

HYDRO-TECHNICAL ASPECTS OF THE DESIGN OF (NATURE BASED) FLOOD PROTECTION MEASURES

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CONTENT

- INTRODUCTION
- MODELLING
- DESIGN DISCHARGE
- SOME OTHER DESIGN STEPS
- AFFORESTATION
- CONCLUSIONS



INTRODUCTION

Flood protection:

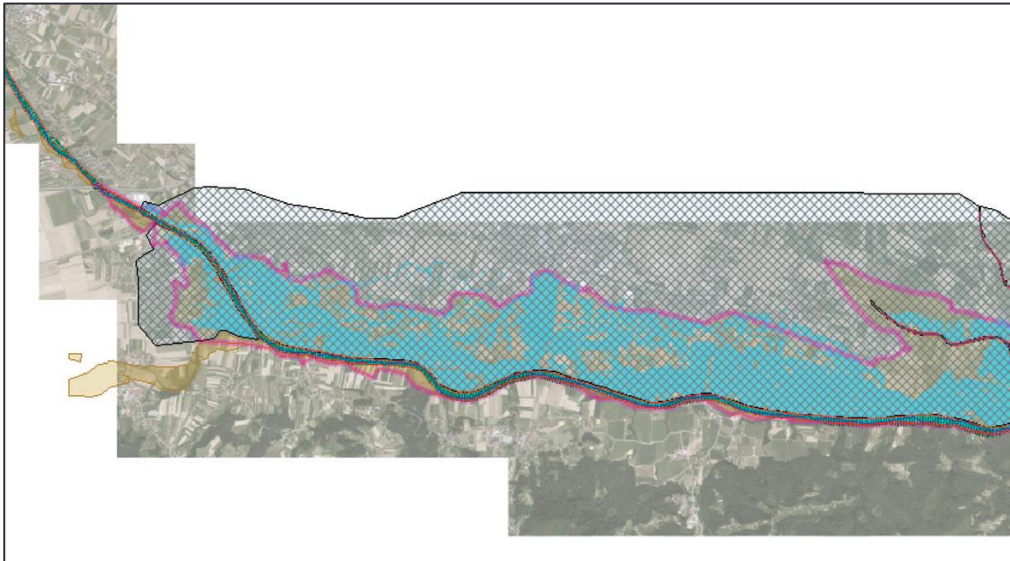
- Numerous options are available for flood protection covering multiple grey and green measures.
- The main aim is to ensure flood safety.
- In Slovenia so-called dry-reservoirs are very „popular“.



INTRODUCTION

Modelling:

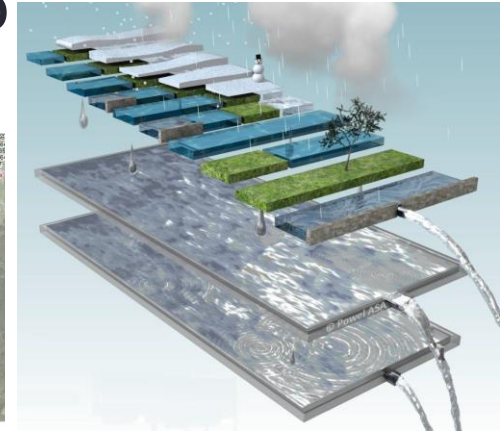
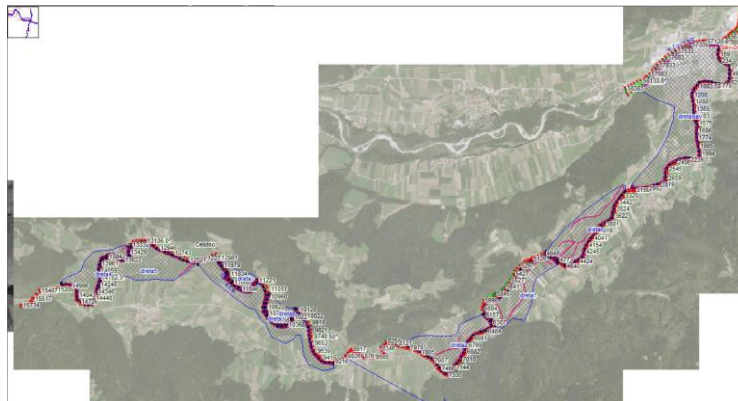
- Is important for the understanding of processes that define the water/hydrological cycle.
- Is part of the flood forecasting system.
- Is required in the design of hydro-technical structures such as dams, levees and also in case of green measures or preparation of flood maps,....



INTRODUCTION

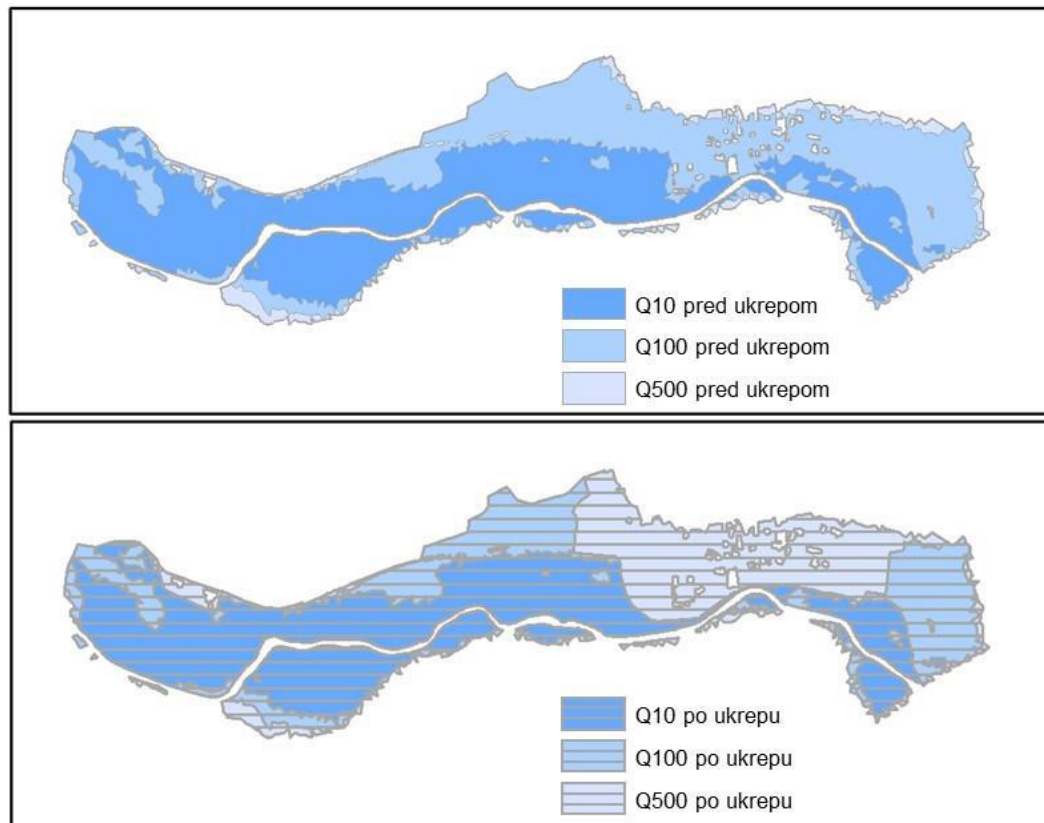
In order to assess the impact of the planned measure most often a combination of models needs to be applied:

- Hydrological model describes the rainfall-runoff relationship
- Hydraulic model is used for flood routing on floodplains and river network.
- Flood damage model can be used to calculate the flood damage.



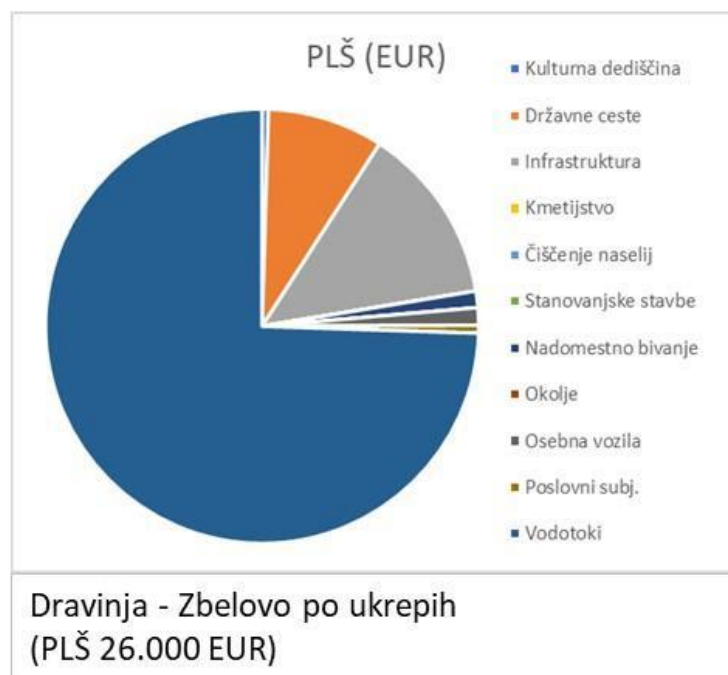
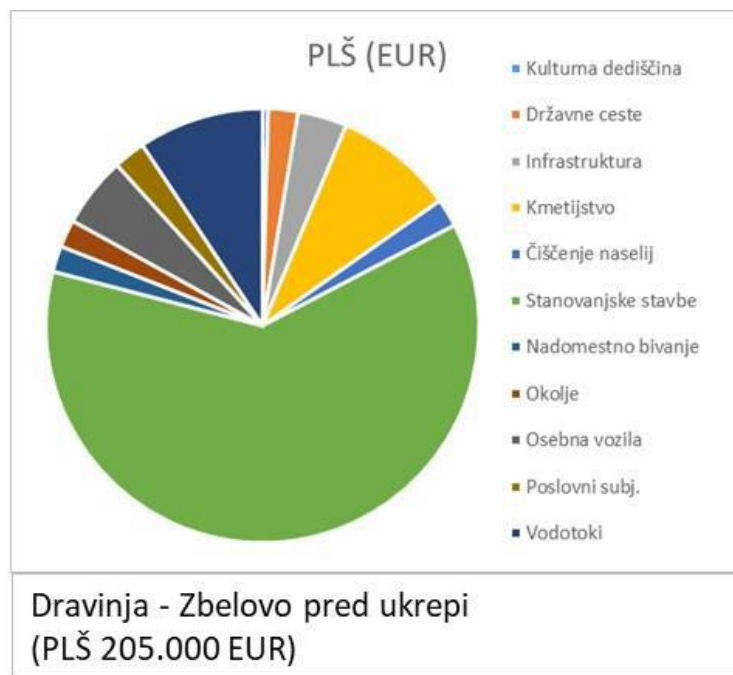
INTRODUCTION

The main result of such modelling exercise is (above-before measure; below-after measure):



