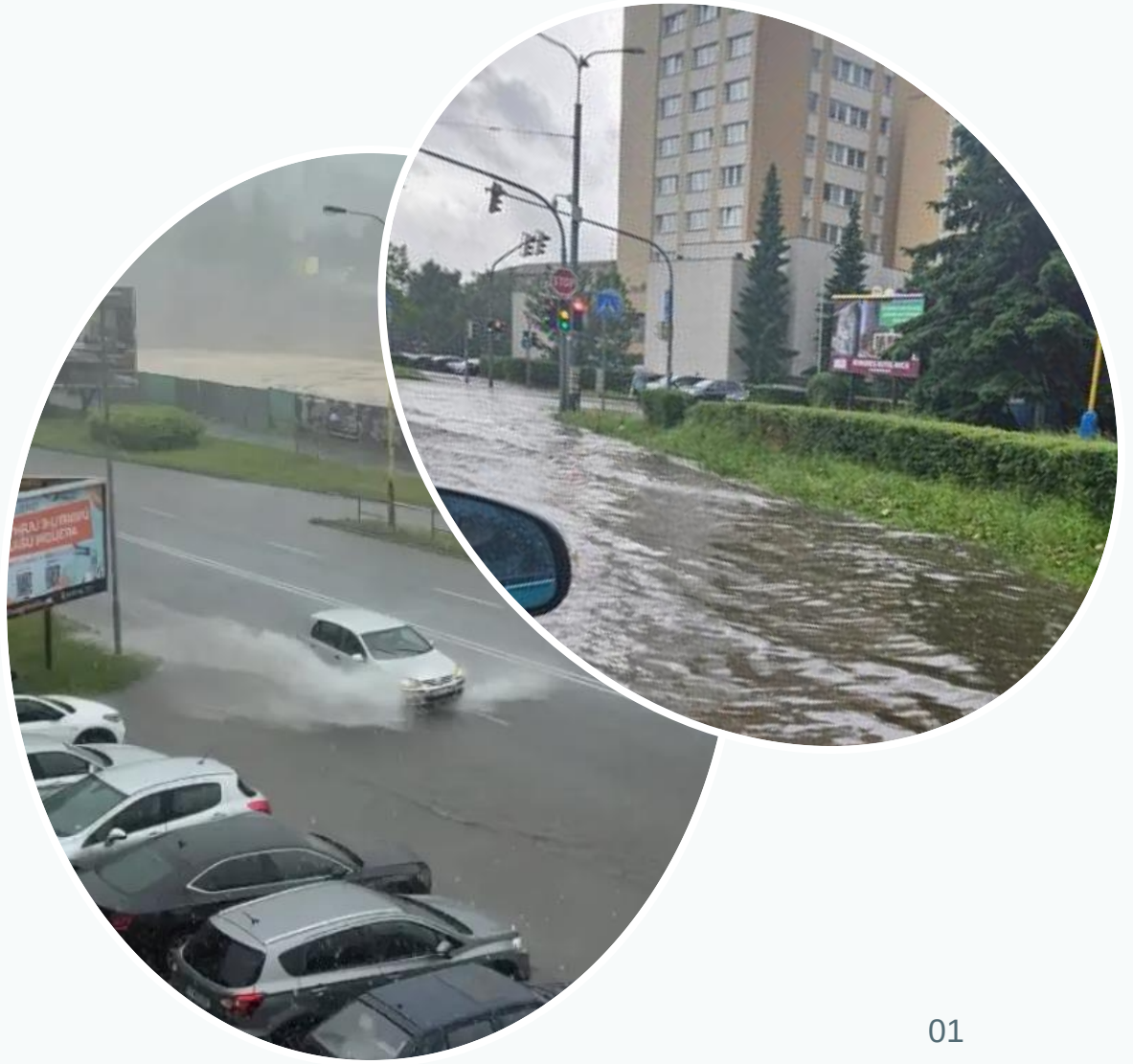
#AquaUrban Project: Innovative water retention solutions for improved quality of life in cities of Košice and Nyíregyháza

Closing event Nyíregyháza, 16 October 2026

Simulations of flash floods in Košice as a tool to support the city's adaptation measures



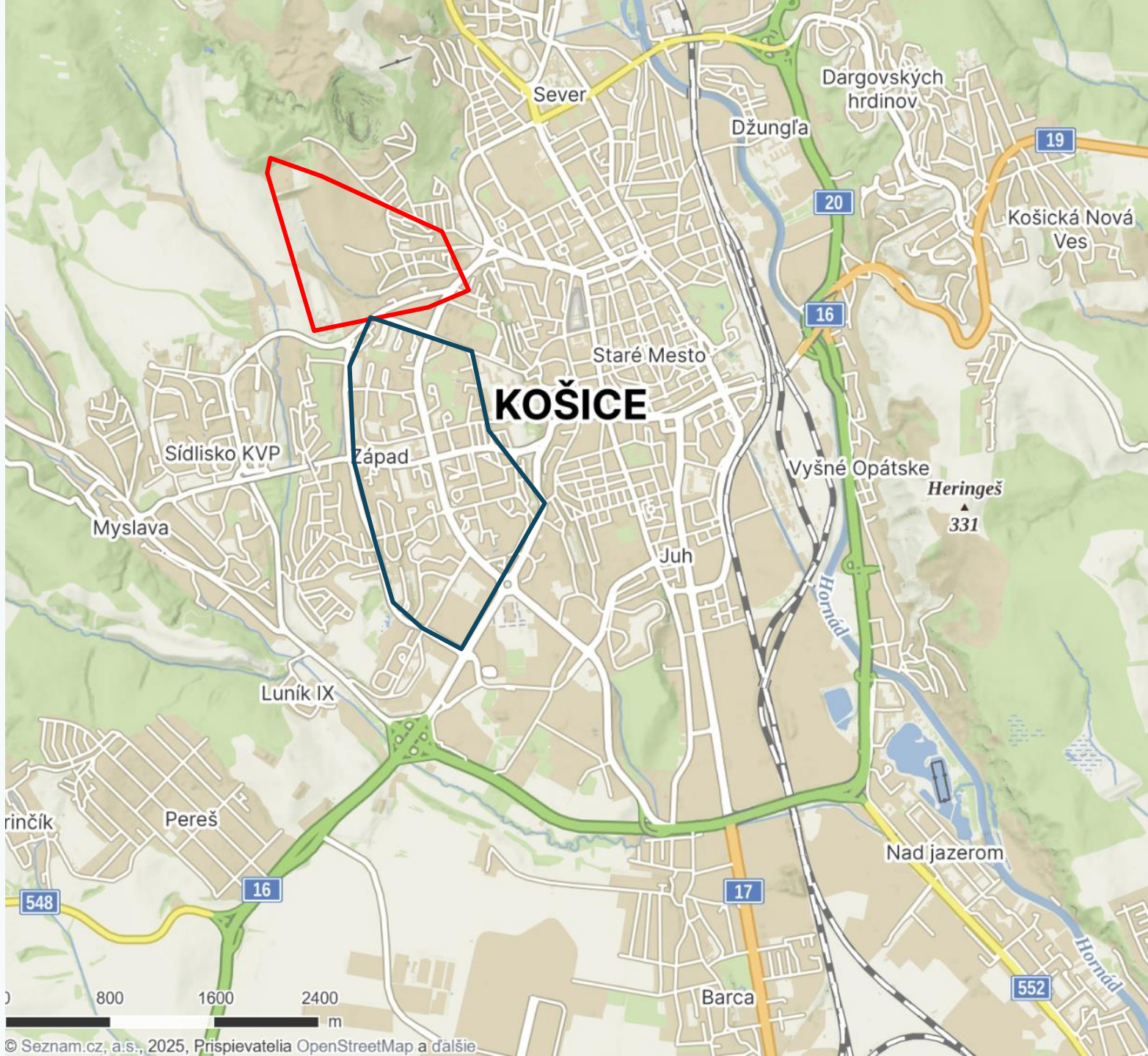
Michal Gallay, Jozef Šupinský, Ján Šašak, Petra Dávidová

