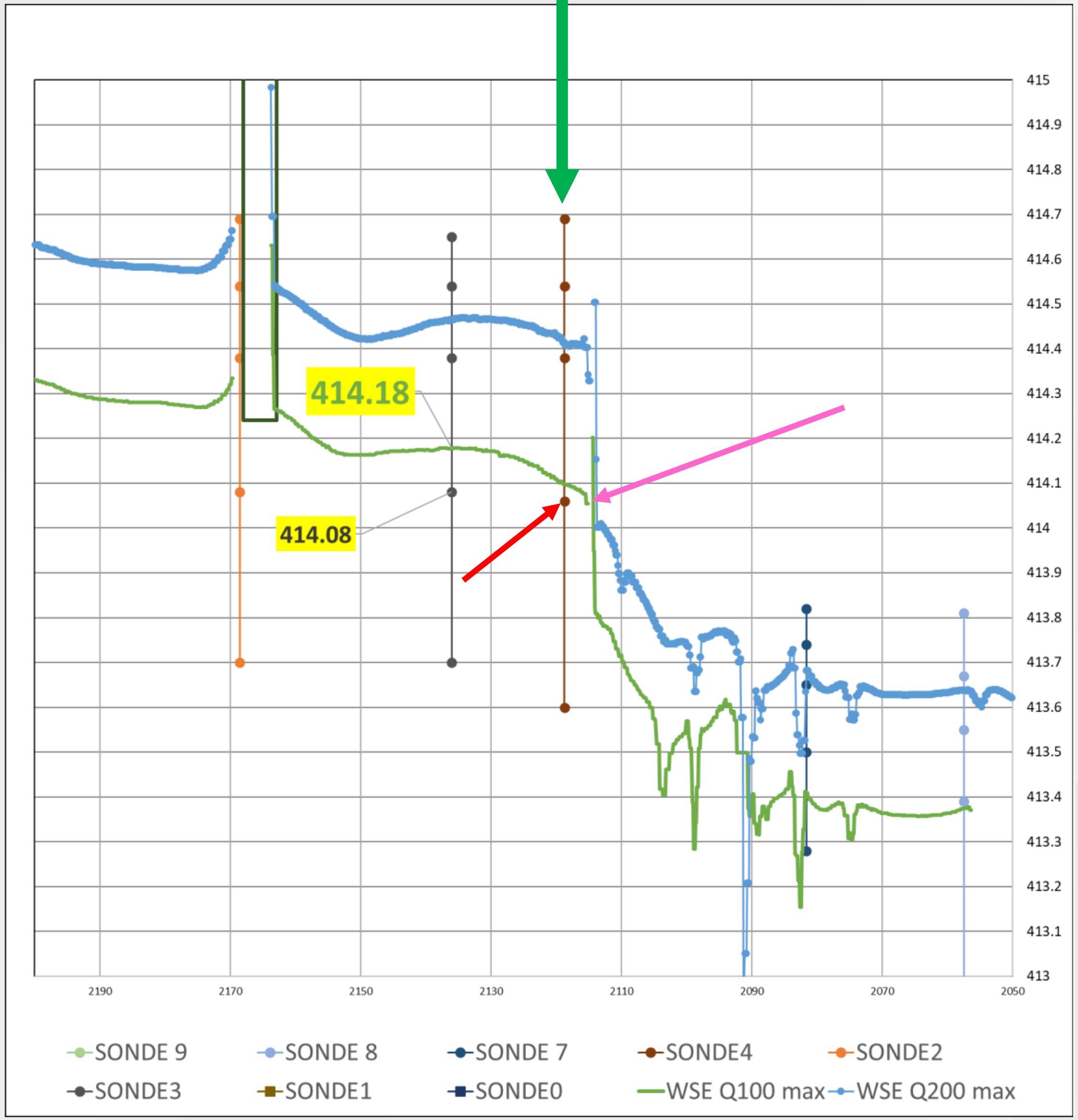
Boundary conditions: weir

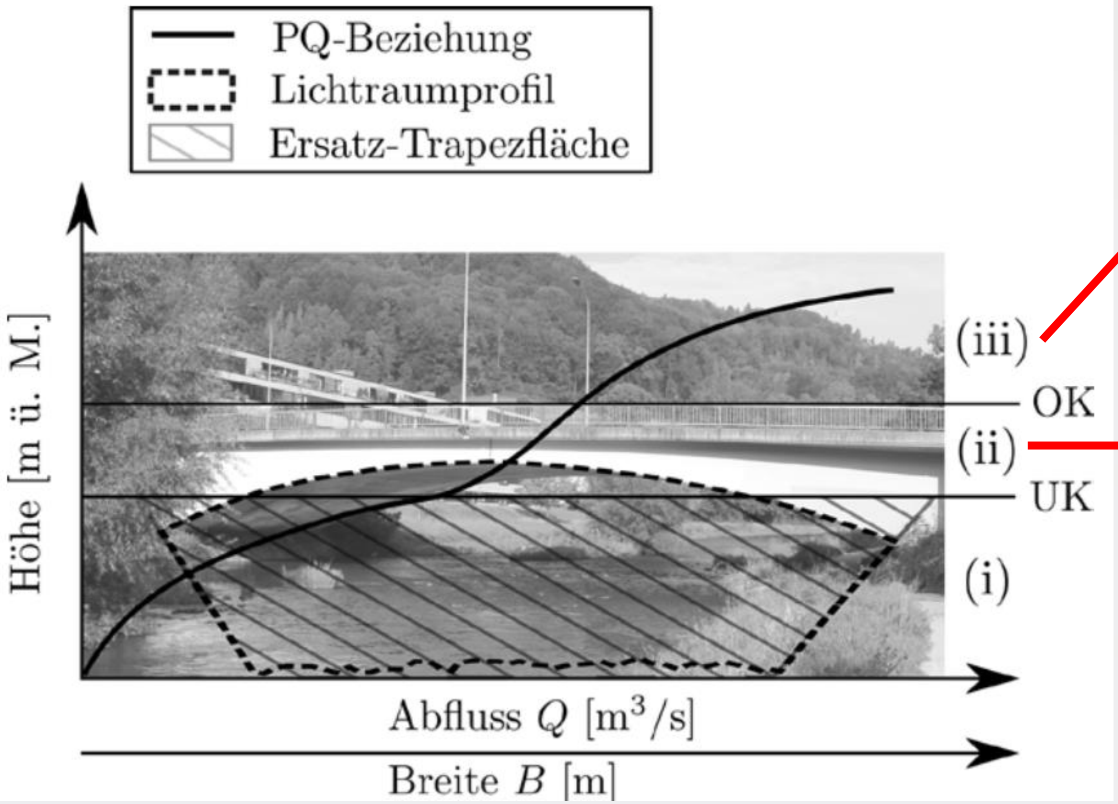
Sensor used for the h-Q relation



Boundary conditions: bridges

Berücksichtigung von Brücken und des Sihldurchlasses im 2D-Überflutungsmodell in der Stadt Zürich

Lukas Vonwiller, Michel Kuhlmann, Mattias Deller, Steffen Corbe, Matthias Oplatka, Marc Hauser



Weir

$$Q_{Wehr} = \frac{2}{3}\mu B\sqrt{2g}h^{3/2}$$

mu = 0.5

Brücke. Für breitkronige Wehre beträgt der Überfallbeiwert μ=0,58 *(Bollrich, 2000)*. Für Strassenbrücken werden in der Literatur Überfallbeiwerte zwischen 0,47 und 0,54 angegeben *(USDA, 2012)*. Im vorliegenden Projekt wird für alle Brücken μ=0,50 verwendet.

Sluice gate

$$Q_{Schütz} = \mu_A A\sqrt{2gh_0}, \quad (1)$$

mua= 0.3

Werten ausgegangen werden muss. Gemäss *USDA (2012)* liegen die Ausflussbeiwerte in den meisten Fällen zwischen 0,38 und 0,50, im Falle von schlechten Bedingungen (sehr hohe Turbulenzen) jedoch zwischen 0,22 und 0,28. Im vorliegenden Projekt werden die Abflussbeiwerte für das Schütz konservativ mit μ_A=0,3 berücksichtigt.