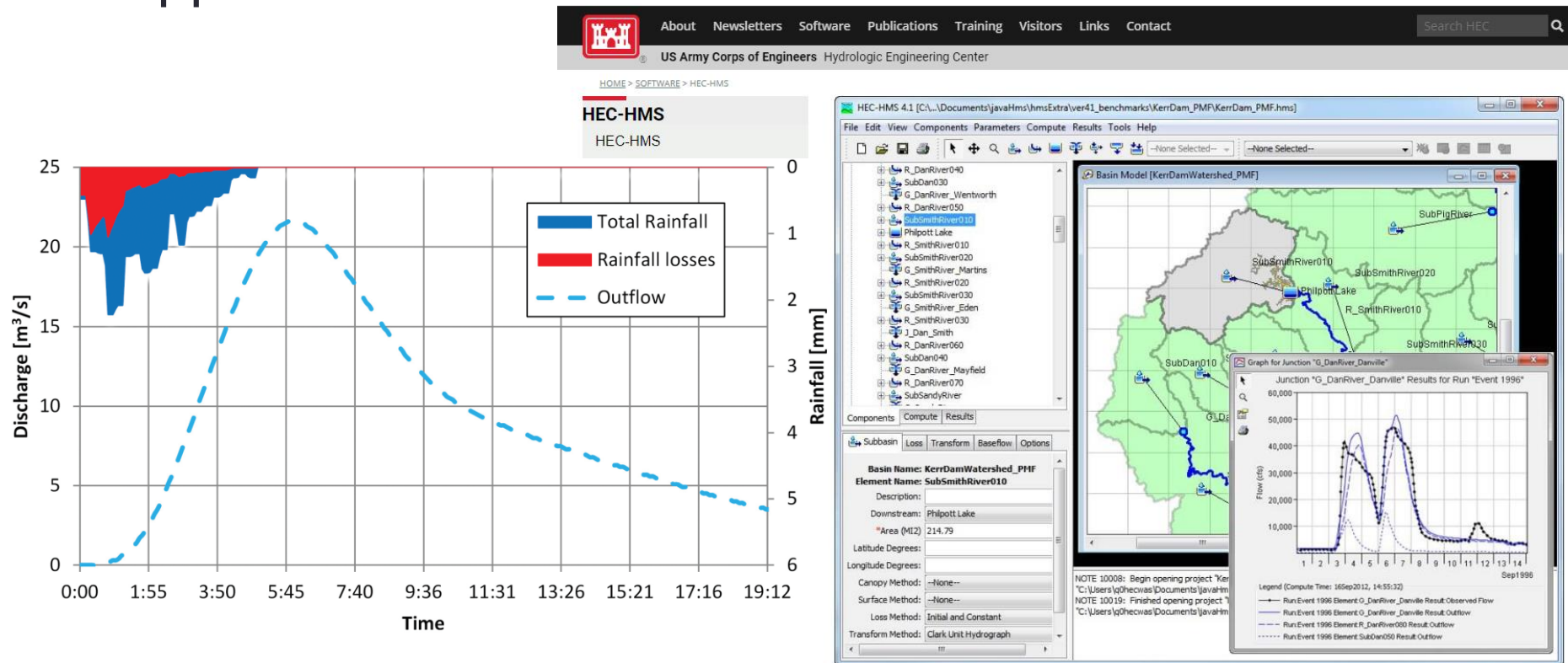
INTRODUCTION

And using flood damage model this information can be related to the expected flood damage:



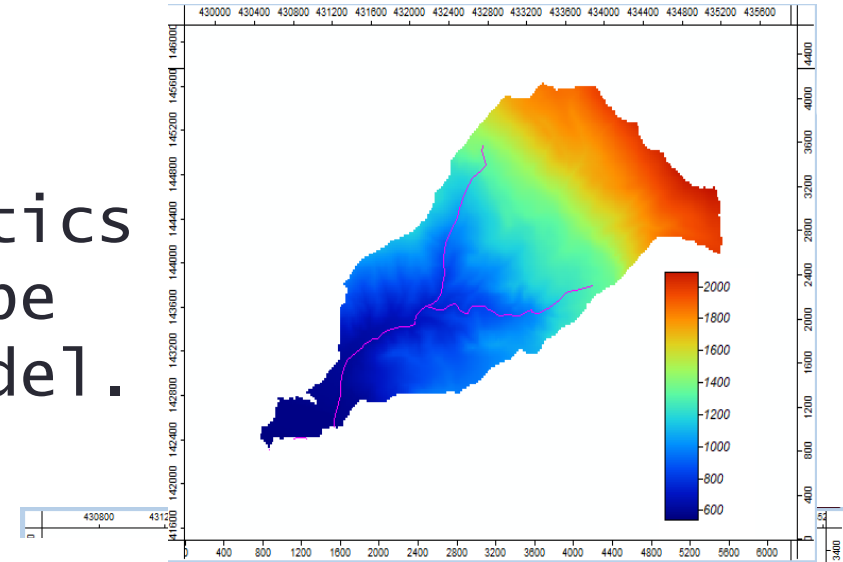
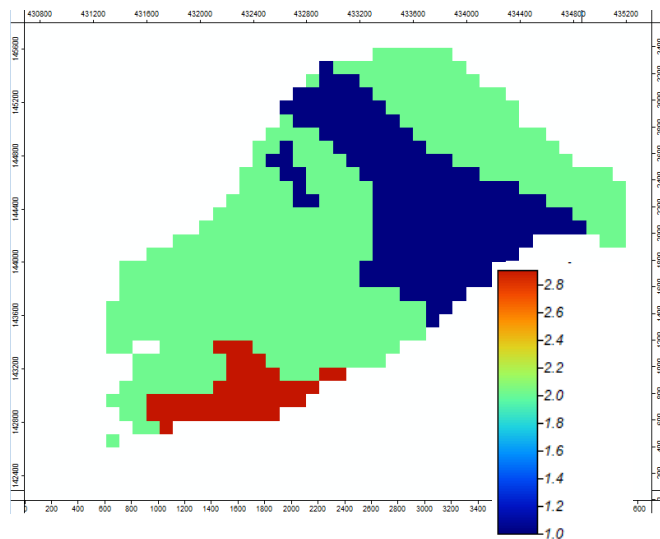
HYDROLOGICAL MODELLING

- Numerous modelling options are available.
- HEC-HMS is one of the most frequently applied models.

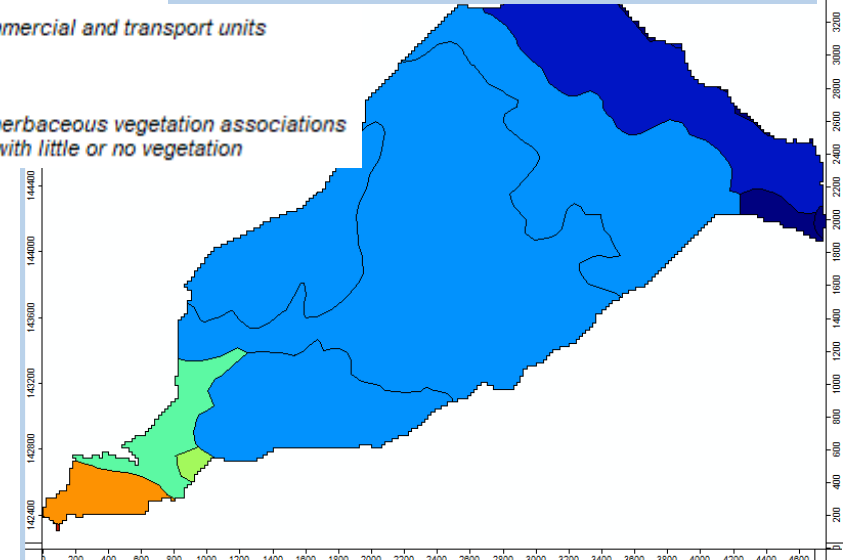


HYDROLOGICAL MODELLING

- Information about catchment characteristics such as land-use, slope is included in the model.

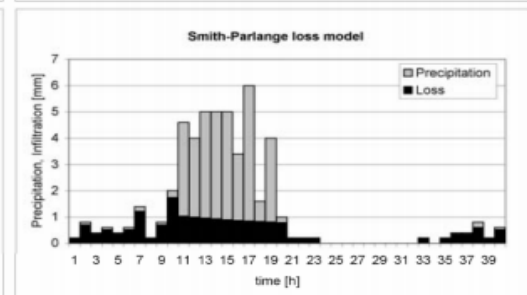
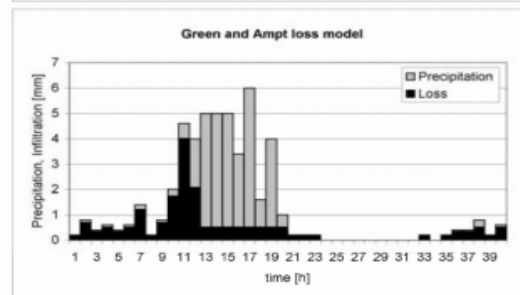
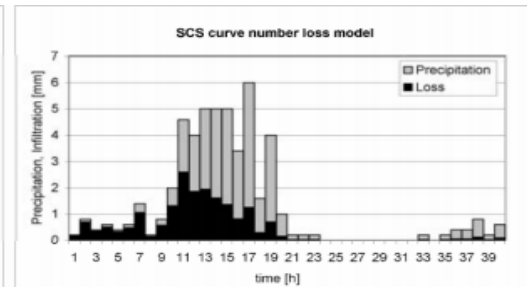
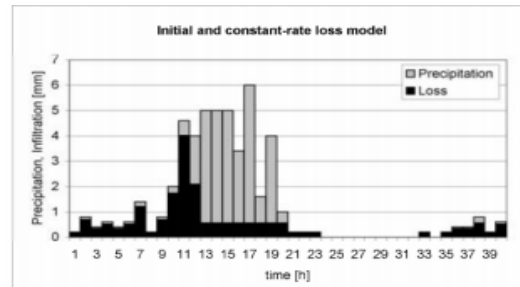
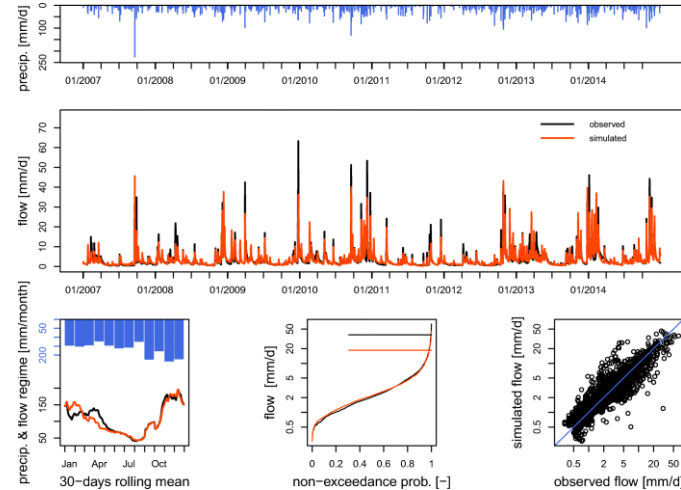


- Inland waters
- Industrial, commercial and transport units
- Pastures
- Urban fabric
- Forests
- Scrub and/or herbaceous vegetation associations
- Open spaces with little or no vegetation