Institute of Geography, Faculty of Science

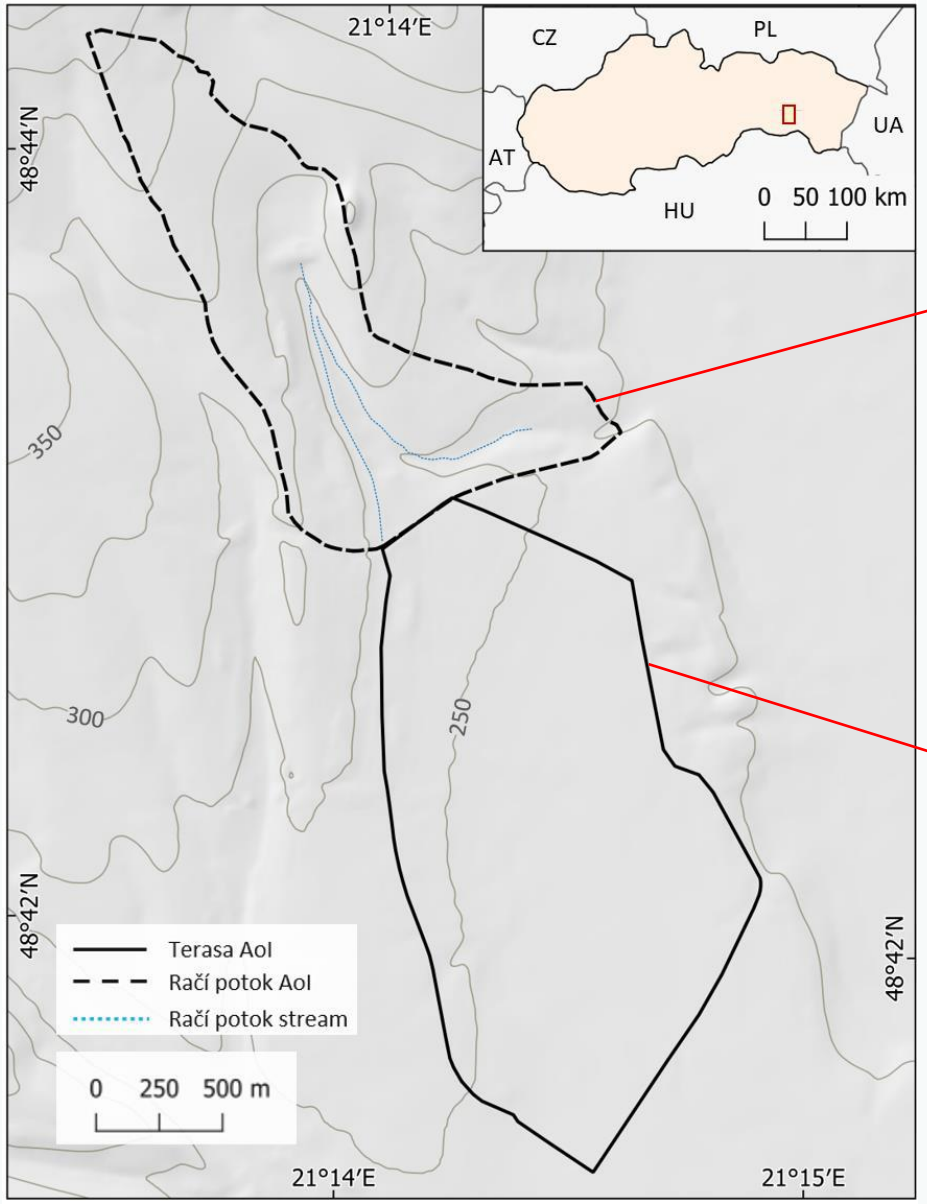
Pavol Jozef Šafárik University in Košice (UPJŠ)

KOŠICE

Two case study areas



Two landscapes, different flood behaviour





- Runoff concentrates along a valley
- Ponds, dams and culverts control its route
- Garages and an access road are exposed



- Water accumulates in local depressions
- Drain inlets remove surface runoff
- Roads and public spaces are exposed

Račí potok: Why revitalise this area

- **Natural flood buffer**: ~2 km² catchment (Bankov slopes) funnels storms; without retention, flash flows threaten nearby homes/garages.
- **Degraded infrastructure**: Silted ponds, over-large outlets, and poor structures drain too fast and degrade habitat.
- **Ecology & microclimate**: Wetland restoration boosts biodiversity, cools air, cuts dust, and improves soil moisture - key blue-green infrastructure.
- **Social & planning value**: Potential nature-based city park with education/trails; guides zoning to avoid flood-prone development.











Which intervention will protect this place?



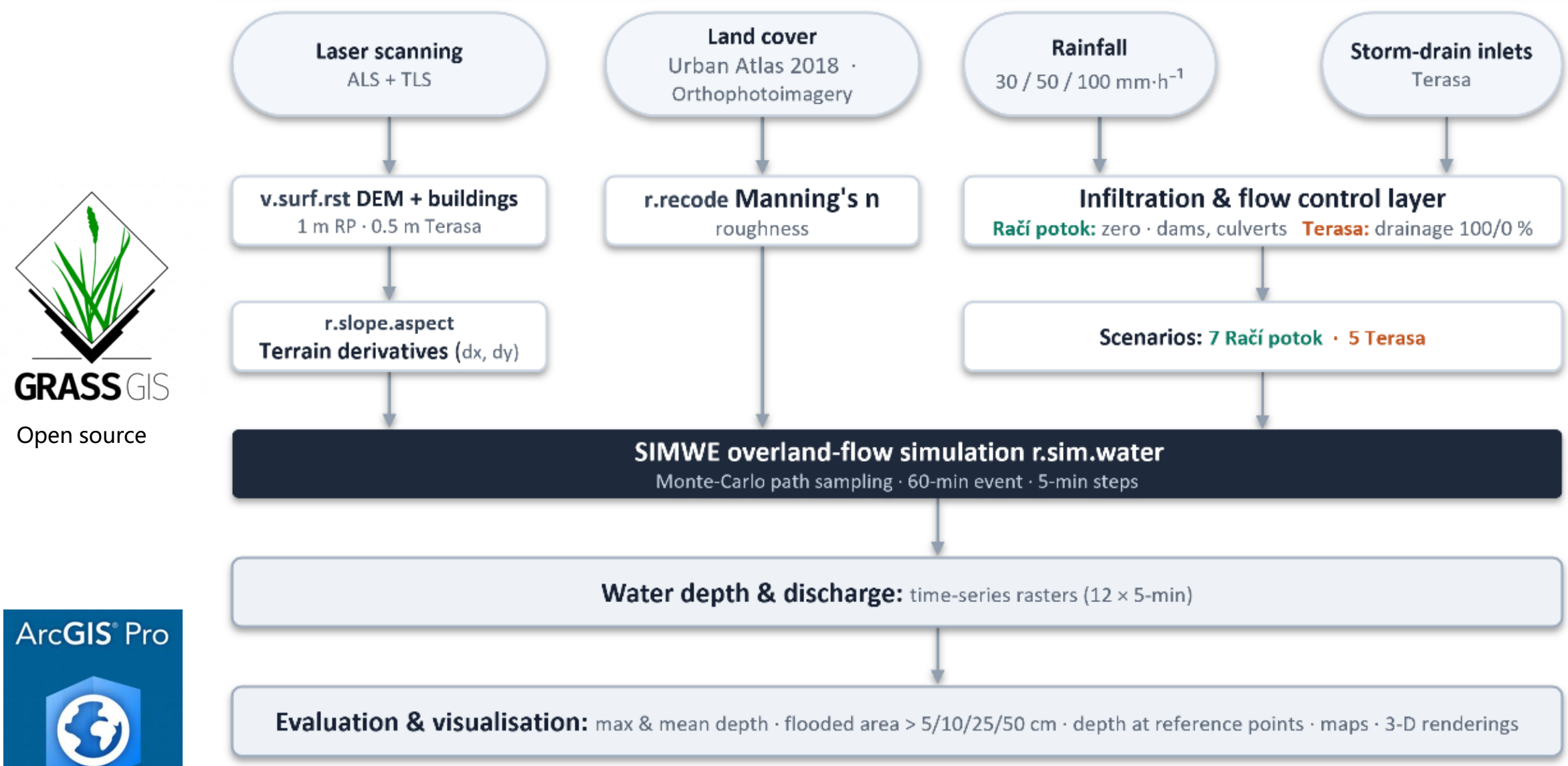
Račí potok: access road near the exposed garages

Restore upstream ponds?

Improve culverts?

Add local drainage?