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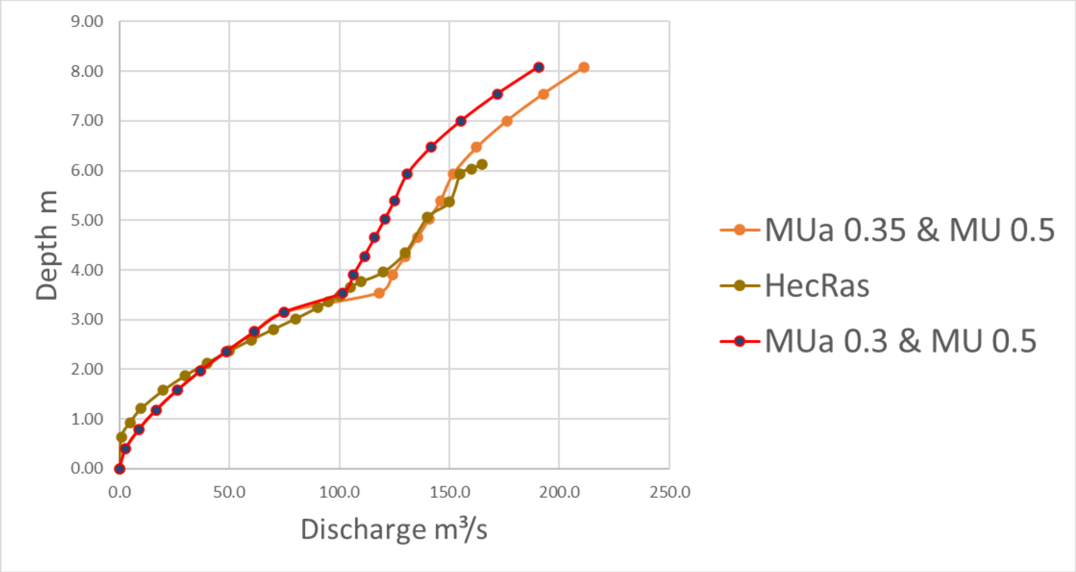
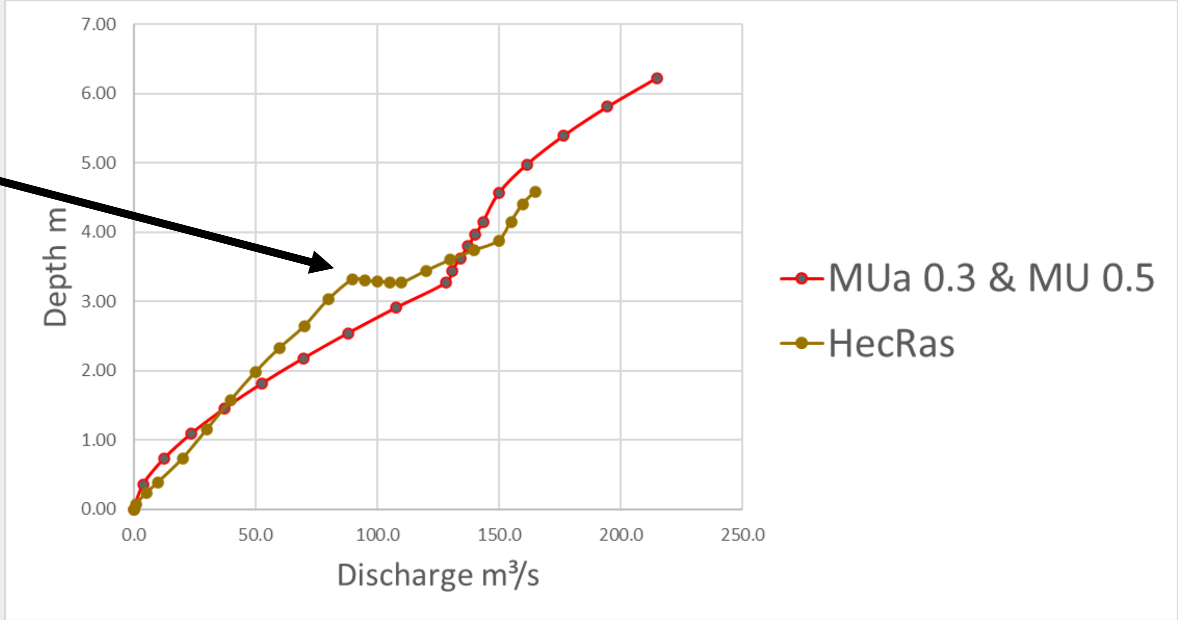
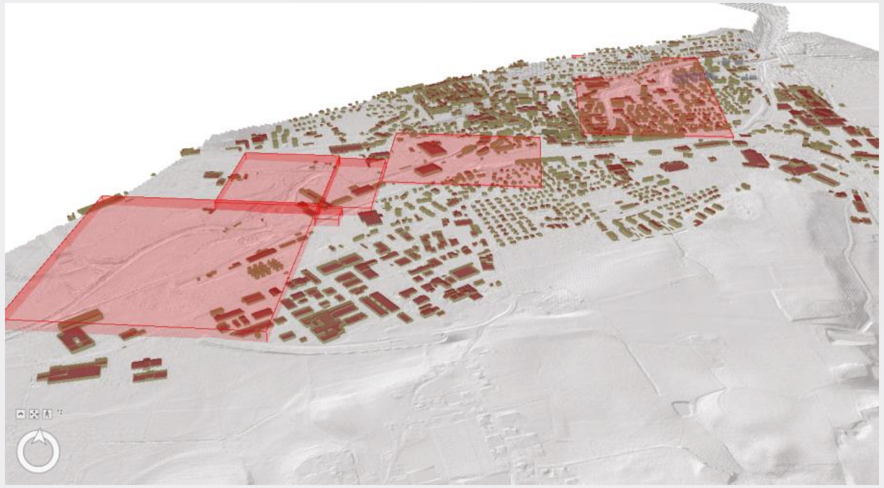
Boundary conditions: bridge