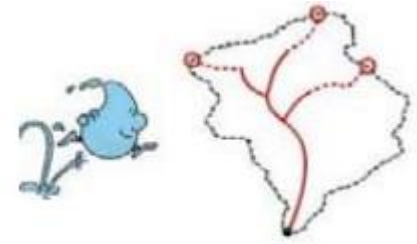


HYDROLOGICAL MODELLING

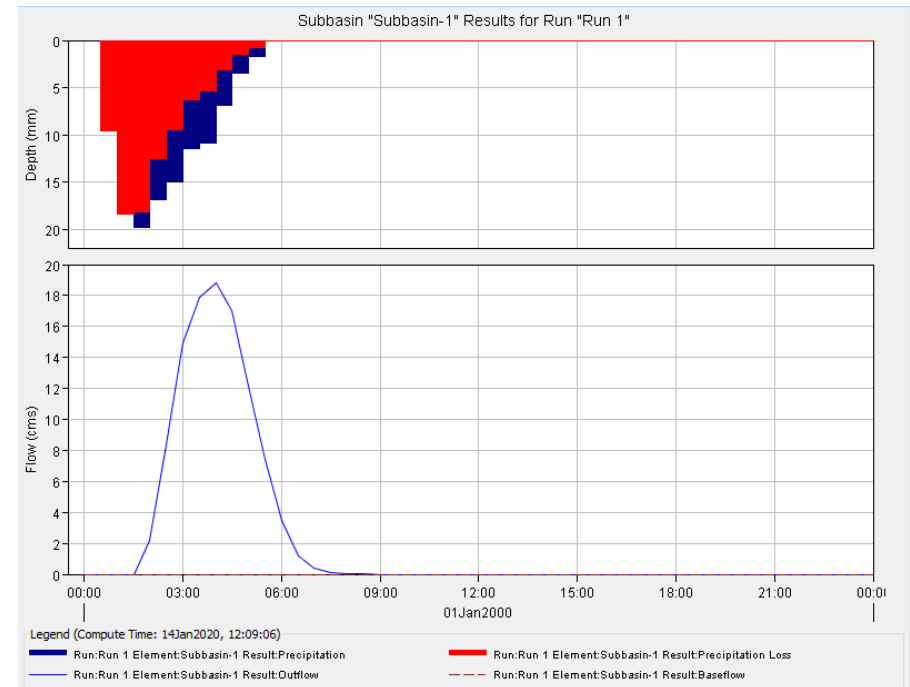
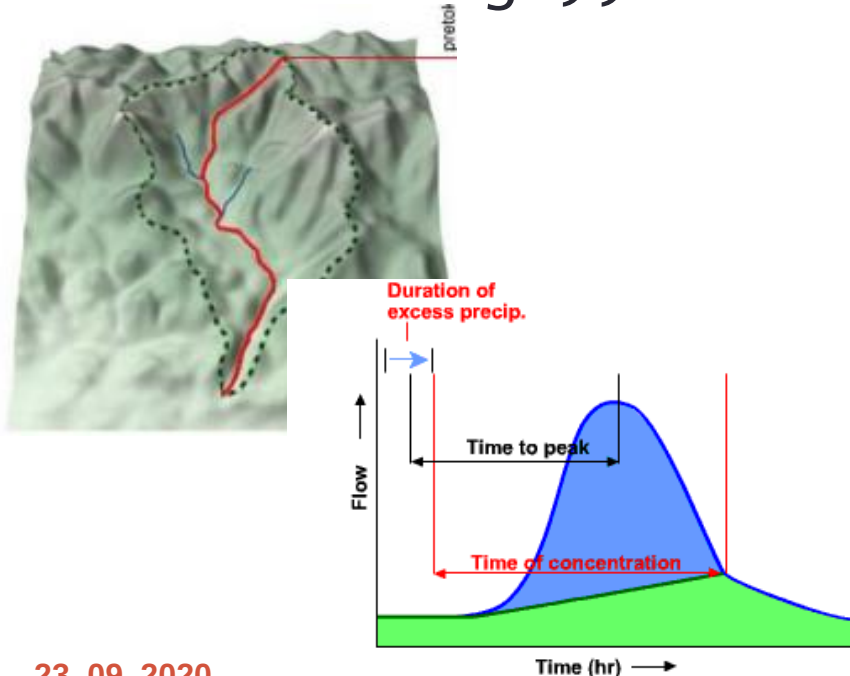
- In case that measured discharge data is available, model should be calibrated.
- There are multiple methods available for the design rainfall event definition.



HEC-HMS

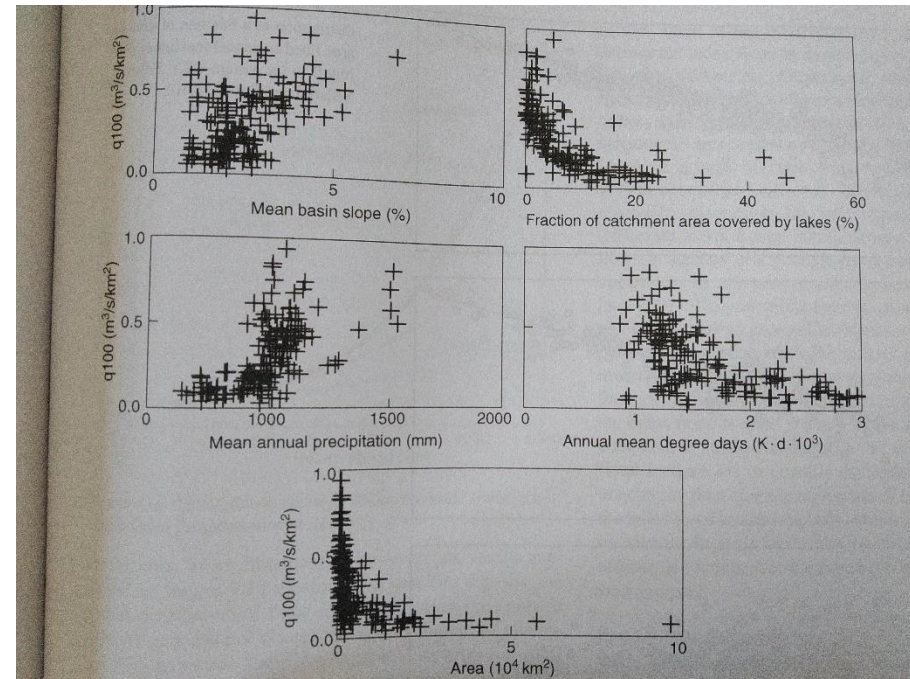
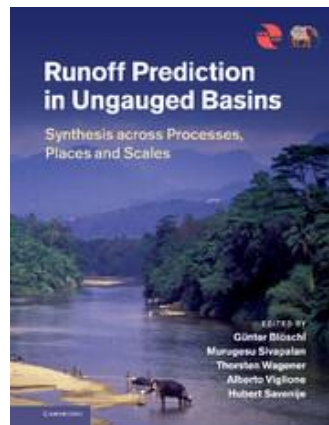


- Return period is usually determined based on modelling purpose (e.g., culvert should be able to convey 100-years flood -> national laws and rules (e.g., Rules on road design)).



ALTERNATIVE APPROACHES

- One should note that presented approach is relatively simple and that more sophisticated methods can be used for the design discharge definition in case of ungauged catchments (e.g., regression methods, index flood methods).
- Mostly similarity is used.



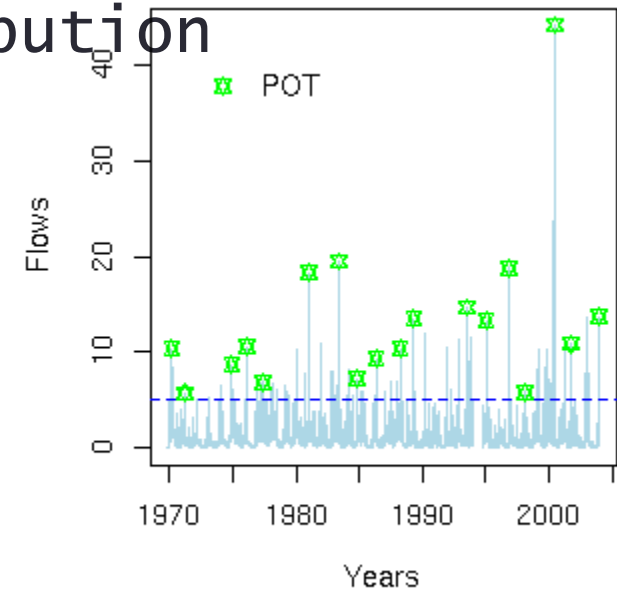
GAUGED CATCHMENTS

- More accurate or less uncertain design discharge estimations can be made in case that measured discharge data is available.



GAUGED CATCHMENTS

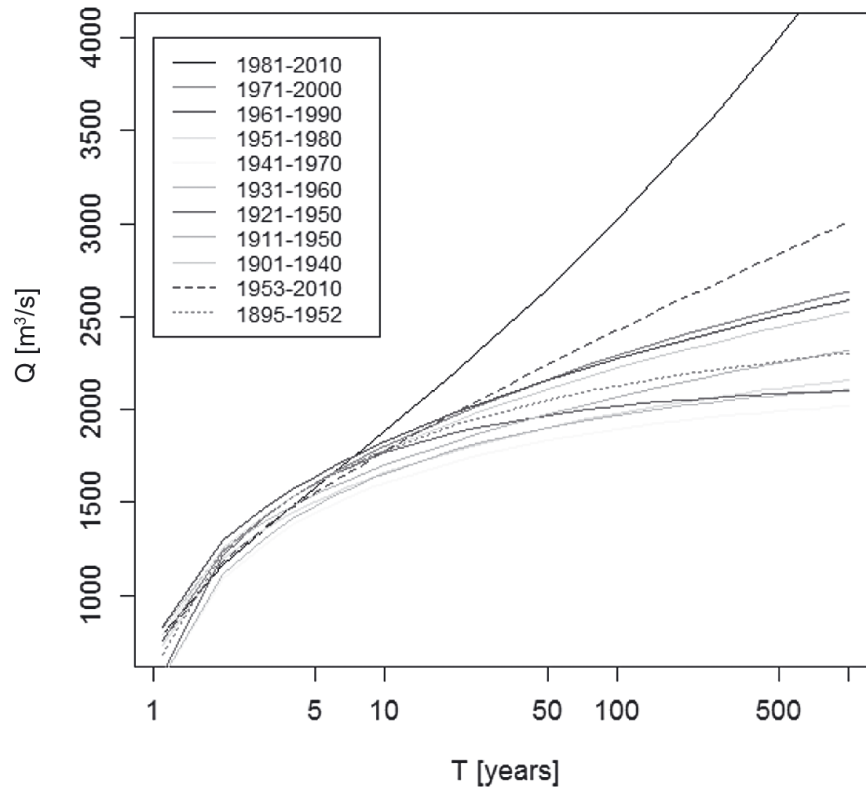
- Flood frequency analysis is preferred option.
- First step is sample definition where one can use either annual maximum method or peaks over threshold method.
- In the second step distribution parameters are estimated.