Workflow of the flash-flood simulation



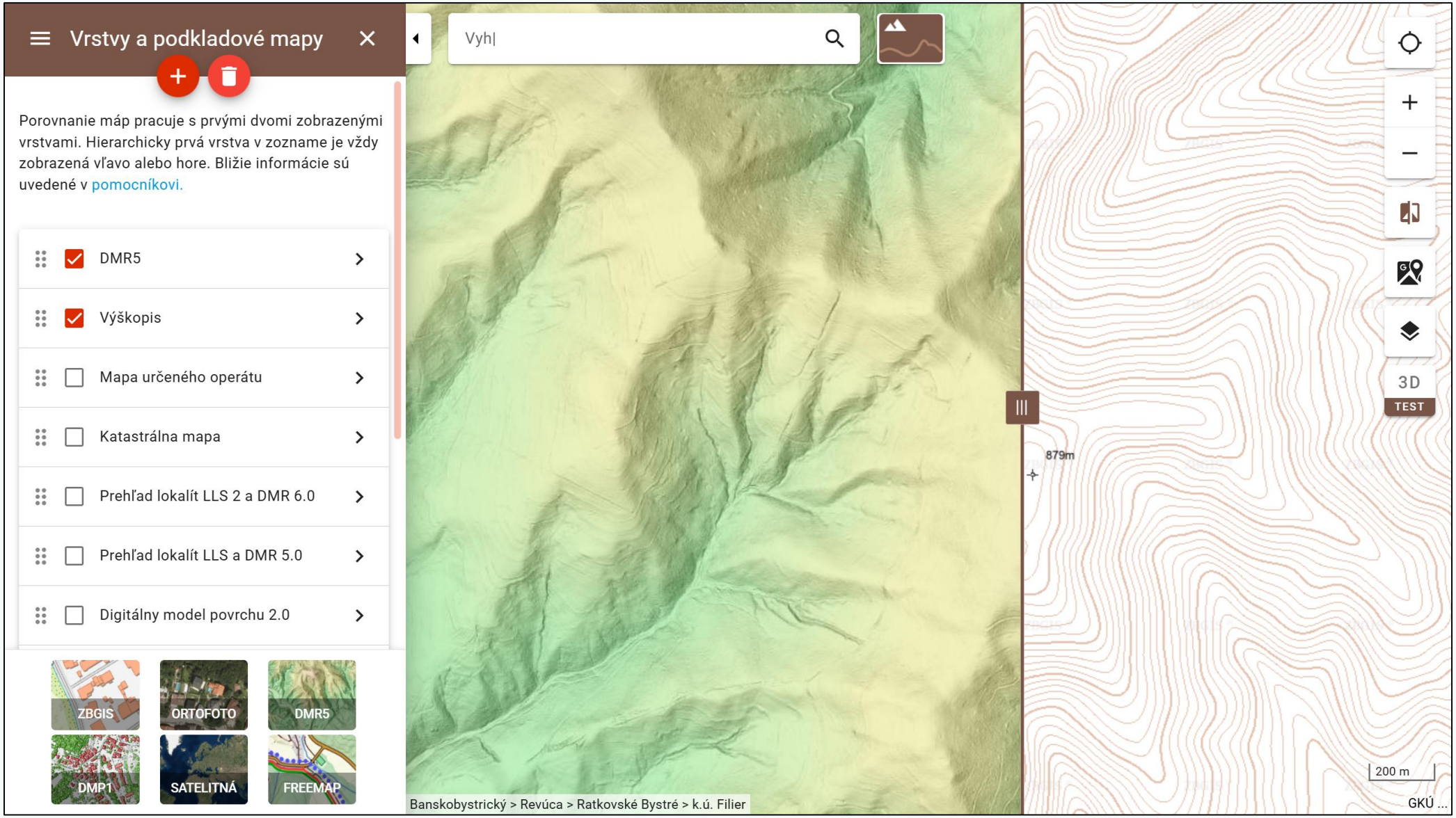
GRASS GIS

Open source

ArcGIS® Pro

Highly detailed LiDAR terrain model of Slovakia enables detialed flood modelling

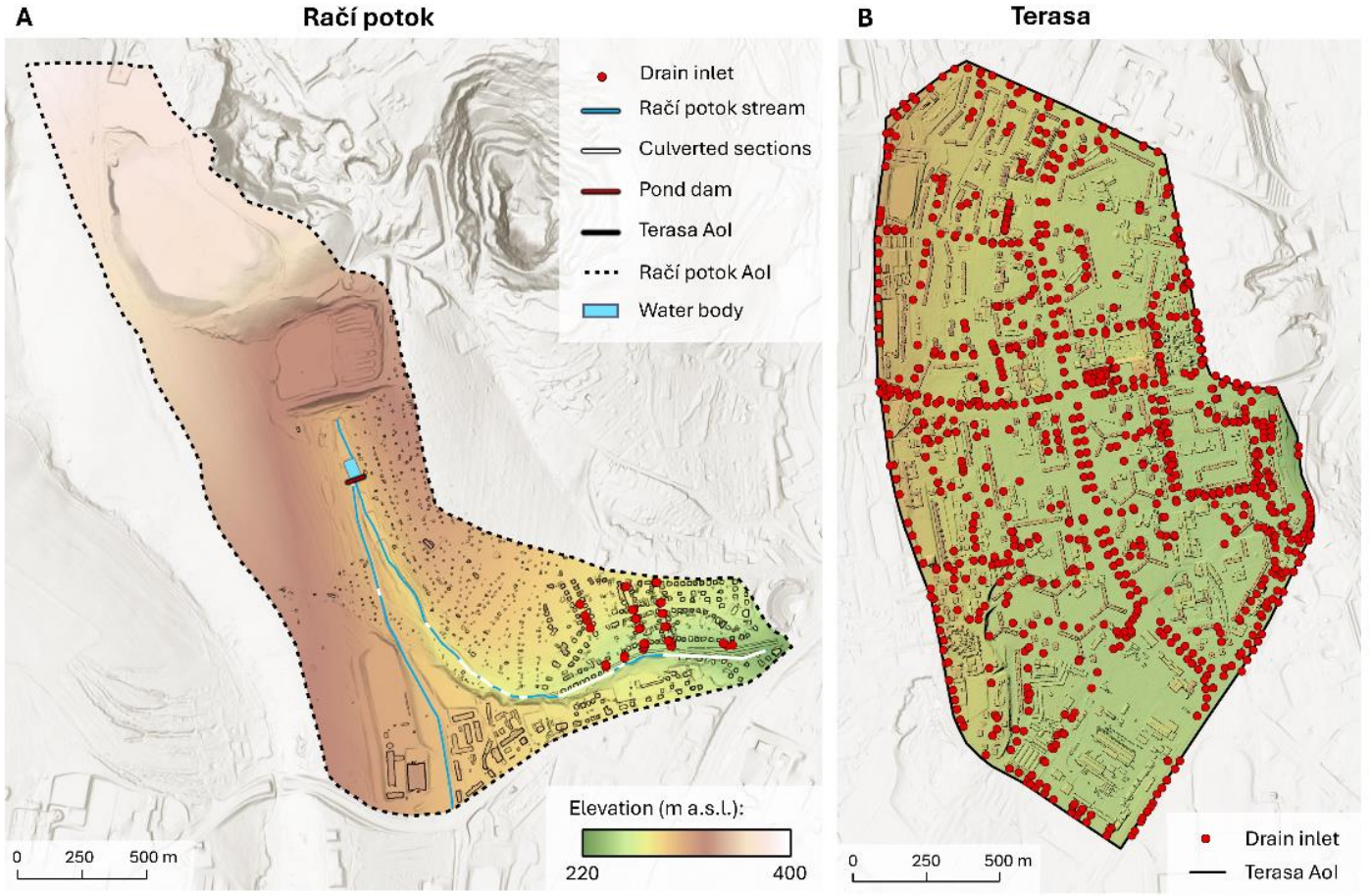
https://zbgis.skgeodesy.sk/



A detailed model of where water flows







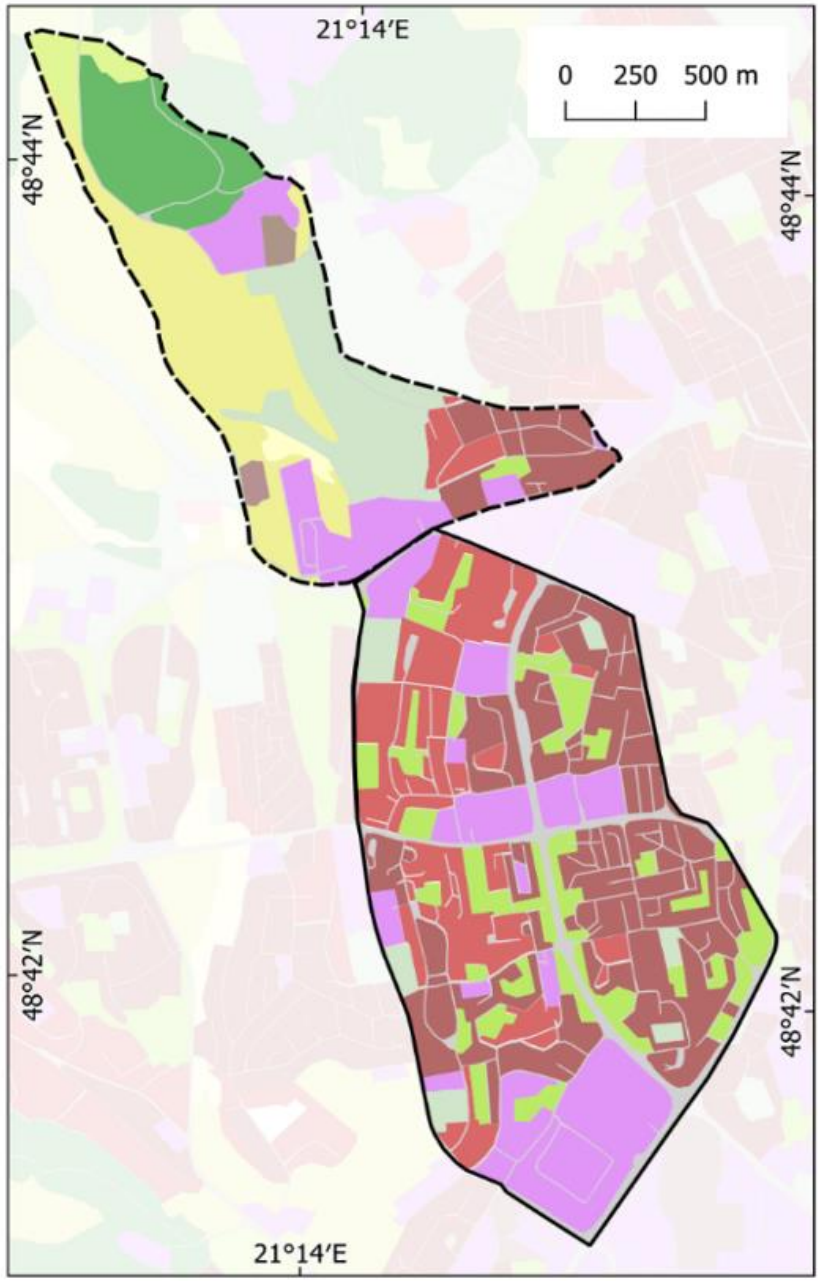
- Digital Terrain Model and Buildings (0.5 m / 1 m cell size)
- Field checks of hydraulic structures
- Rainfall and infrastructure scenarios

- **Simulating 60-minute rainfall of differing intensities**
- **5-minute outputs**

EU Copernicus Programme

Urban Atlas 2018

- Land cover
- with associated Manning’s roughness coefficients
- and infiltration rates used for overland flow simulation
- Acquired from published research.

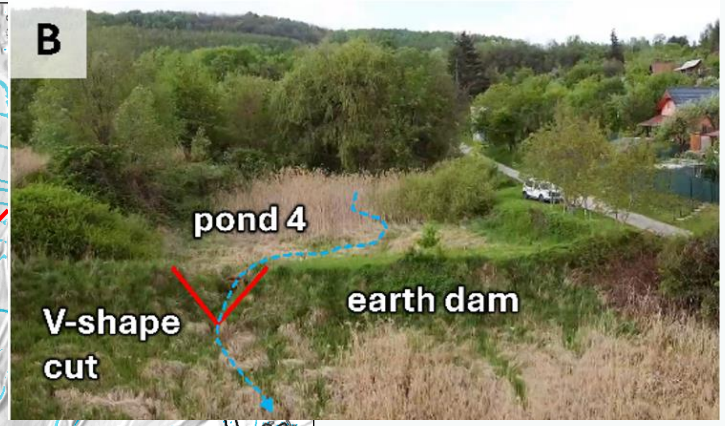


Urban atlas category	Manning's n	Infiltration rate (mm/h)
Continuous Urban Fabric	0.5	5