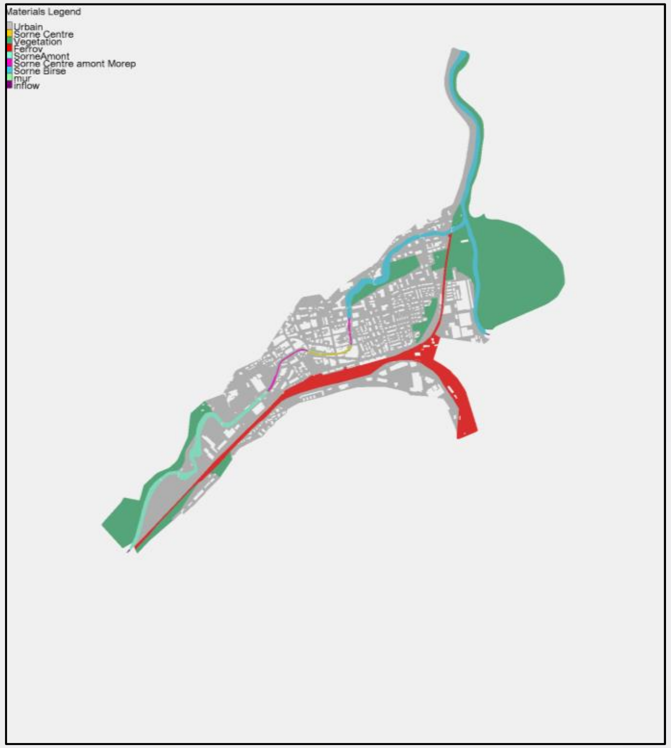
Backwater effect from the Birse river



Update of the model: DEM & mesh

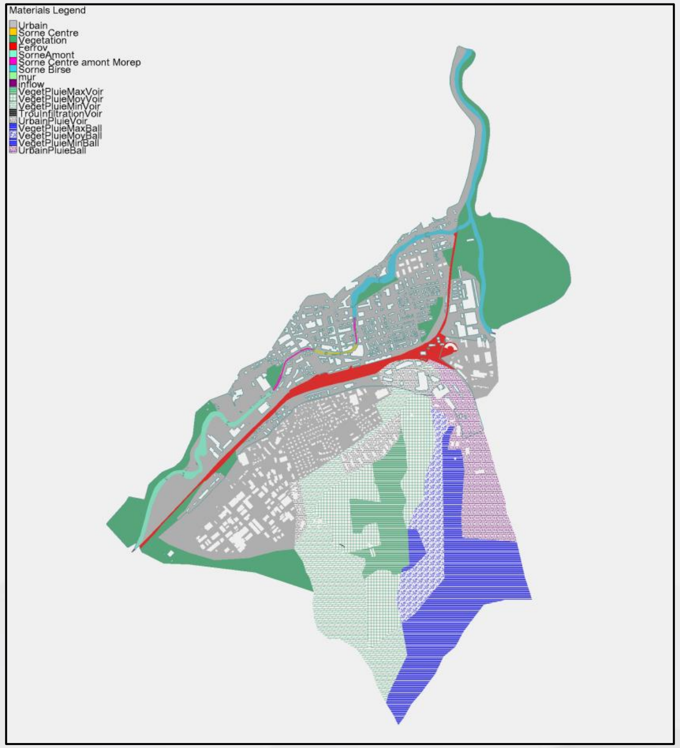


22 DEM → 25 DEM



1’590’725 elements

Extension for the runoff model



4’230’366 elements

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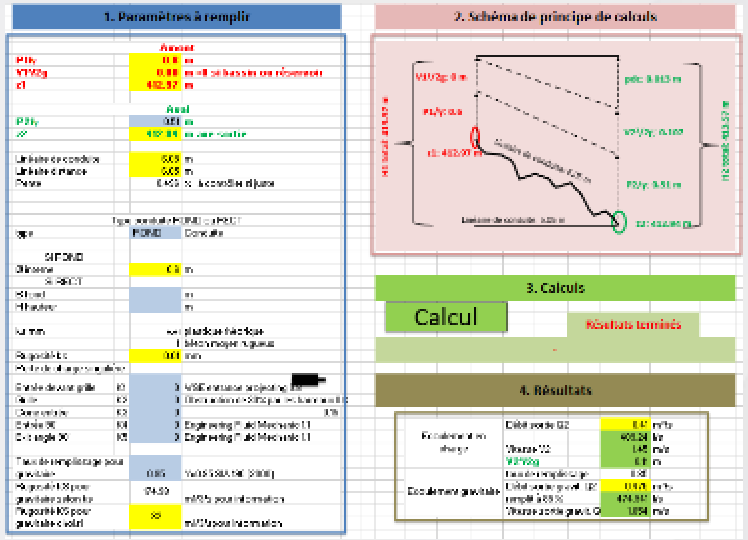
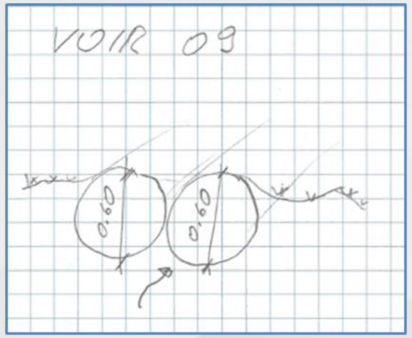
Update of the model: DEM & mesh

- Integration of the capacity of 7 structures and GPS survey of the Voirnet (build of 3D model of the stream)
- Total material index: 15
- Capacity of the structure simplified with Excel:
  - 0 to xx m³/s (85% full) uniform open flow
  - xx to yy m³/s in charge





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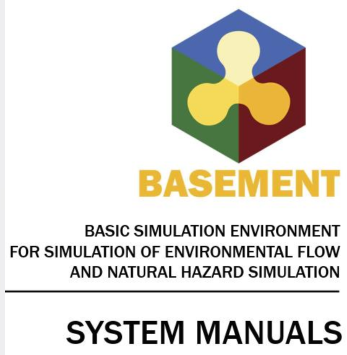
Extension with runoff model: Data from MeteoSwiss

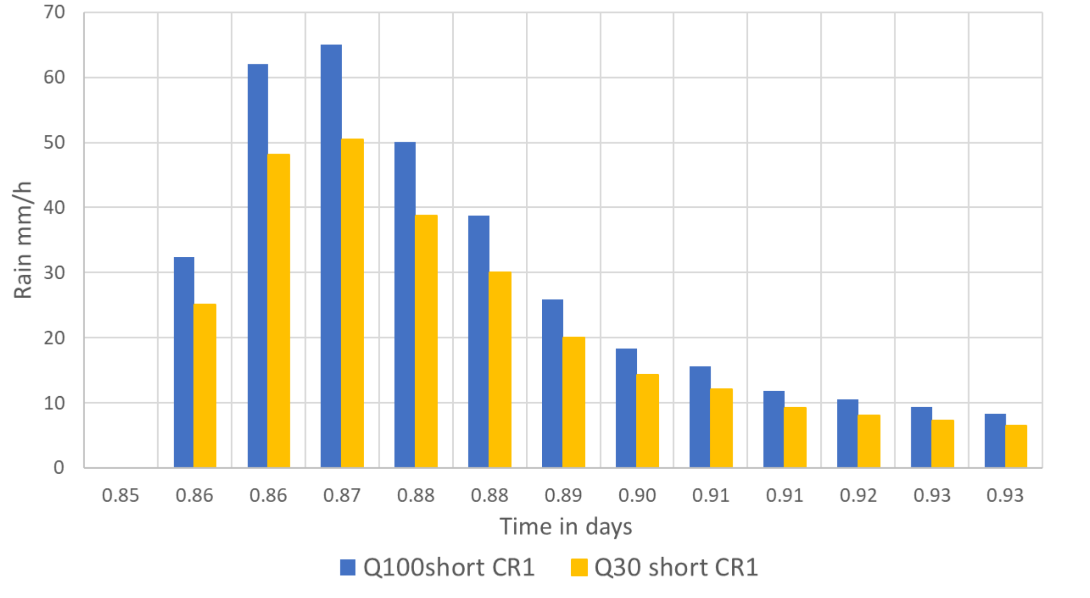


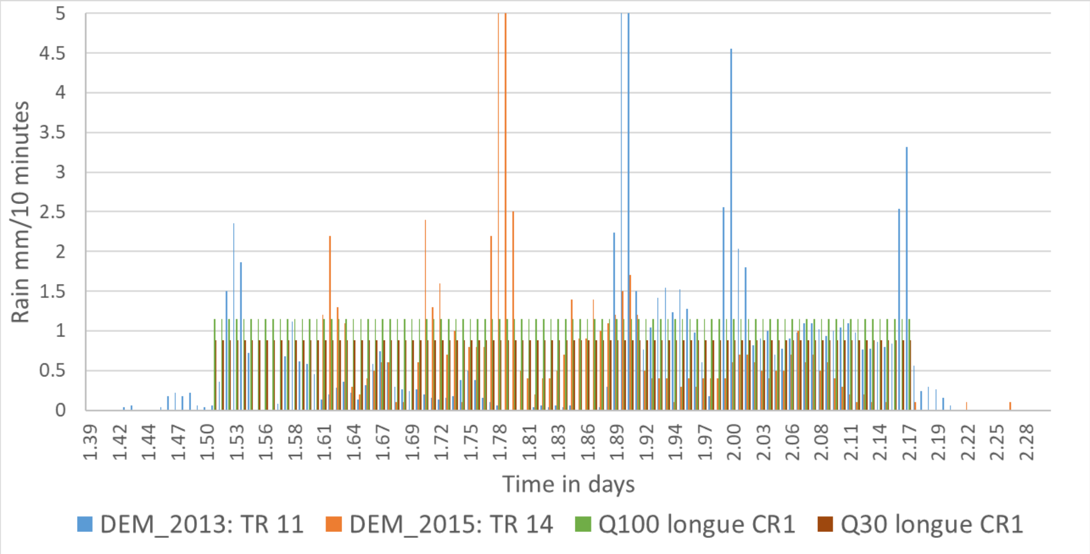
Source (water volume)

- Type: total (as discharge, m3/s), distributed (as rain, mm/h)
- Sink behaviors:
  - Exact (as prescribed)
  - Available (as prescribed or less)
  - Infinity (as much as possible)

- Statisical analysis of the station of Meteoswiss in Delémont and Fahy with extrapolation for rain of 1hour, 2 hours, 6 hours, 12 hours, 16 hours and 1 day for a return period of 30years, 100 years and 300 years.
- For 2 hours of rain, used the rain distribution of overland flow map (FOEN).
- For 16 hours, a uniform rain.