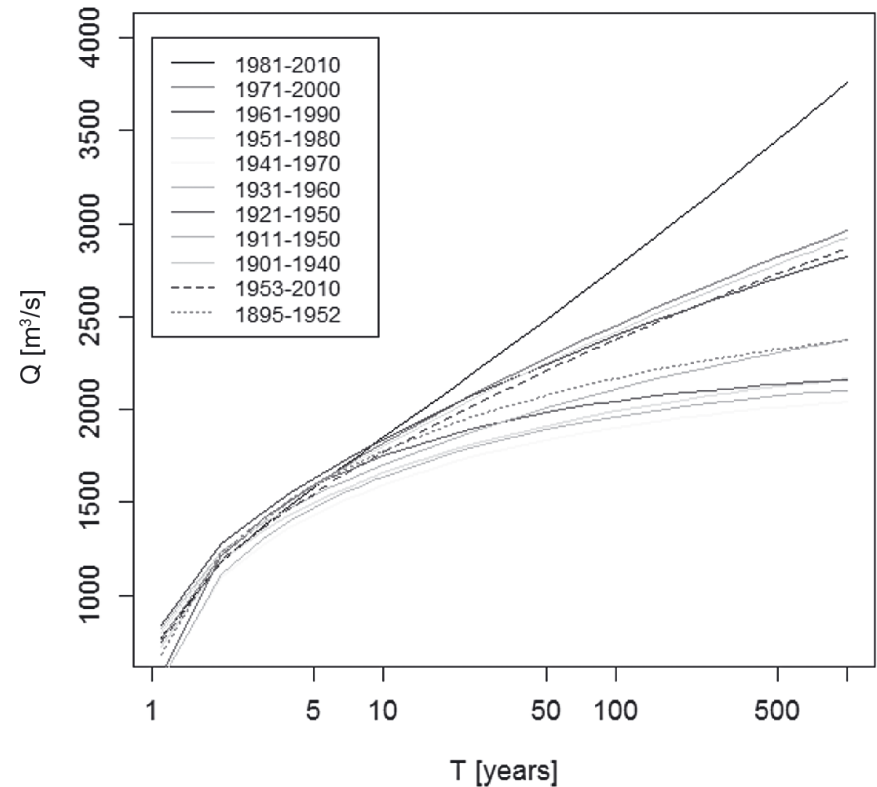
GAUGED CATCHMENTS

- Different distributions and parameter estimation techniques are available:

Log-Pearson 3

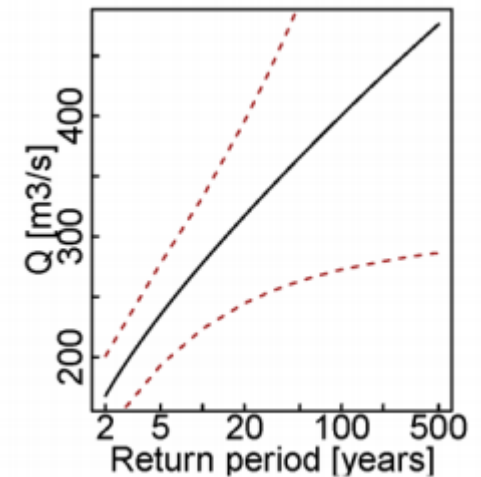
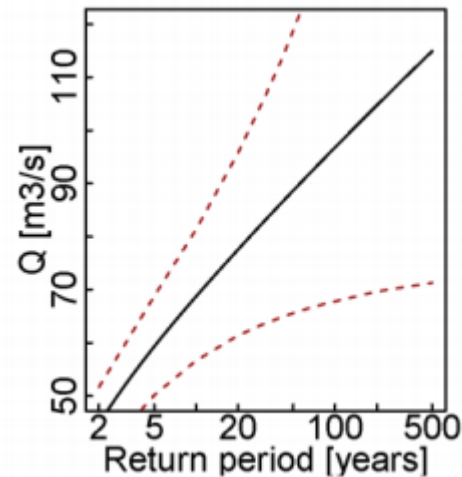


GEV



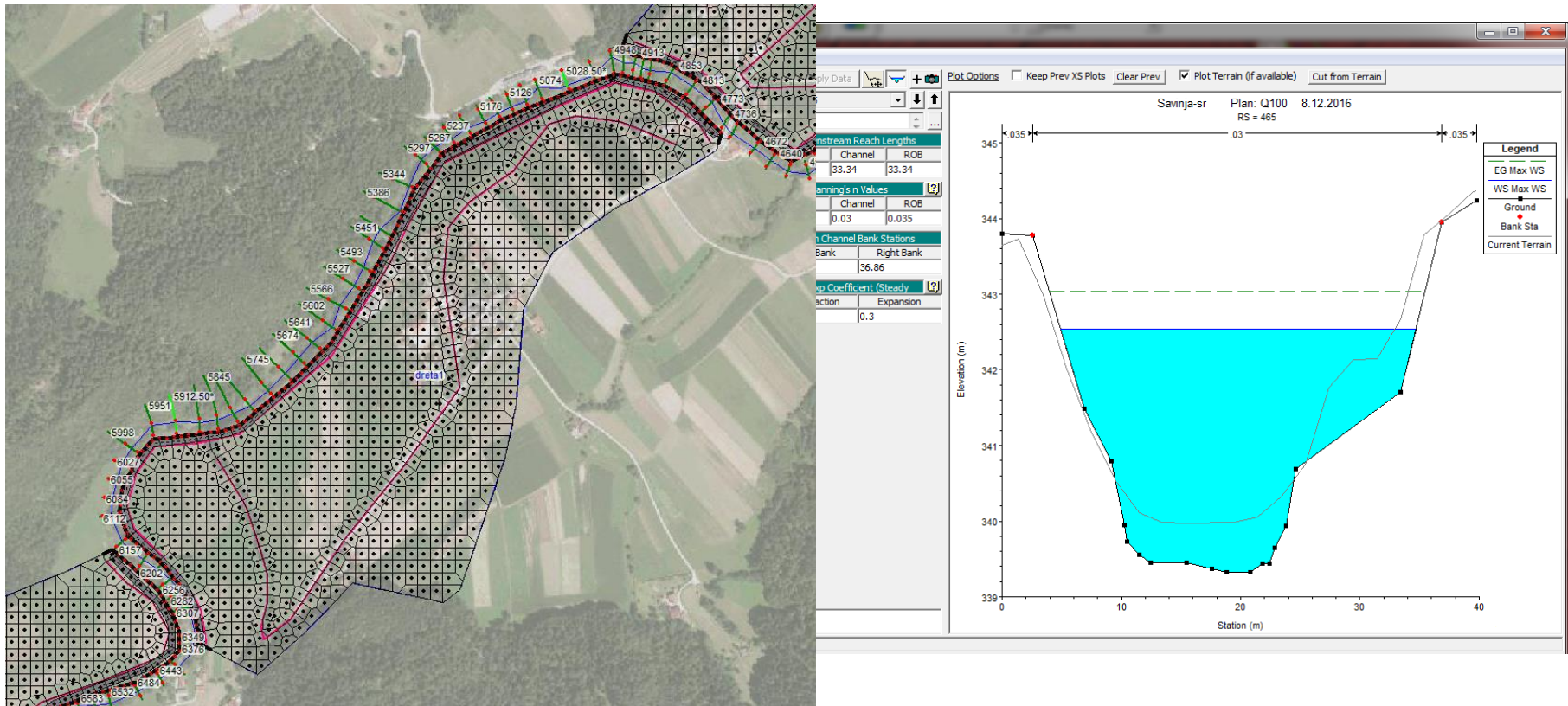
GAUGED CATCHMENTS

- Consideration of confidence intervals is needed:



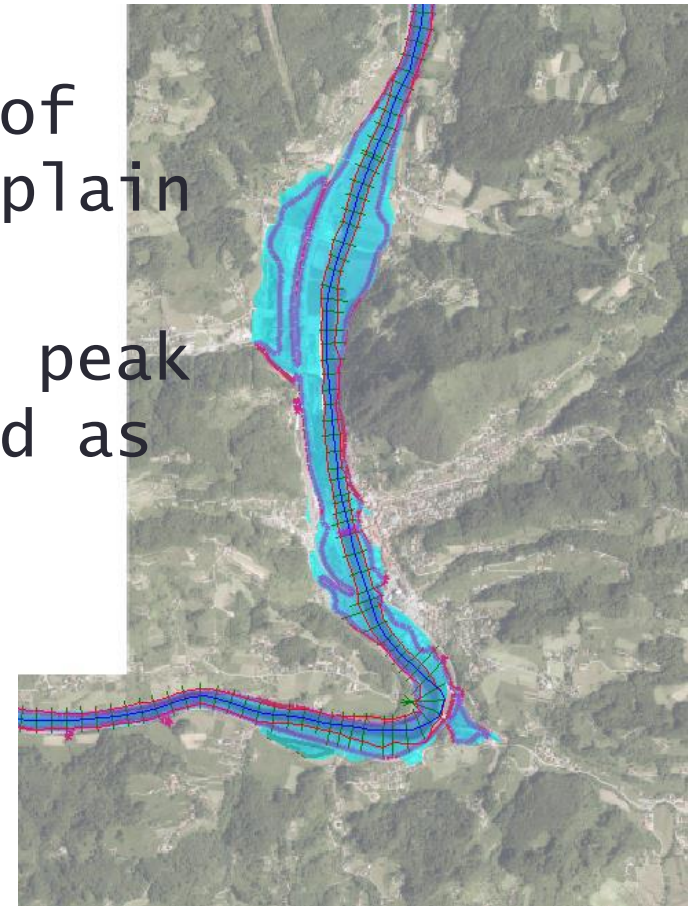
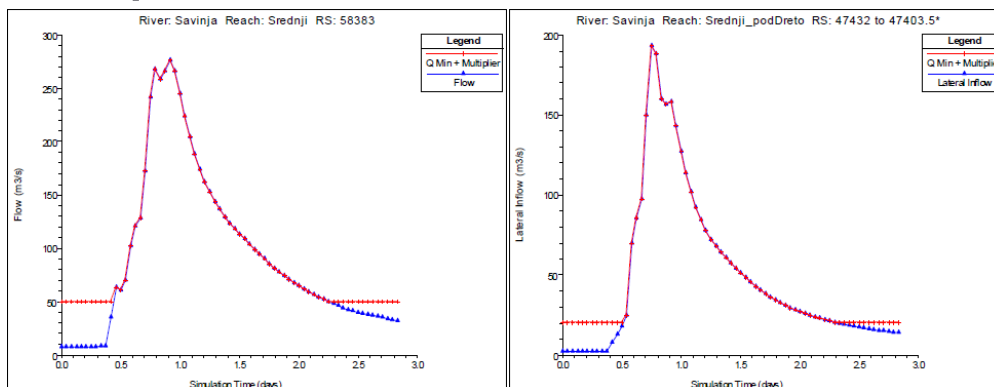
HYDRAULIC MODELLING

- Again multiple models are available, one most frequently applied is the HEC-RAS