Discontinuous Medium Density Urban Fabric	0.5	5
Discontinuous Low Density Urban Fabric	0.5	5
Discontinuous Dense Urban Fabric	0.5	5
Industrial, public and private units	0.5	10
Sports and leisure Facilities	0.03	5
Green urban areas	0.13	20
Forests	0.4	35
Herbaceous vegetation Associations	0.13	20
Mineral extraction and dump sites	0.5	10
Land without current use	0.13	5
Pastures	0.06	30
Arable land	0.06	20
Other roads and associated land	0.03	0

05 min

Račí potok: runoff meets bottlenecks

Simulated rainfall 30 mm in 60 min., no infiltration, soil saturated.



V-cuts in the dams are too wide reducing retention



Culverts restrict flow Water reaches the access road



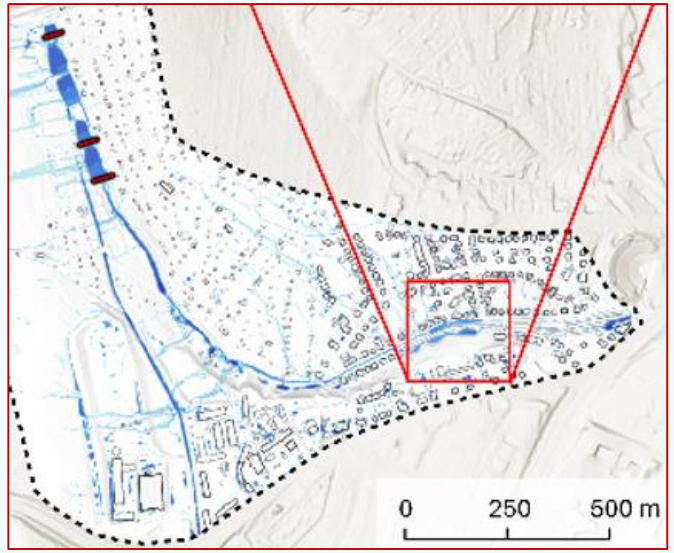
Water concentrating on the streets / unpaved roads cause problems

Water depth:

0 0.02 0.05 0.75 0.1 0.15 0.2 0.25 0.3 0.5 >1 m

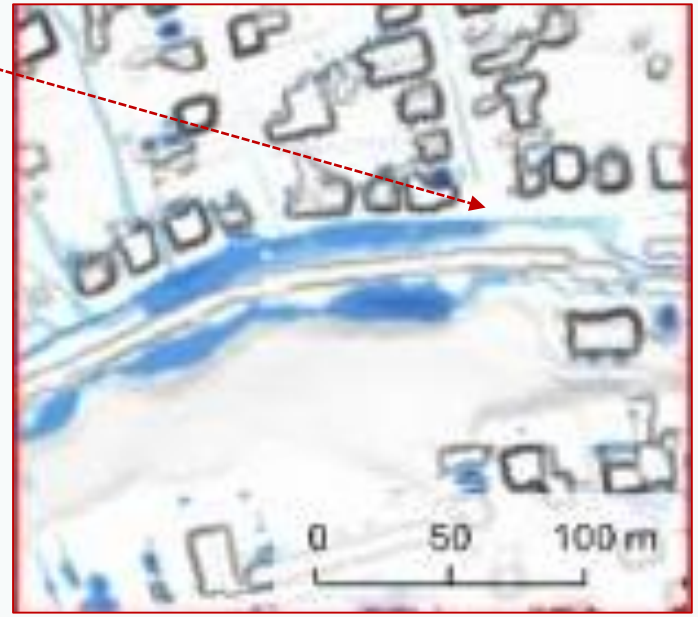
Retention needs complementary local drainage