	Meteoswiss		Hydrological atlas	
	in 16h	in 2h	24h	1h
30	85.0	45.0	99.0	43.0
100	110.0	58.0	123.0	58.0
300	139.0	72.0		



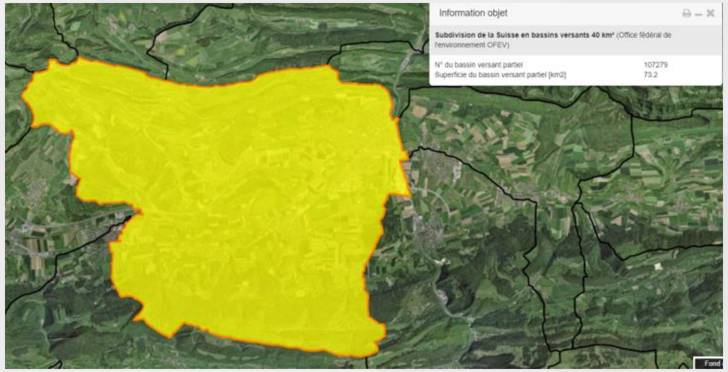


Runoff calibration (1)

	Overland flow map (FOEN)	sd ingénierie		
TR	100	100	100	100
Duration	1h	1h	2h	16h
Mm/h	60mm/h	46.7mm/h	58mm/2h 29mm/h	110mm/16h 6.9mm/h
Runoff coefficient	Consolidated land, rock 1 Agricultural land 0.45 Marsh, reed bed 0.45 Garden house, glacier 0.5 Forest, scree 0.35		Roofing 0.9 Roads 0.7-0.9 Rocks 0.7 Fields 0.2 Woodland 0.1	
Correction	Max + or - 0.1 depending on the flow delay (flow availability)	-	-	-
Correction2	If slope <25% no correction	-	-	-
Minimal depth	> 0.015m		> 0.01m	> 0.01m

→ no consideration of soil saturation

- Modification of the runoff coefficient according to the saturation of the soil. The runoff coefficient will be different according to the soil but also depending on the intensity of the rain (experience from flood in Cressier for example, Hydrique).
- The longer the rain will last and the more the soil will be saturated.
- First definition of a global value for short rain and long rain: calibration of the value according to the partial watershed of the Sorne.



Runoff calibration (2)

Summary map of infiltration possibilities (MFR, 2007)

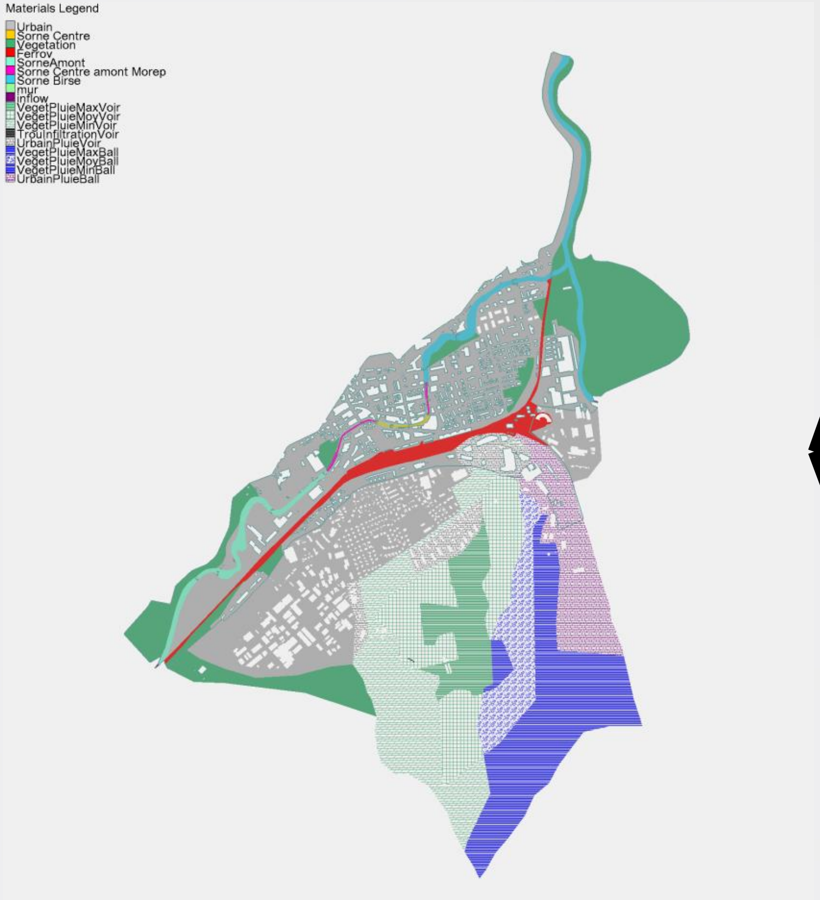
Saturated soil when raining (~wetland)

- We have defined 6 runoff coefficient = f(soil type, rain intensity): 0.2 / 0.3 / 0.4 / 0.7 / 0.8 / 0.95 based on calibration of the FOEN station and rain data from MeteoSwiss.

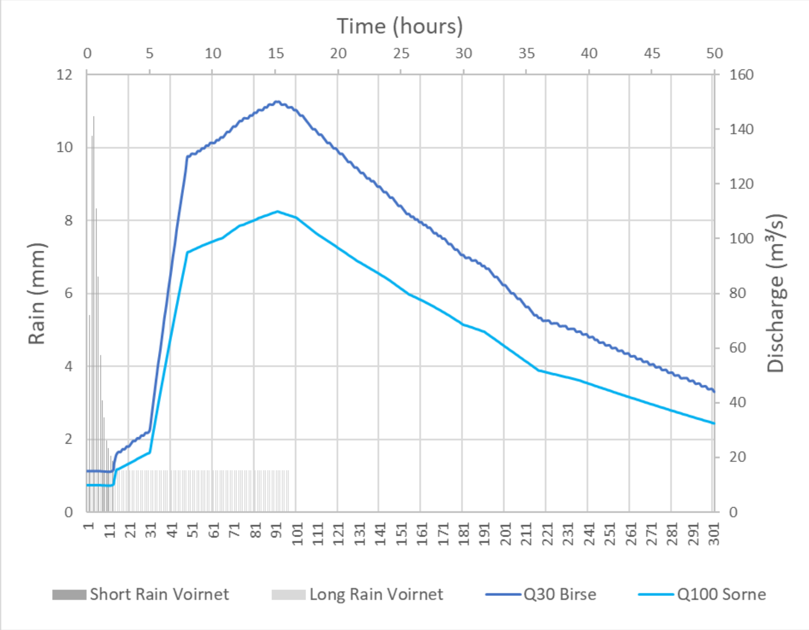
- $Q100_{16h} = f(Int, CR) = f(6.88mm/h, 0.8) = 1.79m^3/s$
- $Q100_{2h} = f(Int, CR) = f(65.08mm/h, 0.3) = 6.37m^3/s$