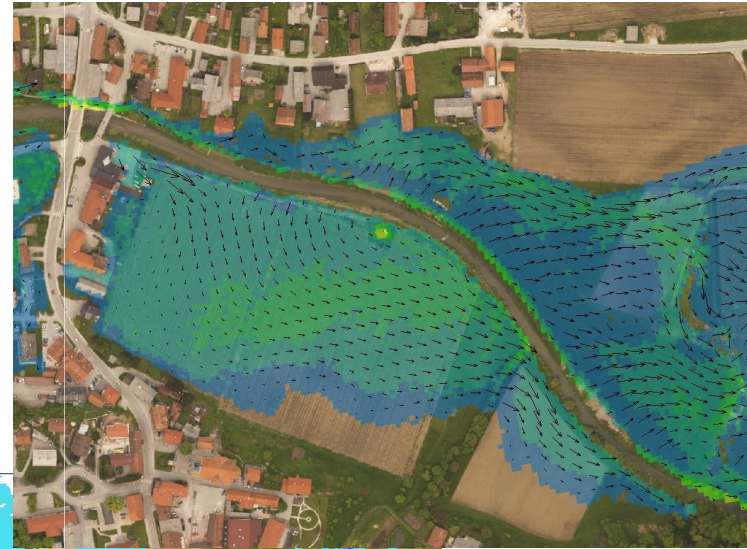
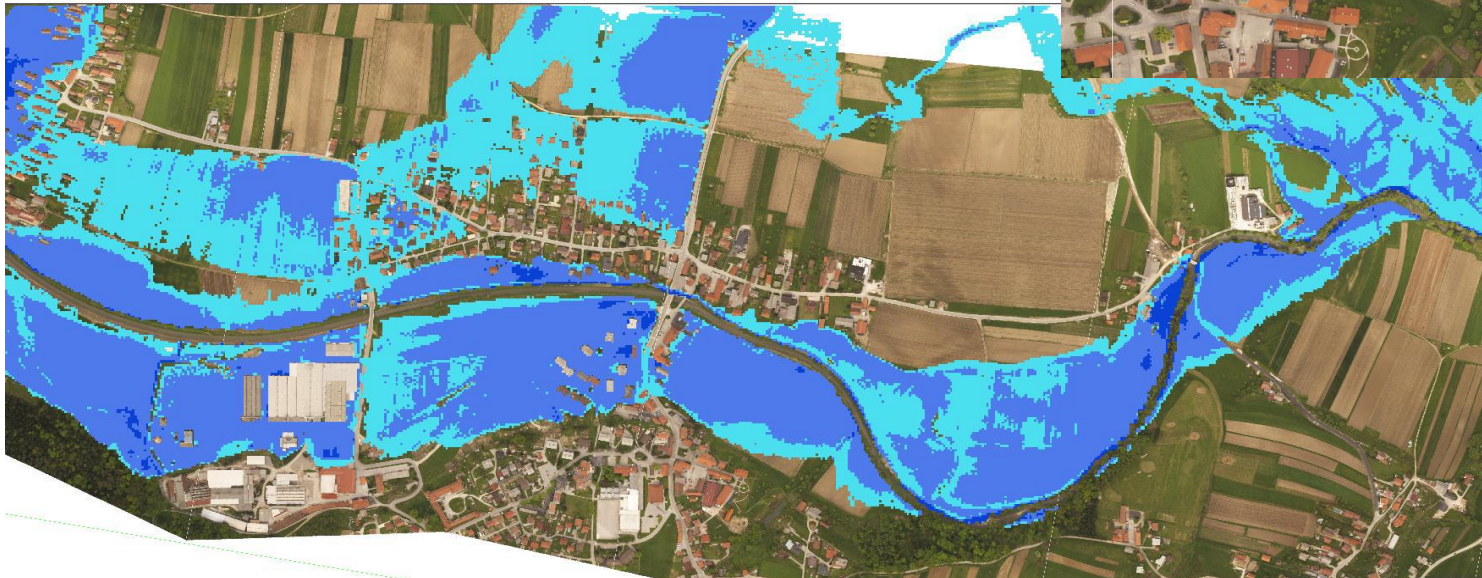
HYDRAULIC MODELLING

- The main parameter that should also be calibrated using measured data is roughness of the cross-section and floodplain areas.
- Either entire hydrograph or peak discharge values is provided as input to the model.



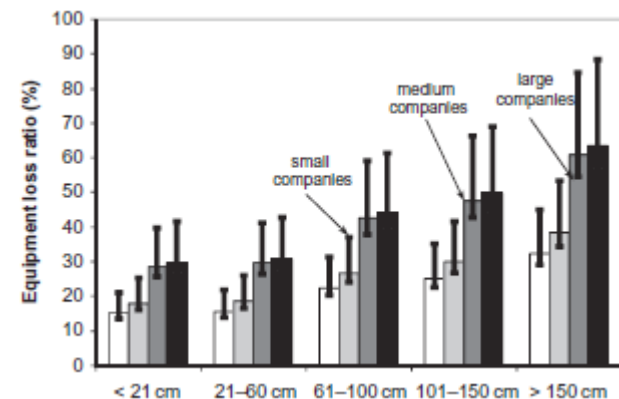
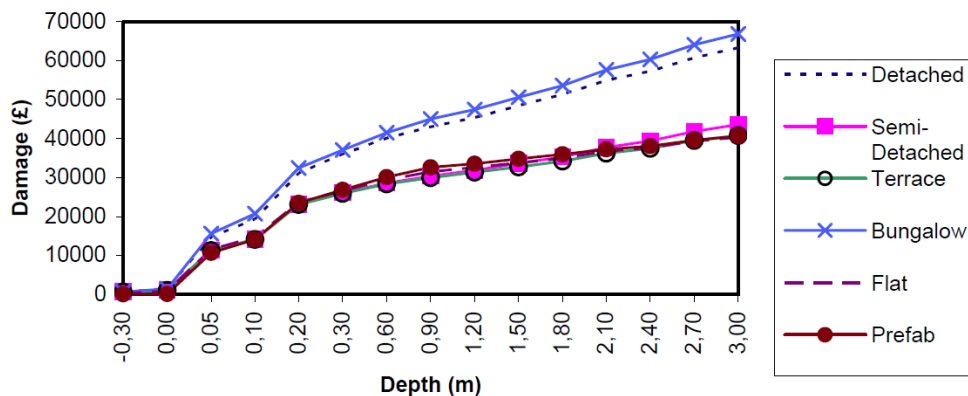
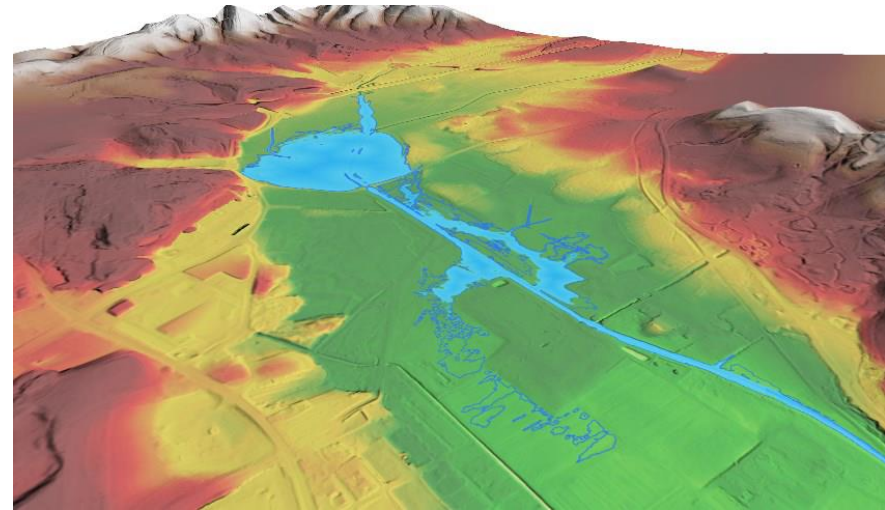
HYDRAULIC MODELLING

- Different results can be obtained based on the combined hydrological-hydraulic modelling approach such as flood maps.



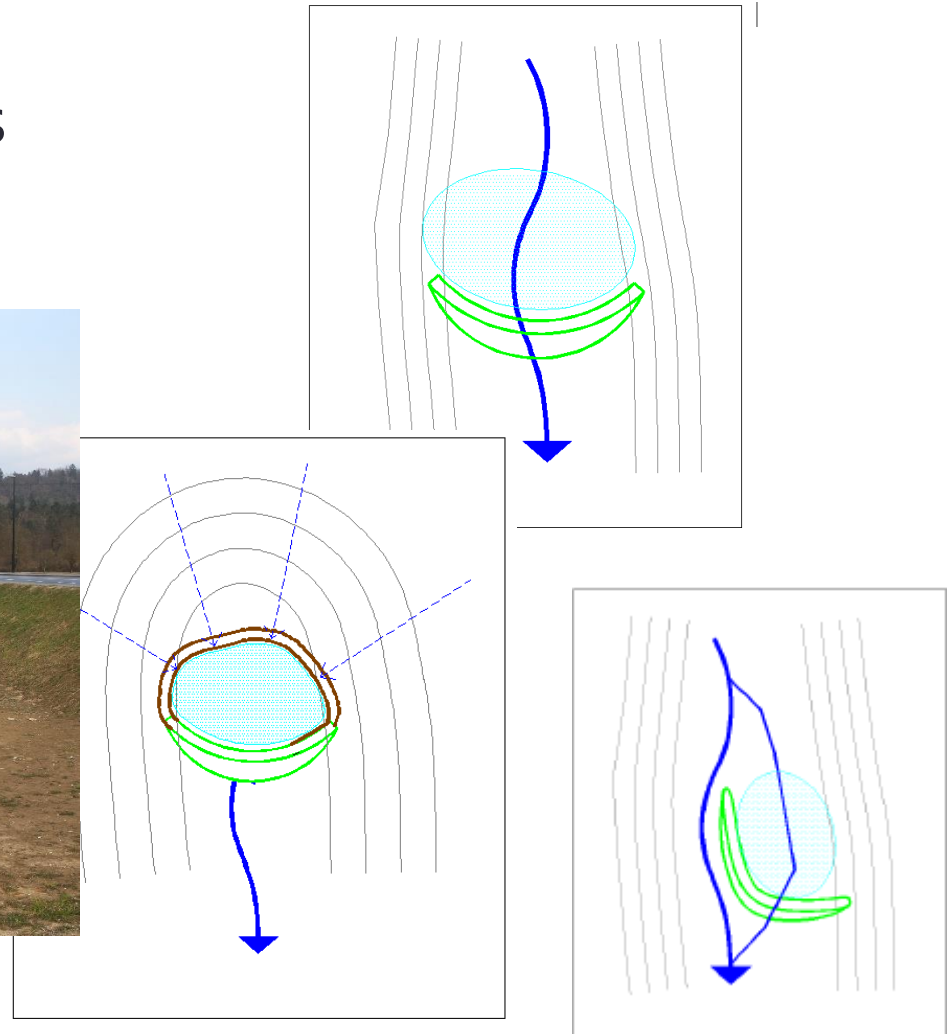
FLOOD DAMAGE MODELLING

- Flood depth and extent is then used as input to the flood damage model.



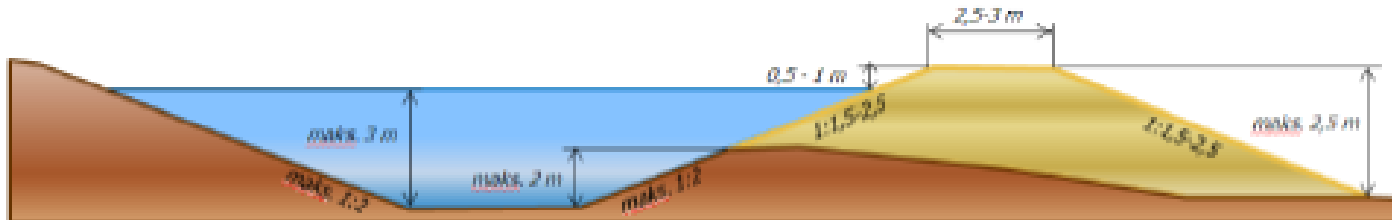
DRY-RESERVOIRS

- Different positions are possible.



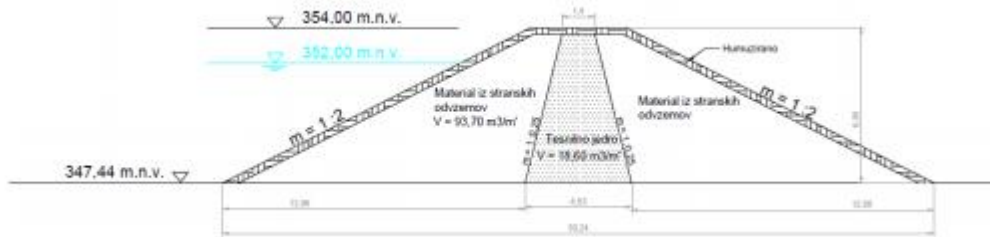
DRY-RESERVOIRS

- Multiple technical characteristics should be considered during the design such as maximum height (up to. Approx. 2.5m), slope (at least 1:2.5), grass should be planted on banks, top of the levee should be at least 2.5–3m, cutoff wall should be correctly positioned, etc.