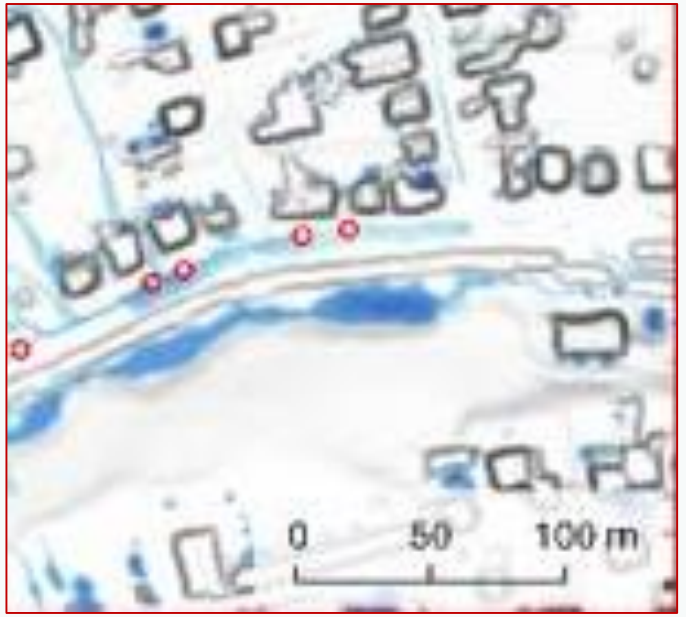
After restoring the dams

Water still accumulates by the garages



Combined measures, including new inlets

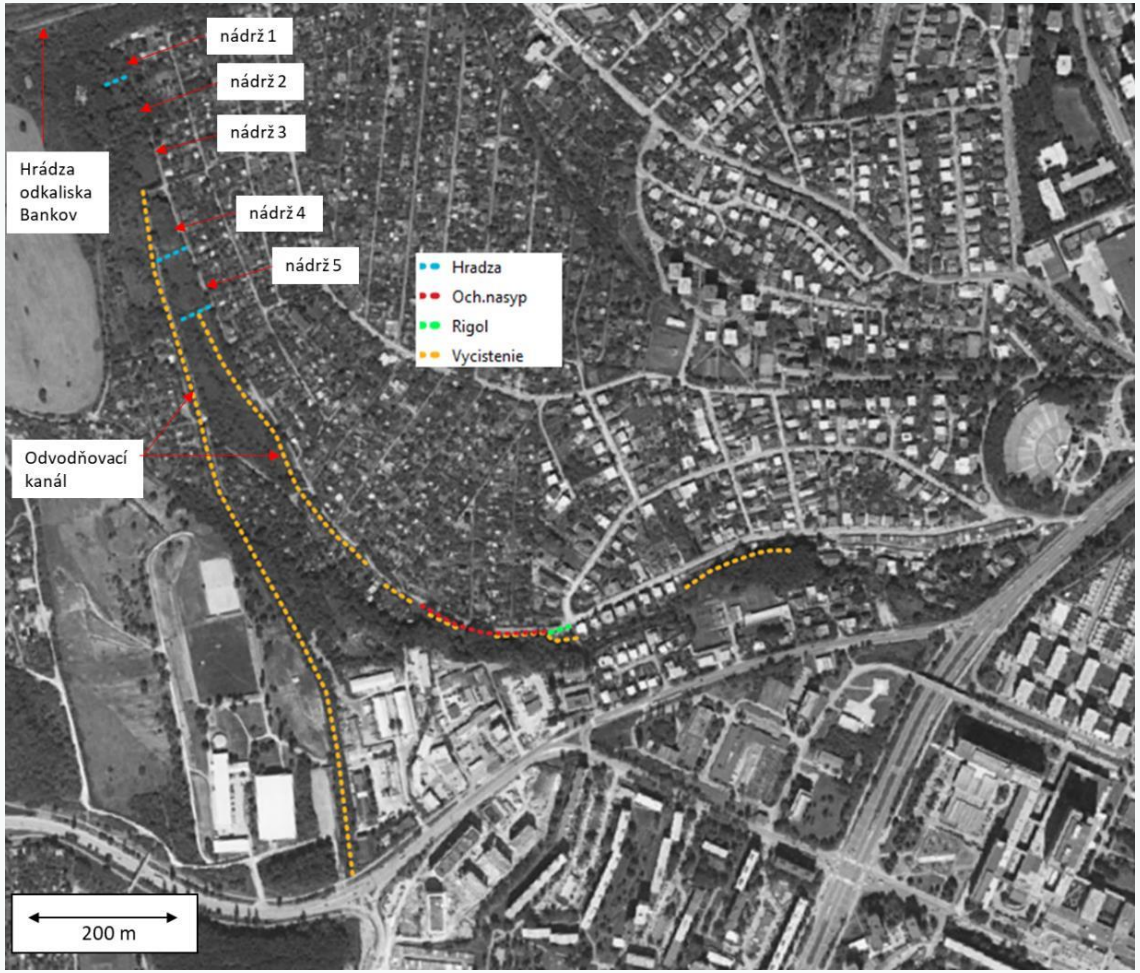
Much less standing water at the garages





Both panels: 50 mm in 60 min, initial basin filling 95%. Blue shading shows modelled water.