	Voirnet			
	Hazard map (Hakesh)	sdi 2h	sdi 2h	sdi 16h
surface km2	1.02			
Runoff coefficient	-	0.09	0.30	0.80
Q30 [m³/s]	3.3	1.48	4.94	1.39
Q100 [m³/s]	3.9	1.91	6.37	1.79
Q300 [m³/s]	5.85			
Qext [m³/s]	7.8			

Results



With inflow (nonstationary hydrograph) of the Sorne river + the Birse river



With rain source (uniform rain corrected by runoff coefficient) for the South of Delémont (stream Voirnet)

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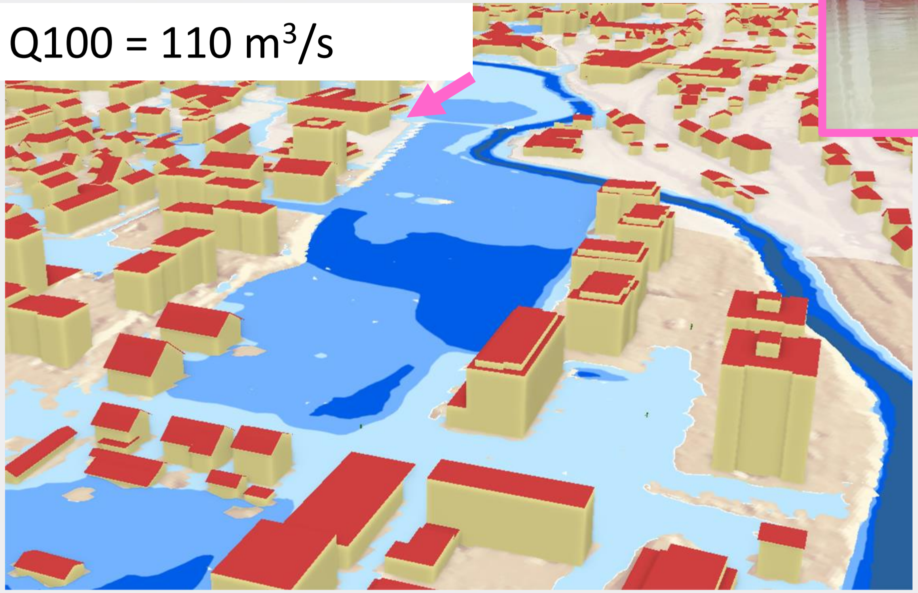
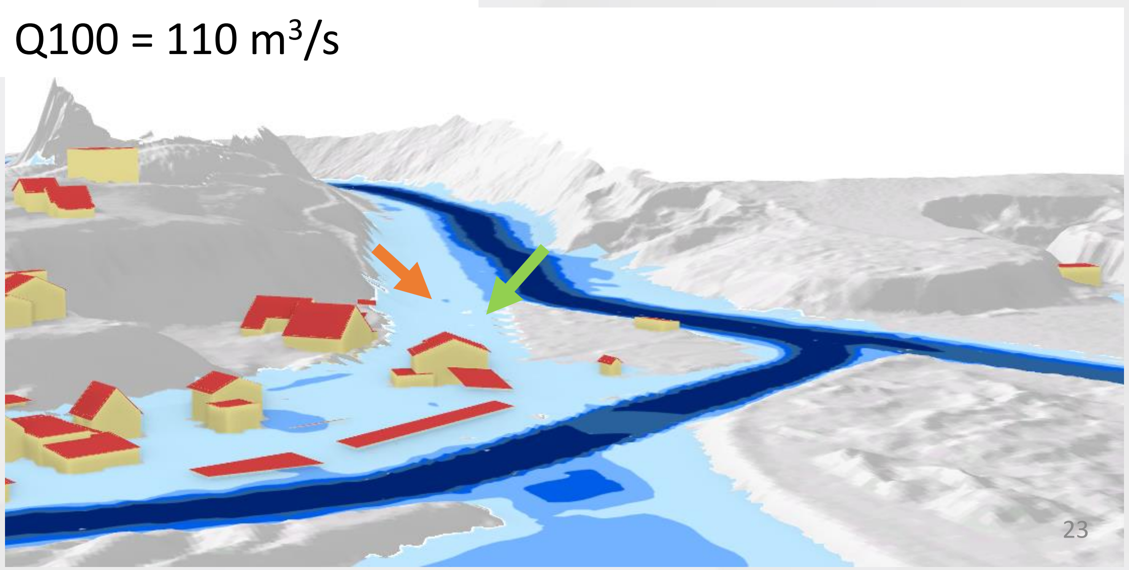
A) Results with hydrograph: actual state