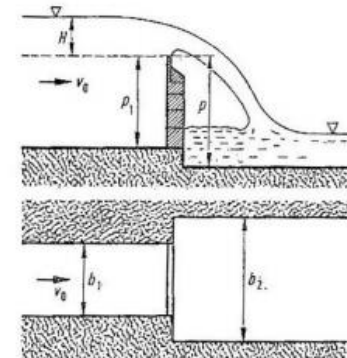
DRY-RESERVOIRS

- Moreover, safety freeboard should be considered, in some cases emergency spillway and outlet should be included.



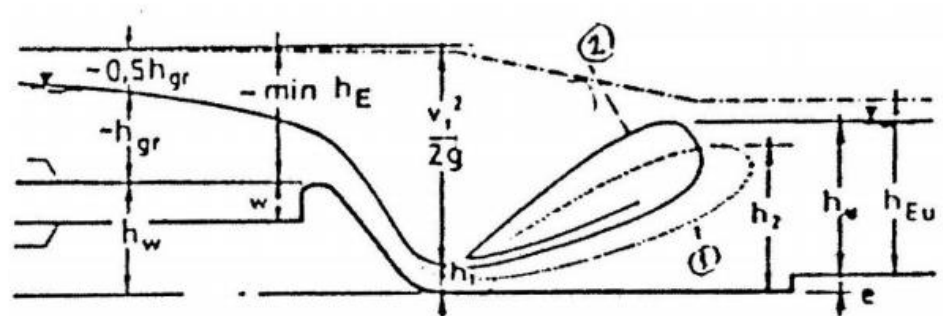
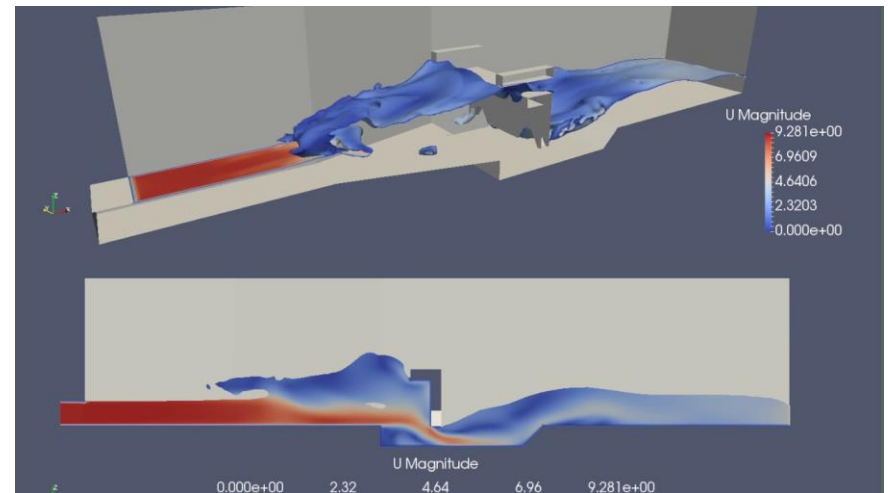
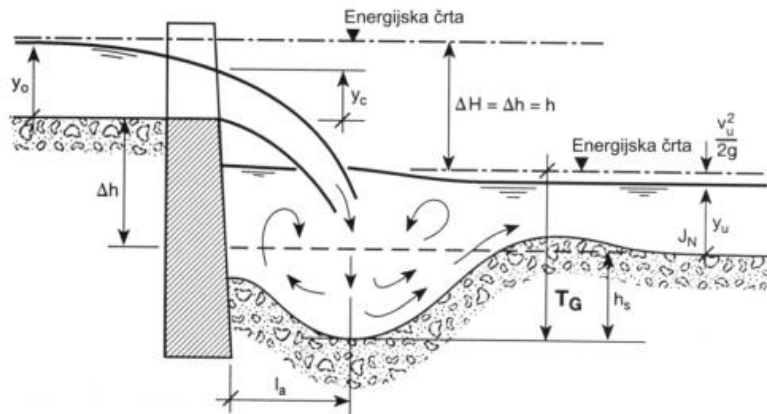
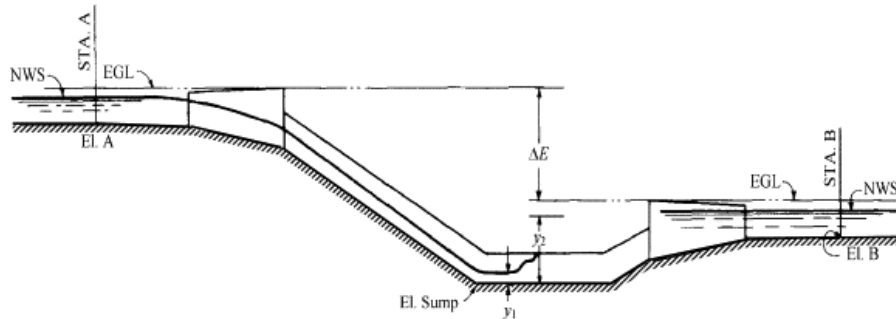
Flow profile under a nappe profile (e.g. Goring, 1970):

$$Q = m_0 \times \sqrt{2g} \times b \times H^{2/3} \quad (2.1)$$



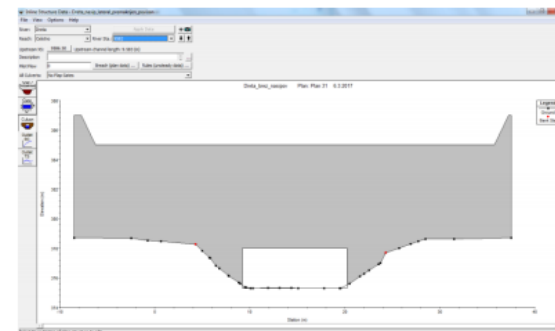
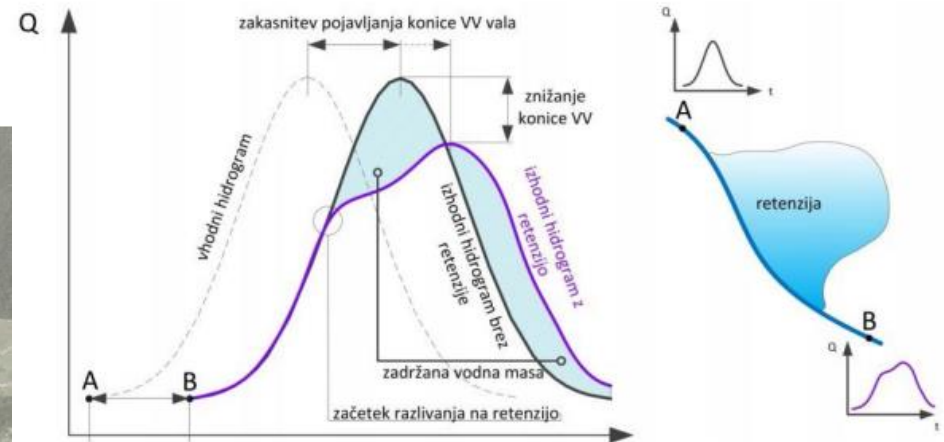
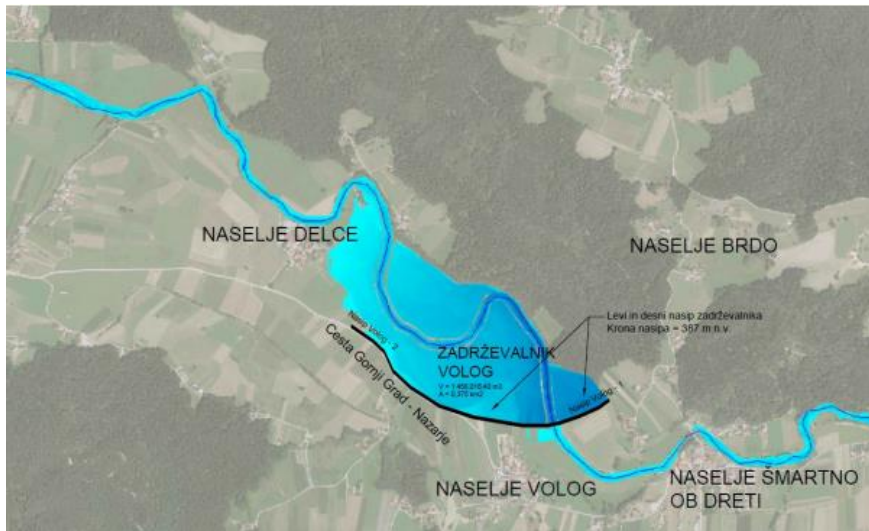
DRY-RESERVOIRS

- Moreover, stilling basin should also be designed.



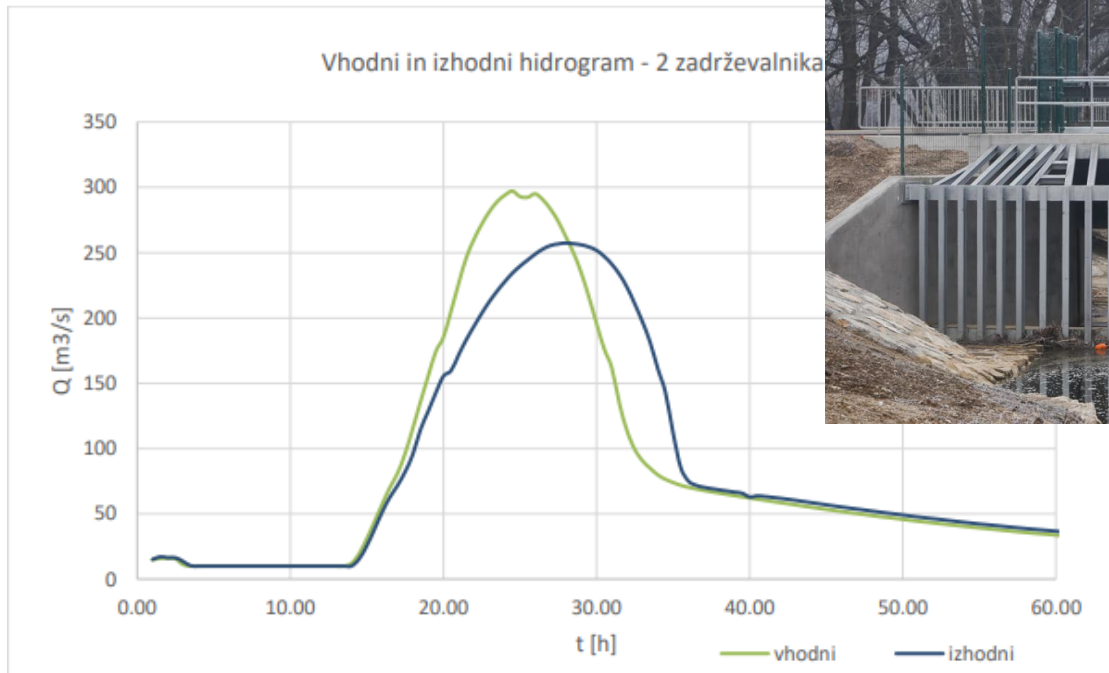
DRY-RESERVOIRS

- Optimal location and impact on the flood safety should be estimated using calibrated models.