Račí potok: priorities for intervention



Concept for further survey and engineering design

Restore retention function

Clear channels and culverts

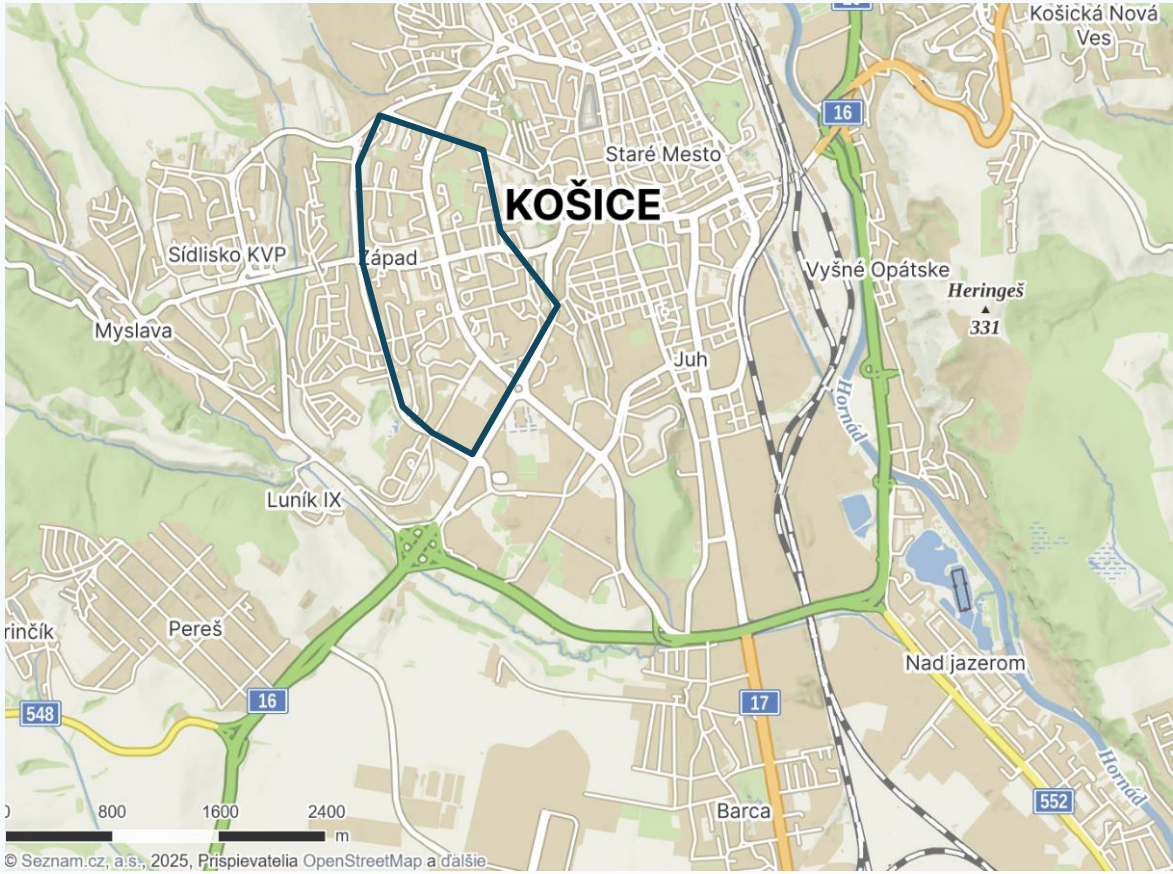
Protect the exposed garages

Plan routine maintenance

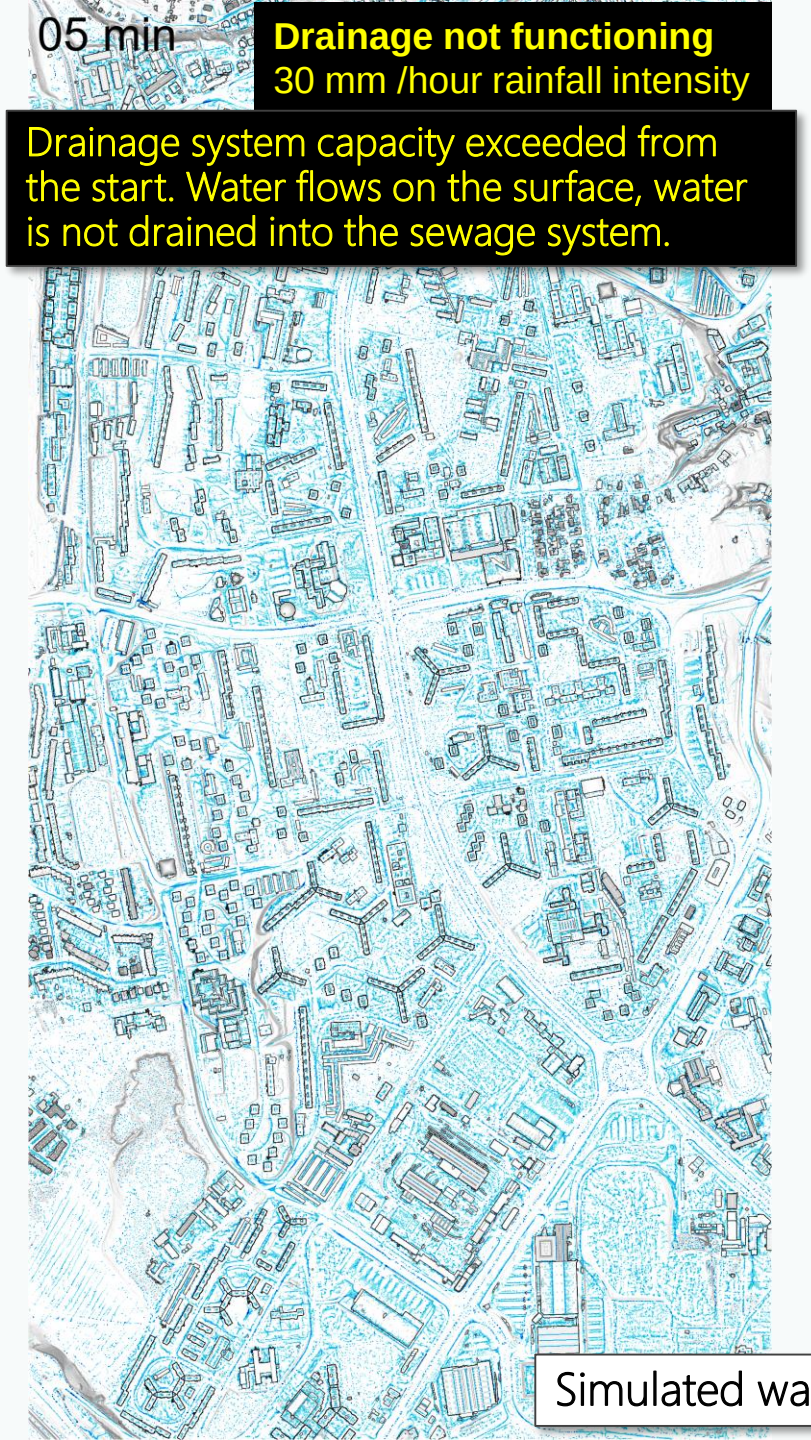
Košice–Terasa: a housing estate from the 1960s and 1970s on a terrace of the Hornád River

Urban landscape (3 km^2)