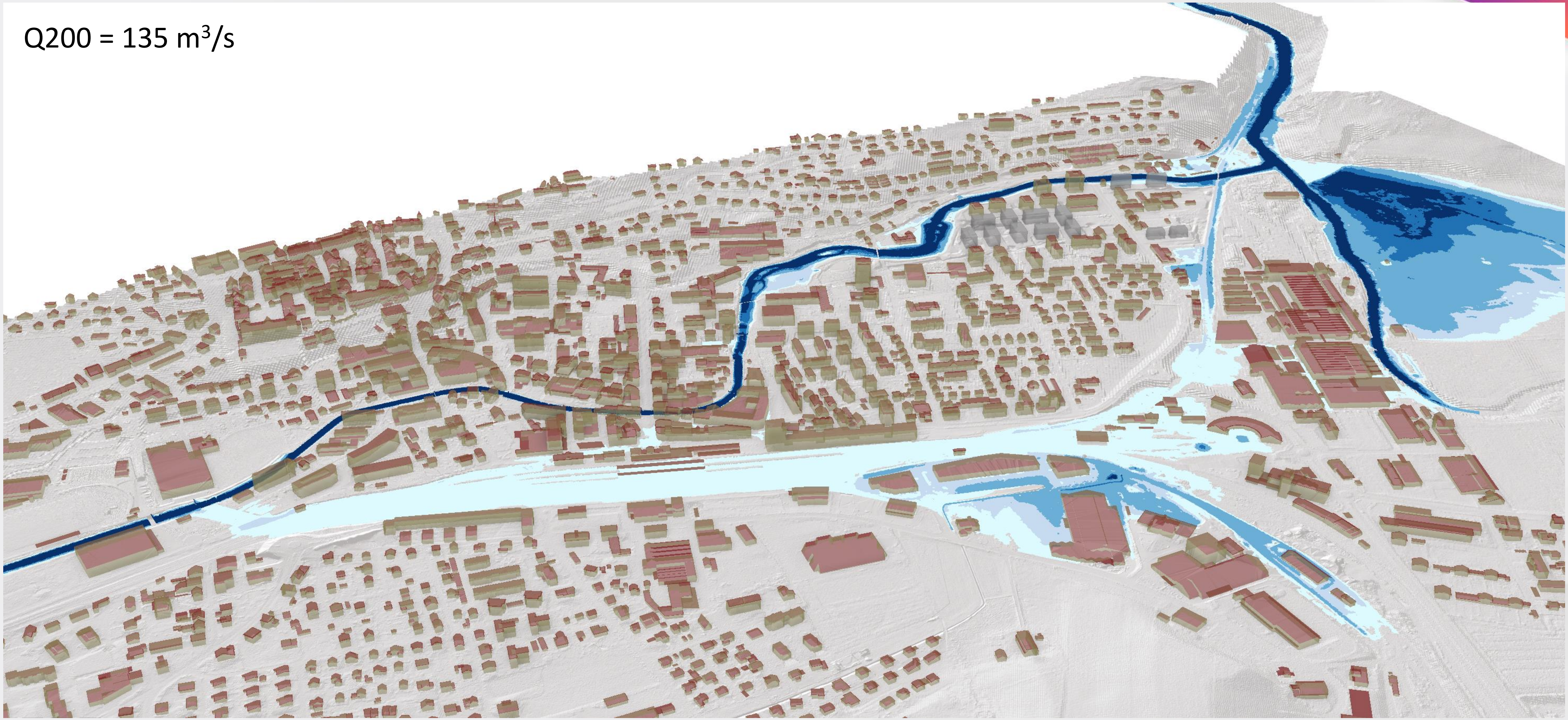
Q100 = 110 m³/s



Q100 = 110 m³/s



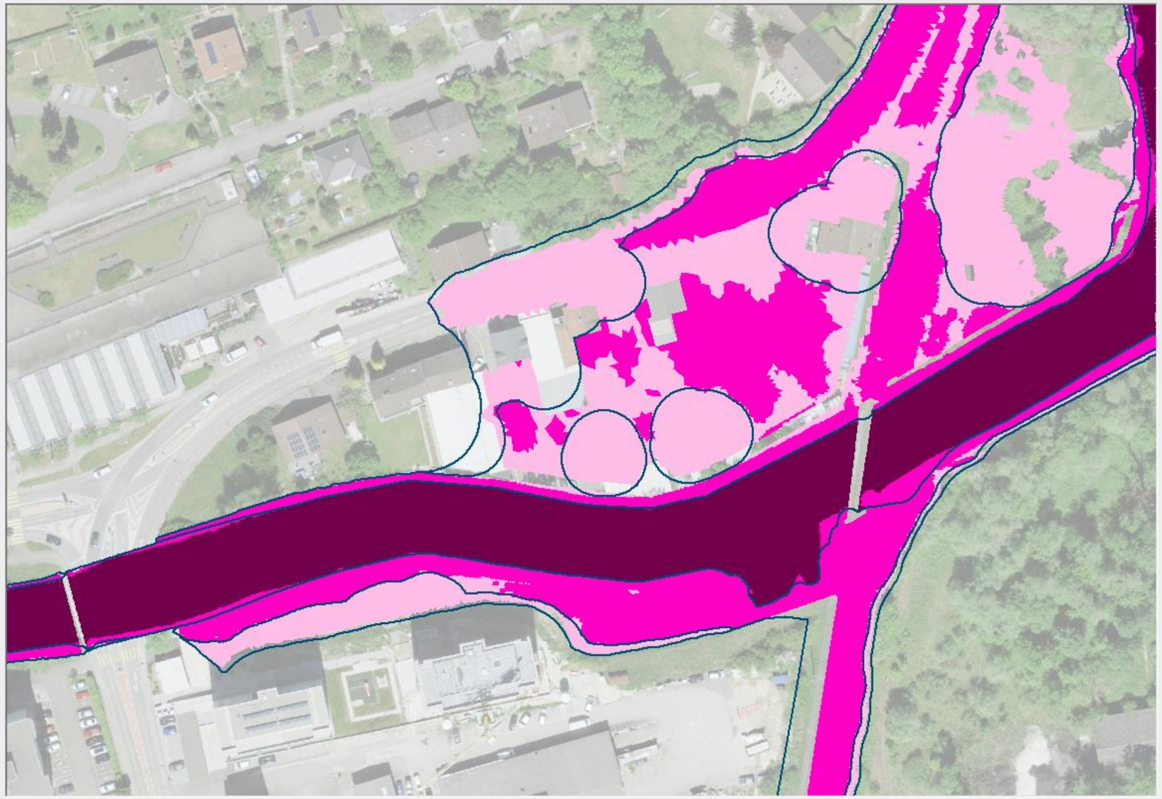
A) Results with hydrograph: final state



A) Results with hydrograph: final state

With GIS treatment

<u>Raw data (elements)</u>



<u>Final map (polygons)</u>

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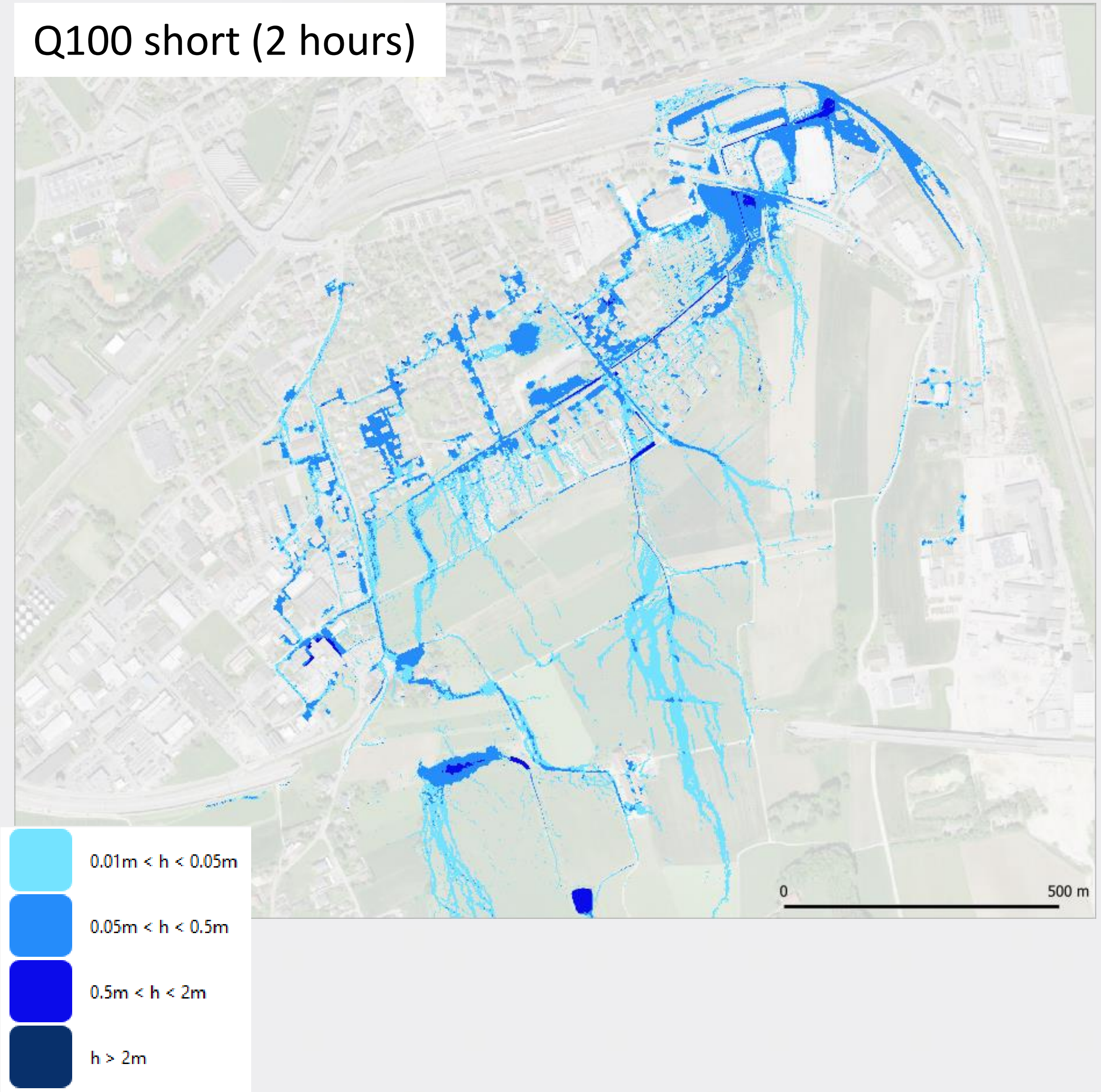
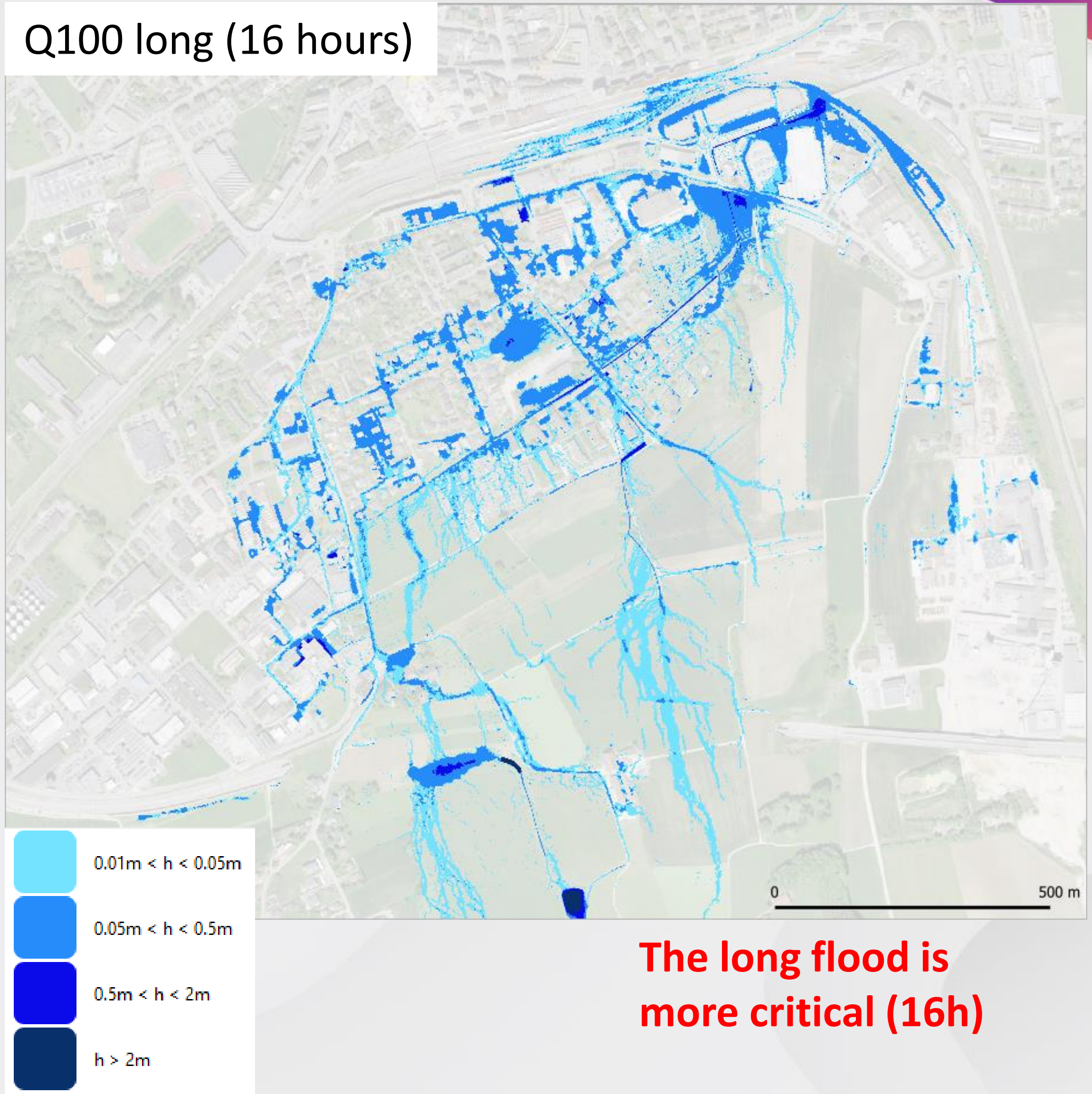
B) Results with runoff (rain consideration)