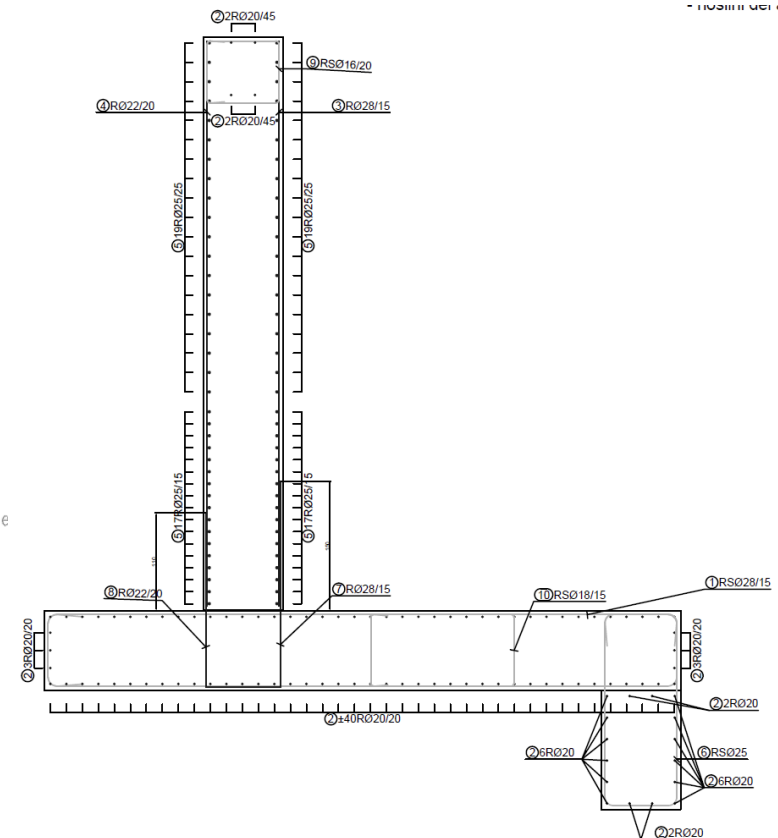
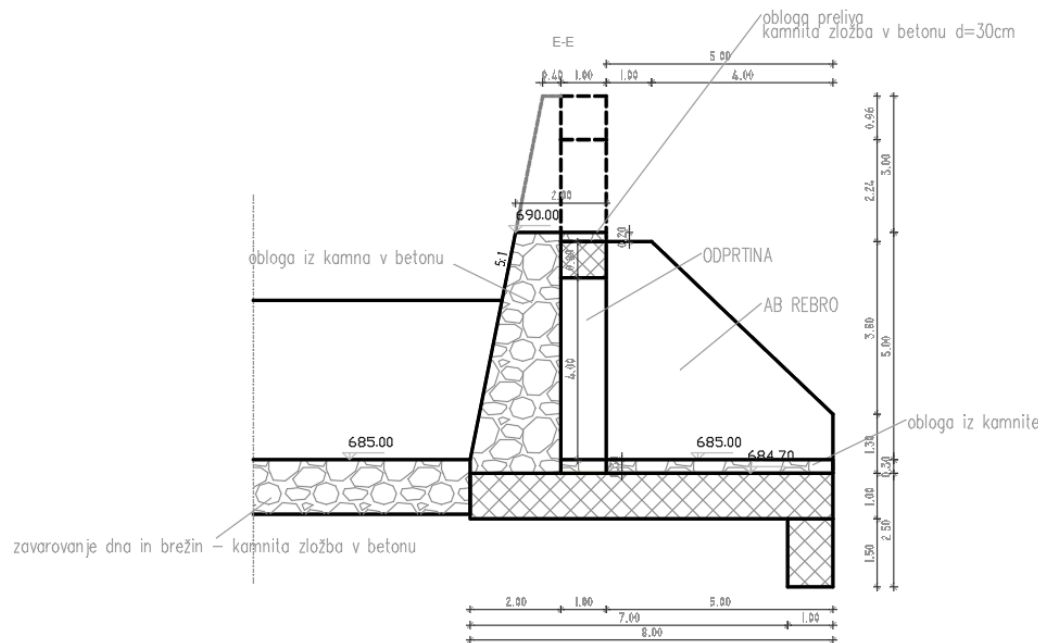
DRY-RESERVOIRS

- Attention should be given to special aspects with respect to local conditions (coarse screen design).



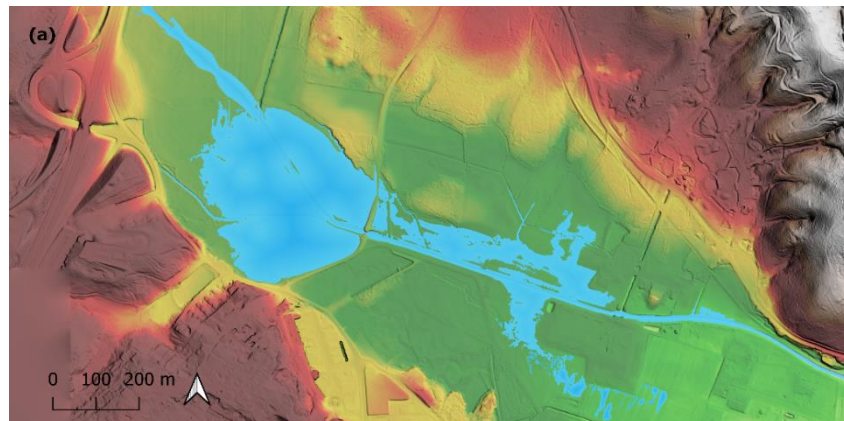
DRY-RESERVOIRS

- Another point that goes beyond the hydro-technical aspects is the stability of the objects.



AFFORESTATION

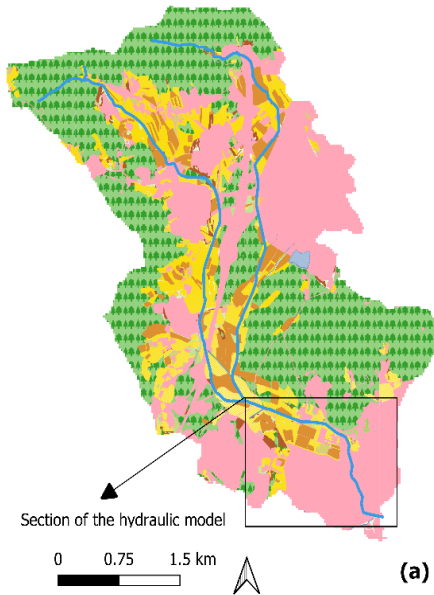
- Case study of the Glinščica River catchment will be presented in the book chapter edited by C. Ferreira: Nature-Based Solutions for Flood Mitigation: Environmental and Socio-Economic Aspects. Chapter title: Modeling and evaluation of the effect of afforestation on the runoff generation within the Glinščica river catchment (Central Slovenia): https://link.springer.com/chapter/10.1007/698_2020_649.



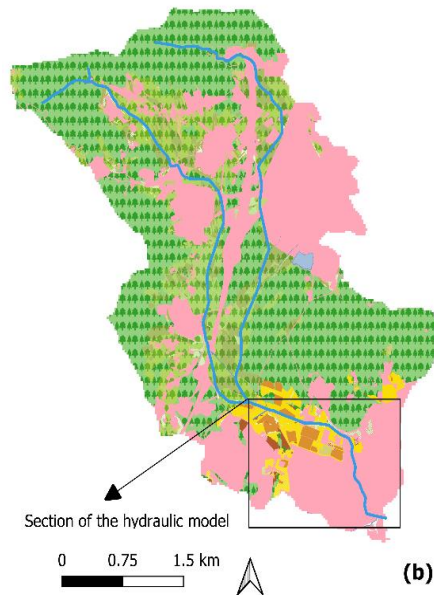
AFFORESTATION

- Different scenarios were considered:

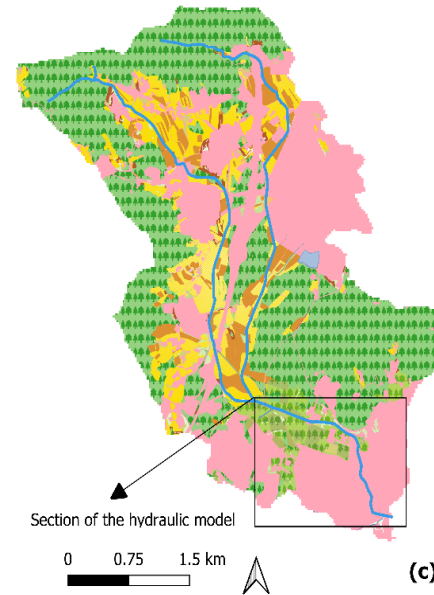
Baseline scenario: "Current land use"



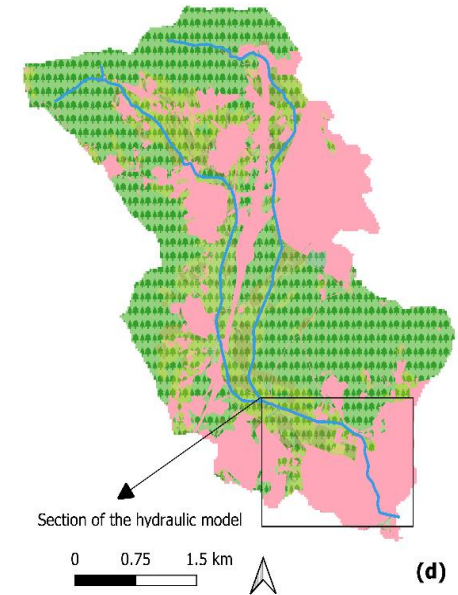
Land use scenario 1: "Afforestation upstream"



Land use scenario 2: "Afforestation downstream"