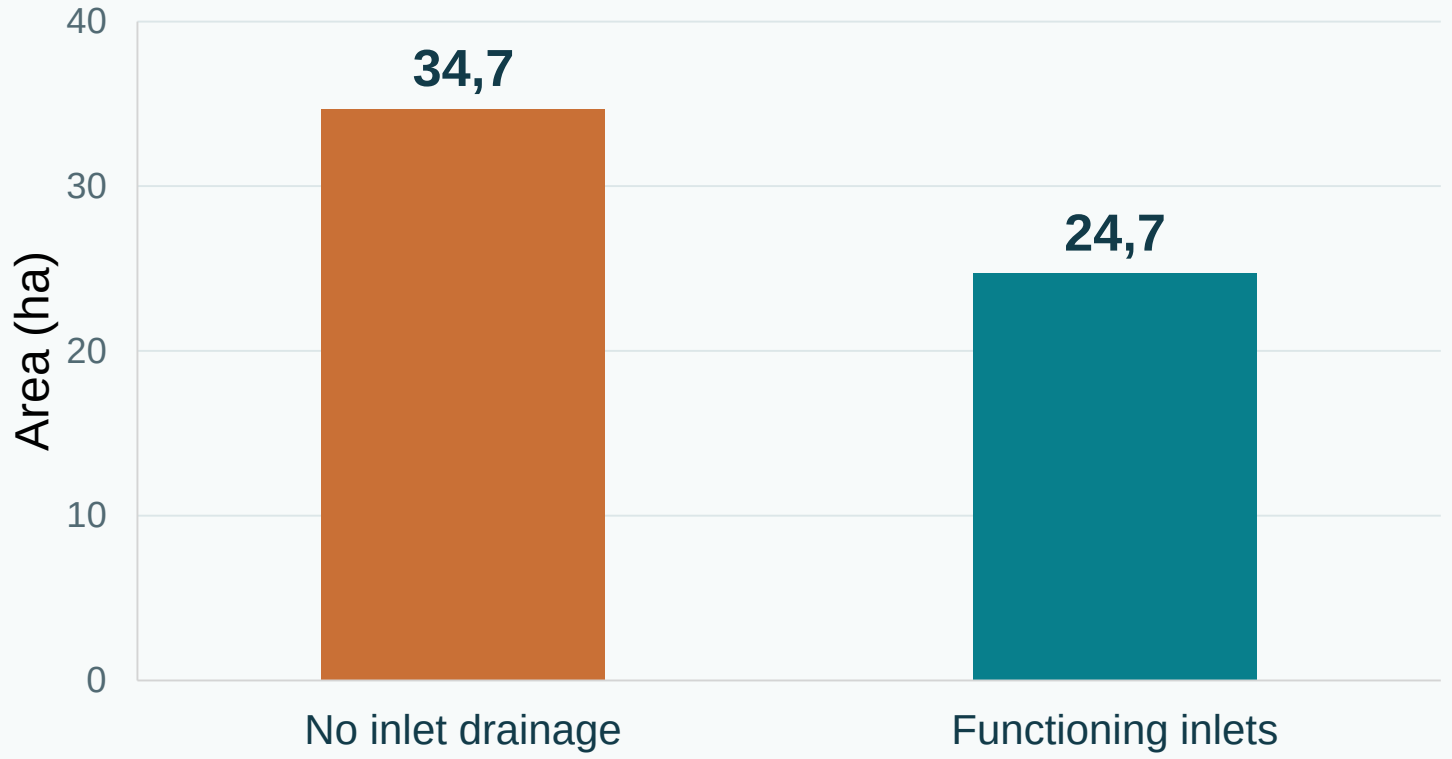




Simulated water depth in meters

Terasa: drainage changes flood extent

50 mm rainfall in one hour



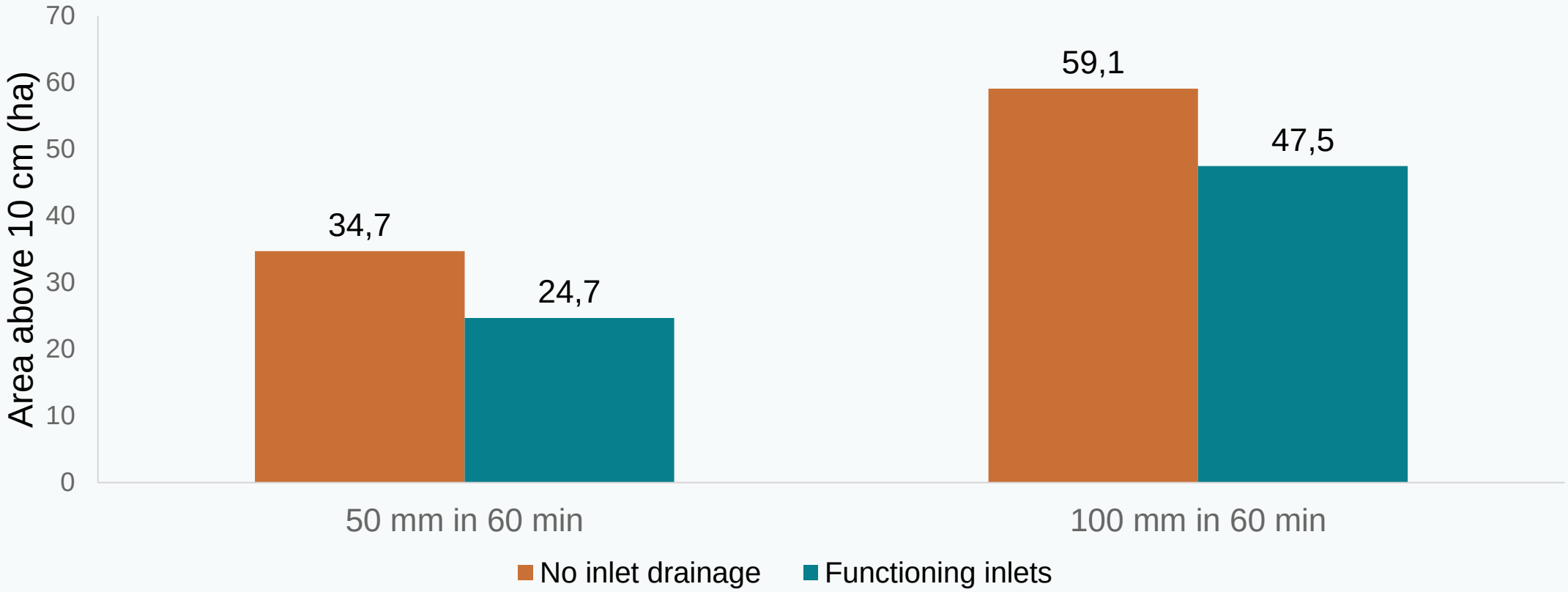
~10 ha

less area with water depth above 10 cm

after 60 minutes

Modelled bounding scenarios. Inlet drainage is a simplified representation of the sewer system.

Additional evidence: heavier rainfall on Terasa

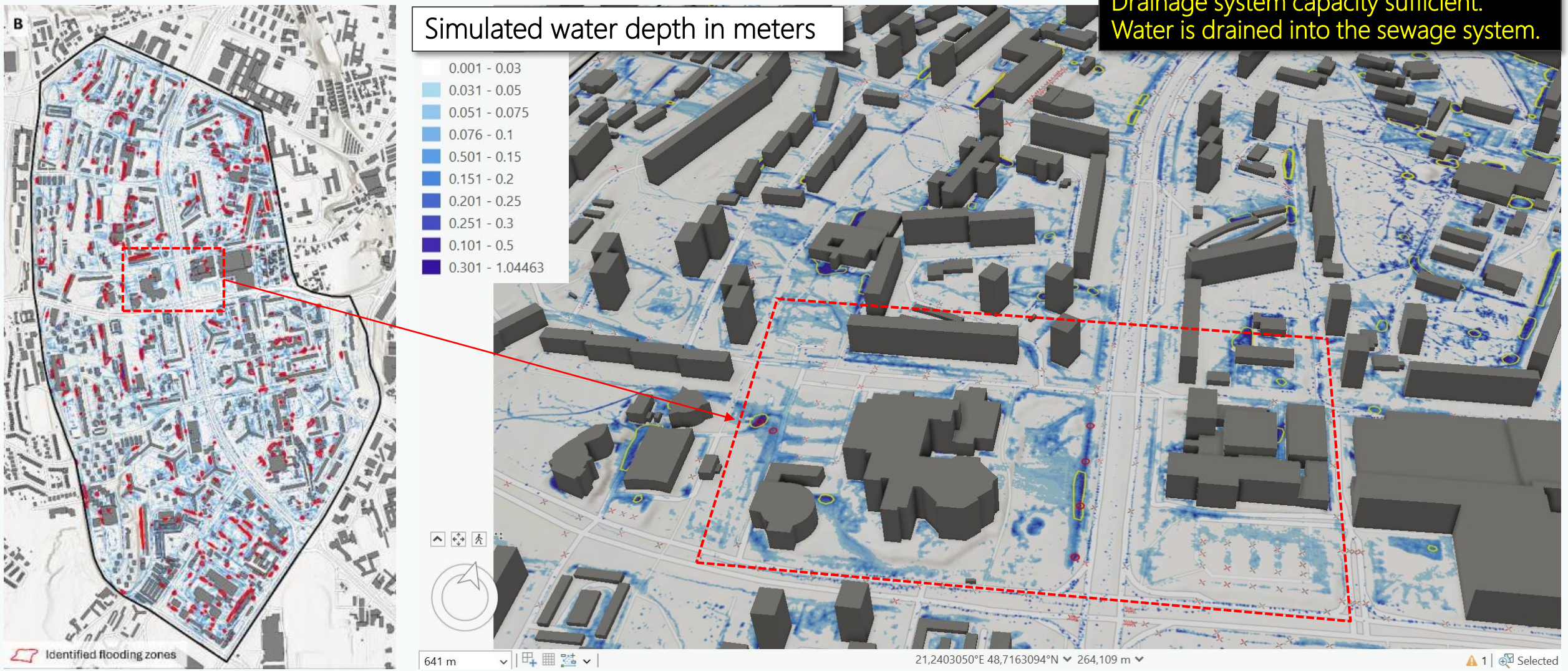


Water depth threshold: 10 cm. Areas evaluated after 60 minutes.

Terasa: drainage changes flood extent

Drainage fully functioning
30 mm /hour rainfall intensity

Drainage system capacity sufficient.
Water is drained into the sewage system.

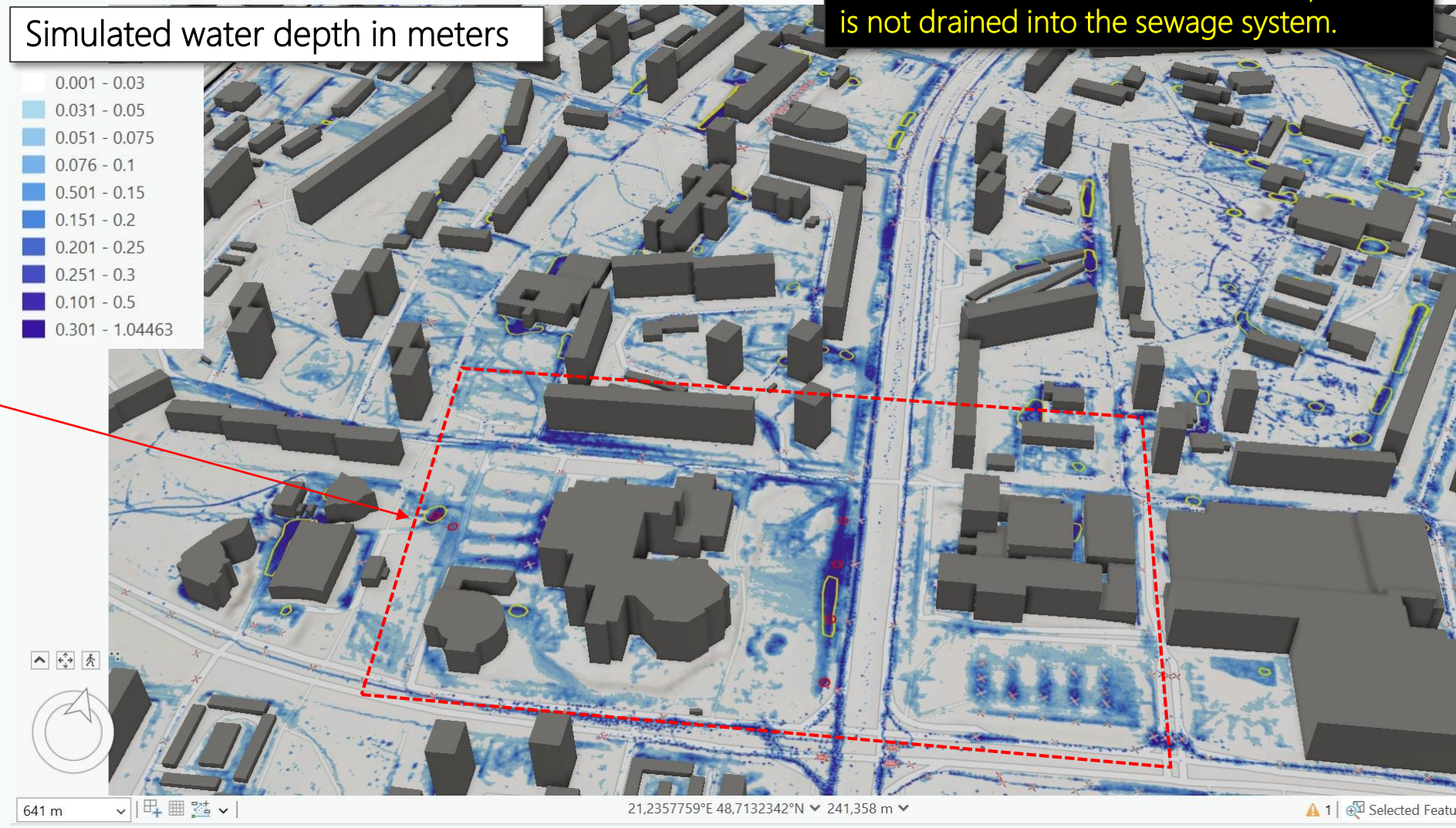


Terasa: drainage changes flood extent

Drainage not functioning
30 mm /hour rainfall intensity

Drainage system capacity exceeded from the start. Water flows on the surface, water is not drained into the sewage system.





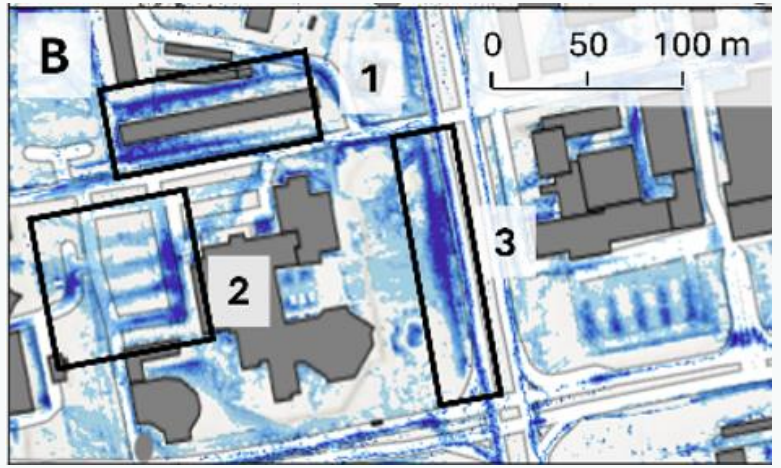
Persistent water hotspots guide local improvements



Existing functioning inlets



Existing not functioning inlets



Added new inlets along flow paths



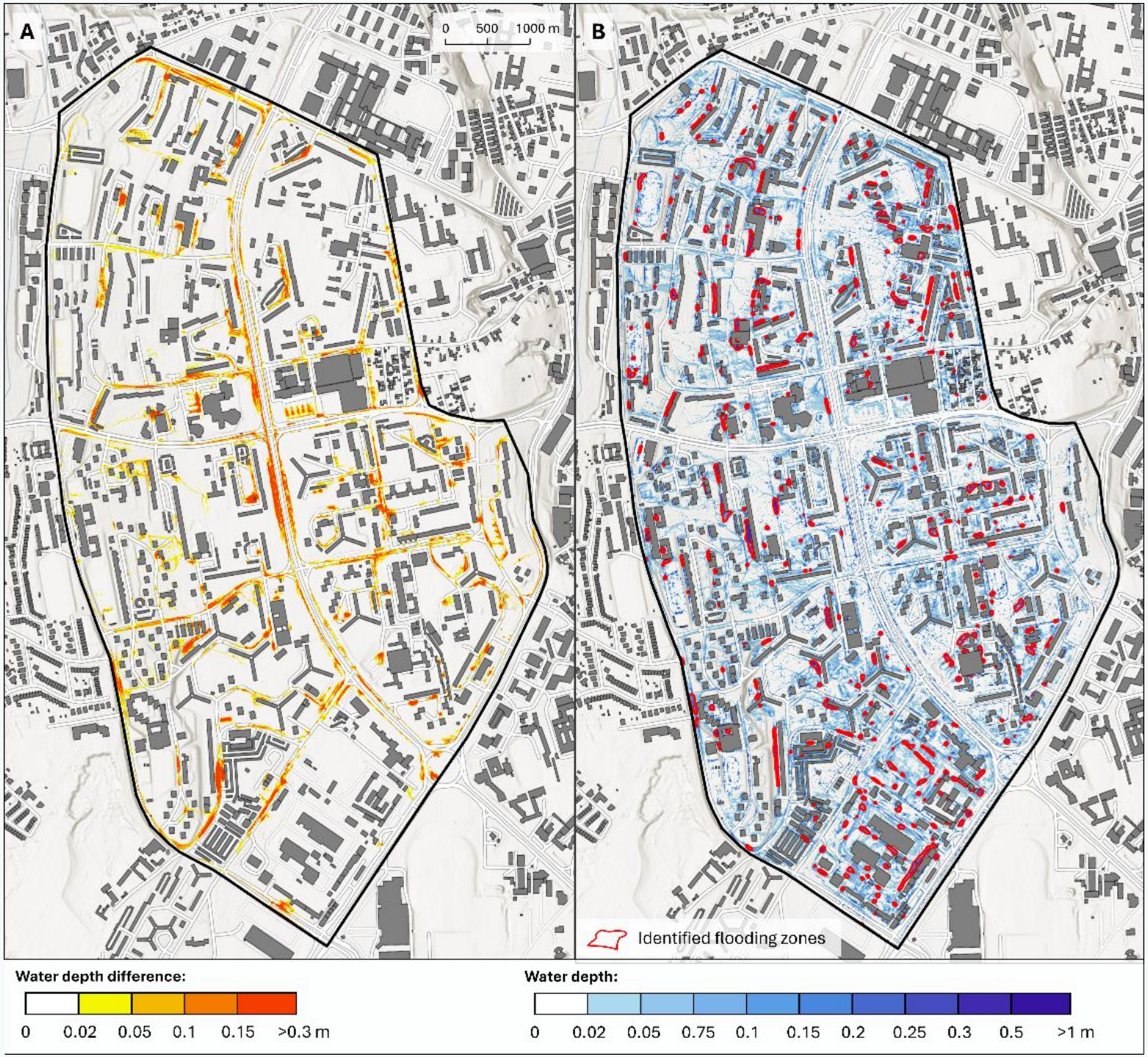
50 mm in 60 min. Red circles: proposed additional inlets.

- **Inspect hotspots during real storms**
- **Check connections and downstream capacity**

Persistent water hotspots guide local improvements

(A) Most efficient drainage inlets: Difference raster between 0% and 100% drain inlet functionality at 50 mm/h, showing the water depth removed by a fully operational inlet network.

(B) Problematic areas: Identified water accumulation zones derived from the current-state simulation.



Bare in mind the model assumptions

Rainfall	Uniform intensity during a 60-minute event
Rain infiltration	Saturated soil represented by zero infiltration
Drain inlets	Local removal of surface water, without pipe hydraulics
Validation	No direct calibration against observed water levels

Using the results in municipal decisions

MODEL OUTPUT	MUNICIPAL USE
Flow paths and hotspots	Priorities for field inspection
Sensitivity to drainage	Priorities for maintenance
Comparison of measures	Options for detailed design
Remaining surface water	Problems still to resolve

What the simulations can tell us

Useful now

Likely flow paths and hotspots

Comparison of intervention scenarios

Priorities for further investigation

Checks before construction

Observations during real storms

Detailed sewer hydraulics

Engineering design and safety checks

The study supports comparative assessment. Exact flood depths need further validation.

Priorities for Košice, lessons for Nyíregyháza

KE: Račí potok

Restored retention with local protection of exposed places

KE: Terasa

Functioning drainage and targeted hotspot improvements

Both cities

Scenario testing followed by field verification



Thank you / Köszönöm

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Interreg Hungary – Slovakia

Co-funded by the European Union

NYÍREGYHÁZA MEGYEI JOGÚ VÁROS ÖNKORMÁNYZATA

NYÍREGYHÁZA

KOŠICE