The long flood is more critical (16h)

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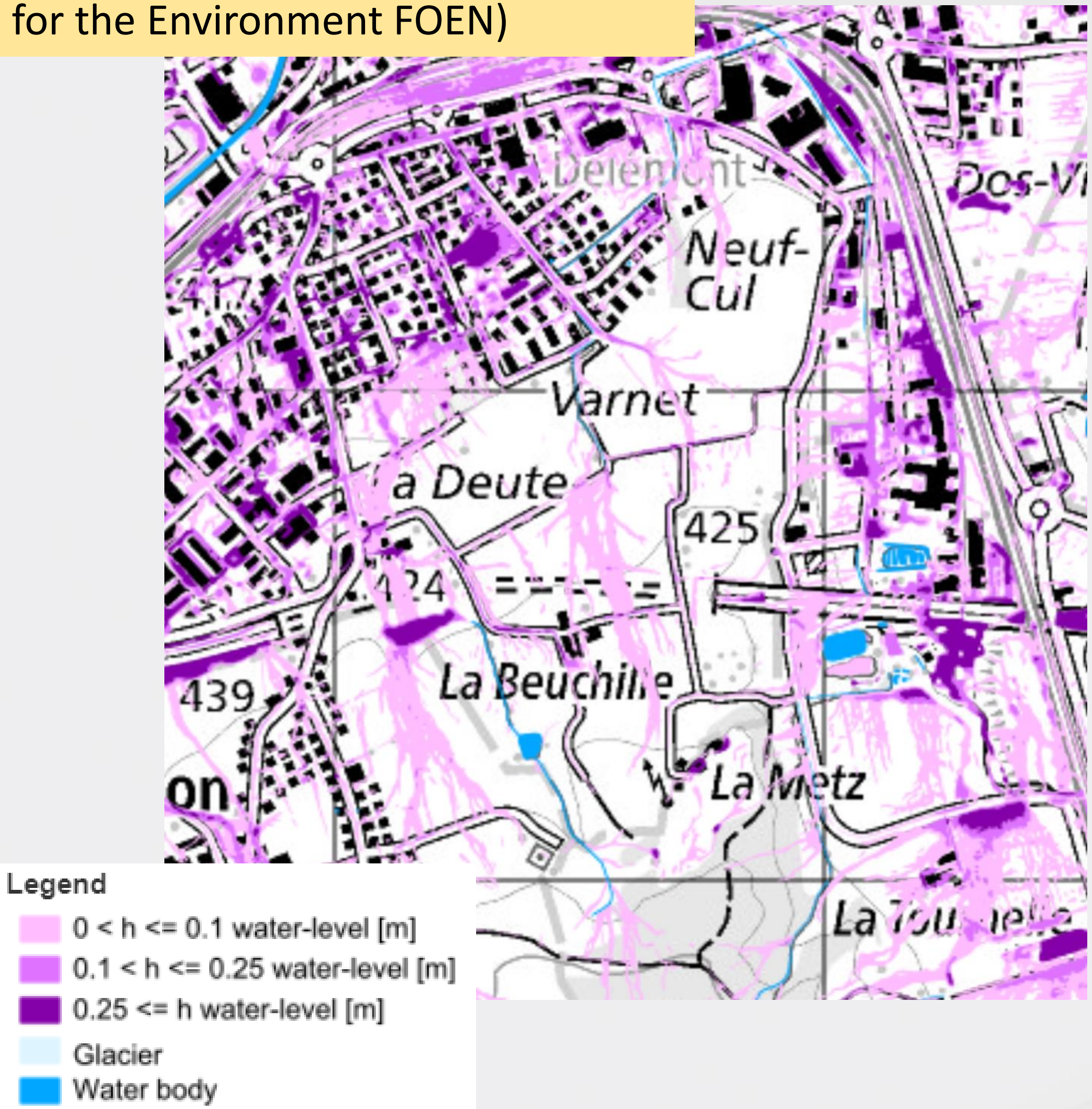
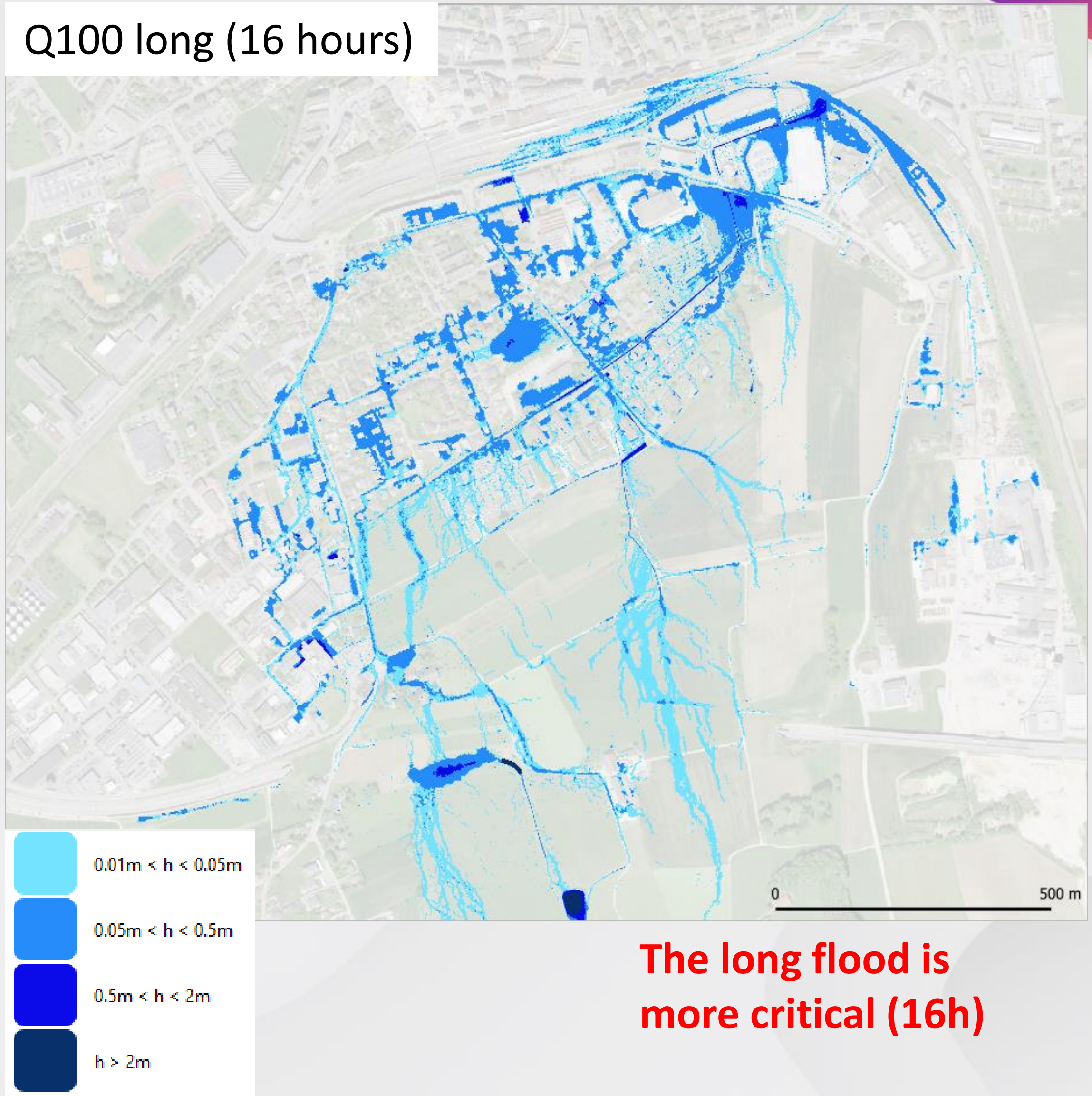
B) Results with runoff (rain consideration)