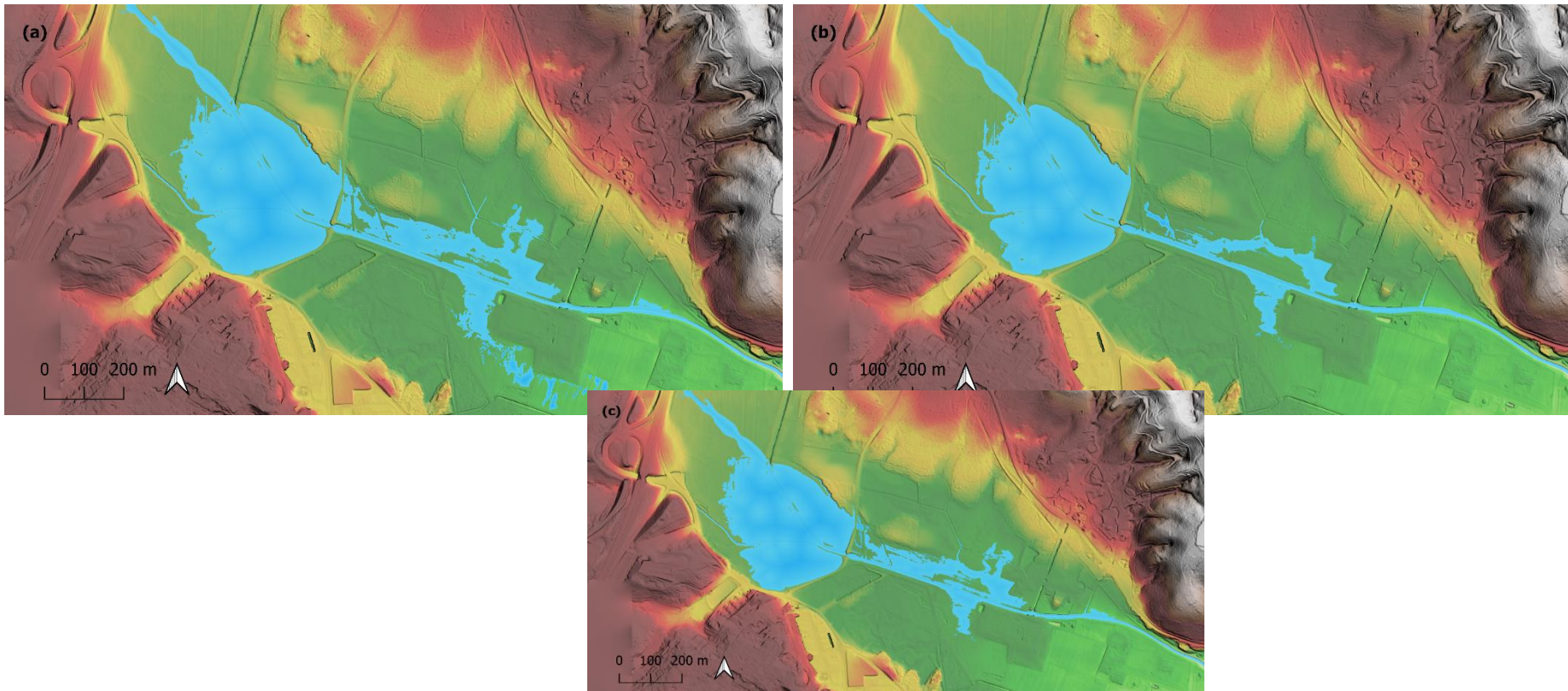


Land use scenario 3: "Afforestation everywhere"



AFFORESTATION

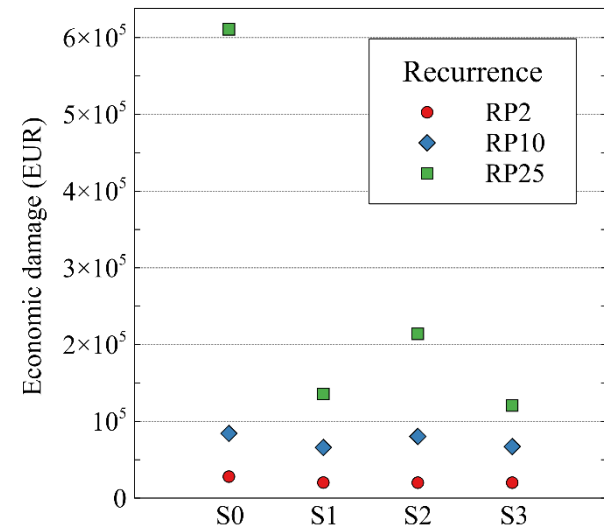
- Comparison between the inundation boundaries for the scenarios “Current land use” (a), “Afforestation upstream” (b), and “Afforestation downstream” (c) for the 10-year return period:



AFFORESTATION

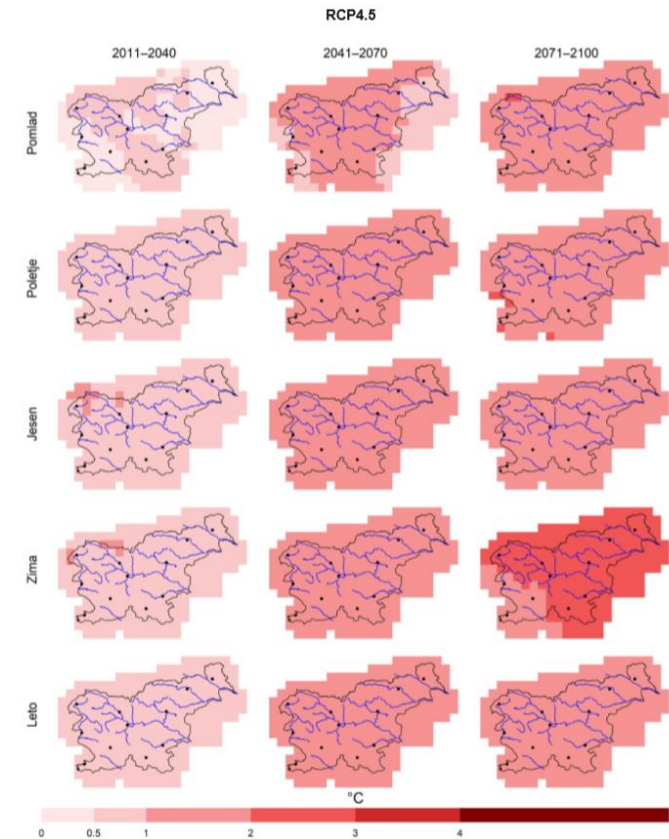
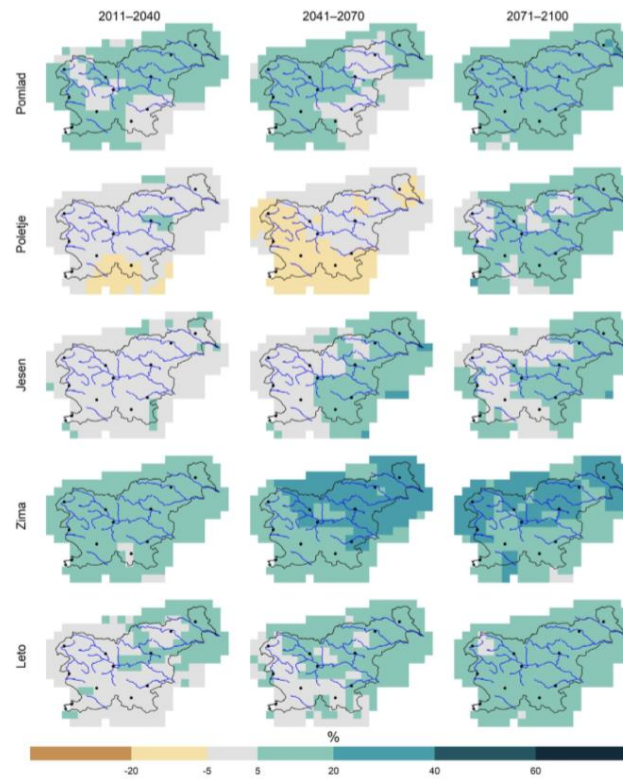
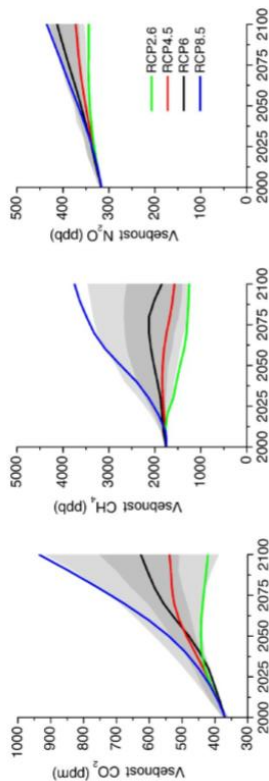
- Economic damage in EUR for different afforestation scenarios under changing probability of flooding (RP: return period). S0 (“Current land use”), S1 (“Afforestation upstream”), S2 (“Afforestation downstream”), S3 (“Afforestation everywhere”).

	“Afforestation upstream”,	“Afforestation downstream”,	“Afforestation everywhere”,
Costs	€ 15,525,924	€ 4,868,351	€ 20,394,275
NPV	€ -2,836,497.85	€ 4,184,035.48	€ -6,124,130.82
IRR	3.28%	7.72%	2.59%
B/C	0.84	1.89	0.69



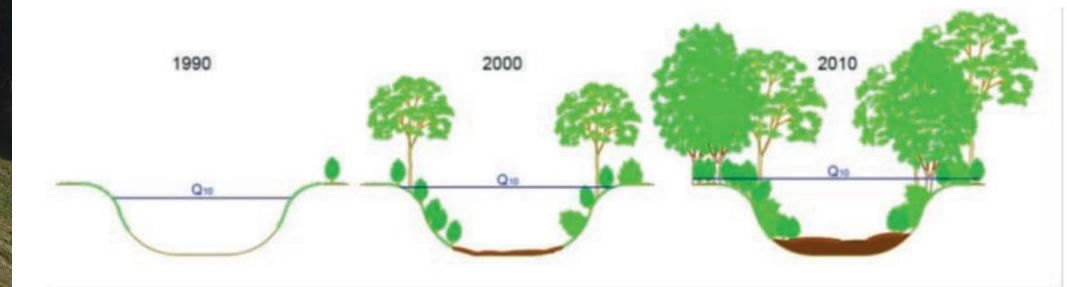
ADDITIONAL ASPECTS

- In some cases consideration of the climate change also needs to be considered in the design process.



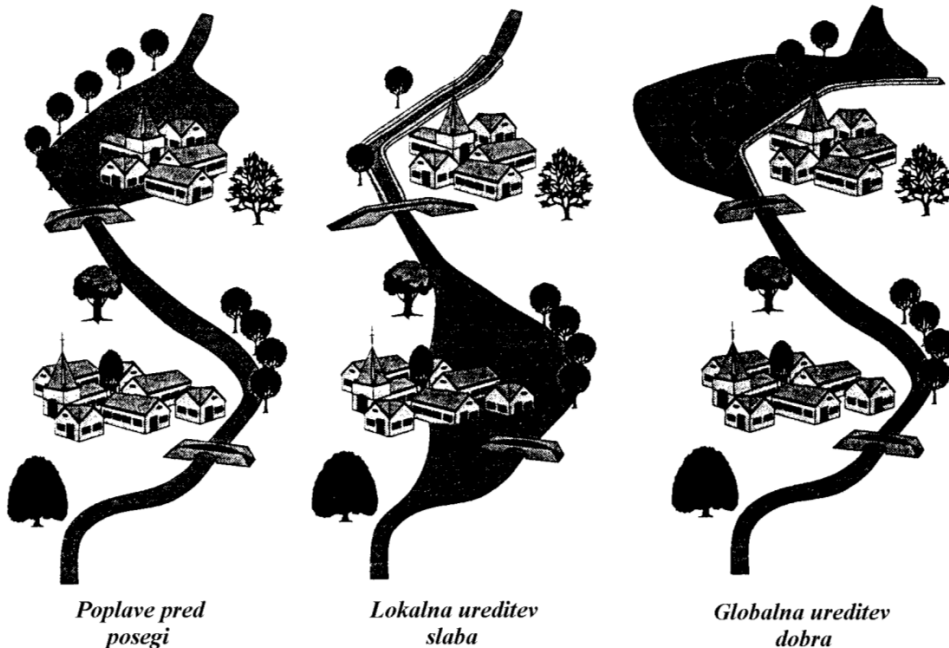
CONCLUSIONS

- Multiple options are available for the flood safety improvements ranging from typical gray measures such as levees to combined gray-green measures such as dry-reservoirs to completely green measures.



CONCLUSIONS

- One should always keep in mind models drawbacks and limitations.
- A. Einstein: „Everything should be made as simple as possible, but no simpler“.



CONCLUSIONS

- We (people) should be aware of the water power and where the natural floodplains are.



Slika 4: Avstrijska vojaška karta iz obdobja 1764-1771



Slika 5: Avstrijska vojaška karta iz obdobja 1821-1836. Potek struge pri Celju.



QUESTIONS?



 Home

Questions

Jobs



Nejc Bezak

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