Overland flow map (Federal Office for the Environment FOEN)

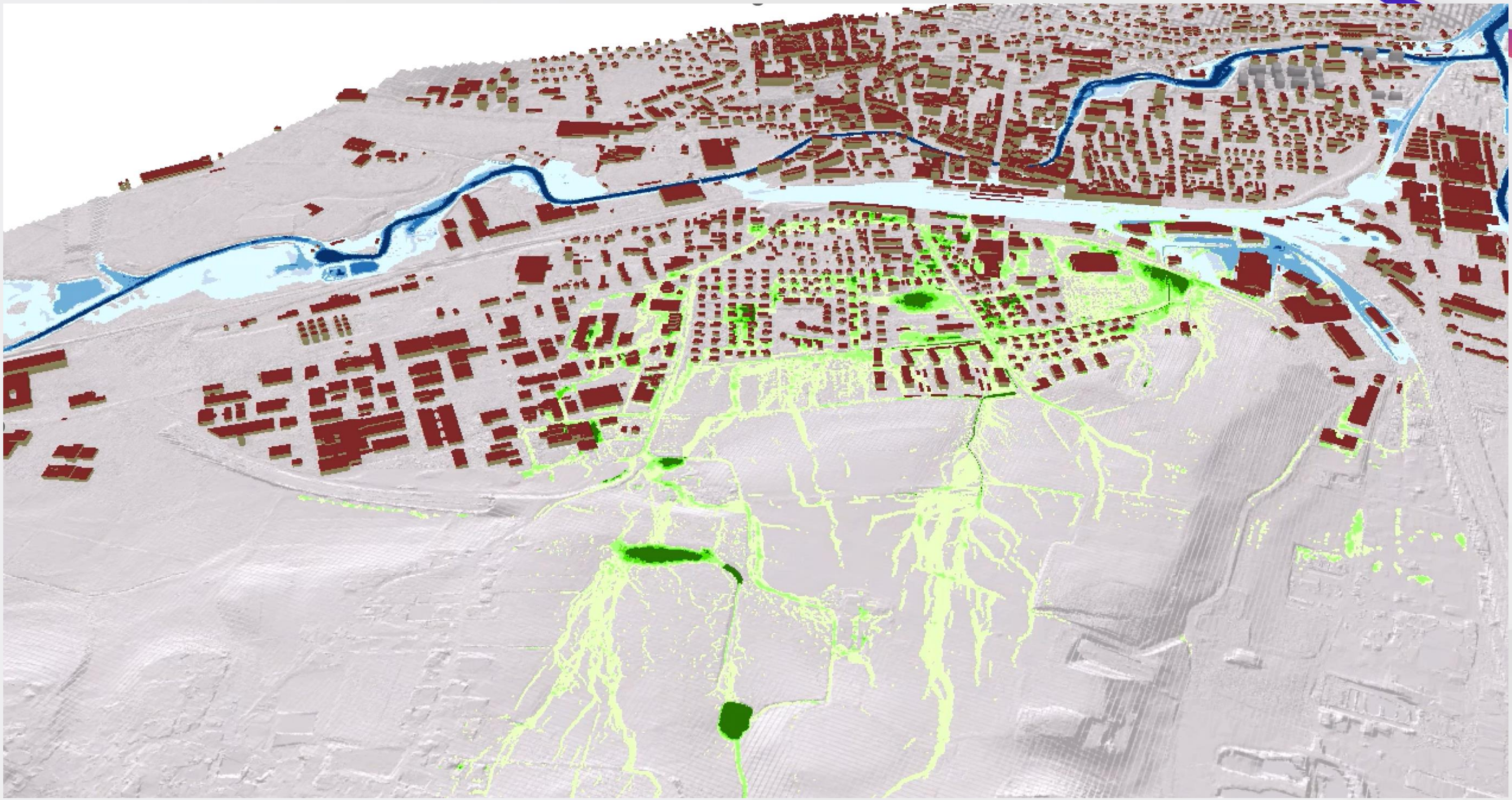


Q100 long (16 hours)



The long flood is more critical (16h)

C) All together



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My 10 learnings

I. Methodology is important
II. Methodology is important
III. Methodology is important
IV. Methodology is important
V. Methodology is important
VI. Methodology is important
VII. Methodology is important
VIII. Methodology is important
IX. Methodology is important
X. Methodology is important

- When you build the model
- When you store the data
- When you update the DEM (around 20 times) and the mesh
- When you add a new scenario
- When you switch from one software to another one

Thanks for your attention

special thanks for all the engineers who were collaborative,

BG

ECOENG Engineers ETH / SIA

PEPI NATALE SA INGÉNIEURS CONSEILS

HUNZIKER BETATECH

MFR GÉOLOGIE - GÉOTECHNIQUE SA

SiT a DeL

LCH PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

2MO

thanks to our client,

VILLE DE DELÉMONT

Service de l'urbanisme, de l'environnement et des travaux publics (UETP)

and thanks to VAW for the excellent software

VAW Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie