Politechnika Wrocławska

Comparison of 2D HEC-RAS Modeling with the Observed September 2024 Flood in Poland: A Case Study of the Bóbr River in Bolesławiec

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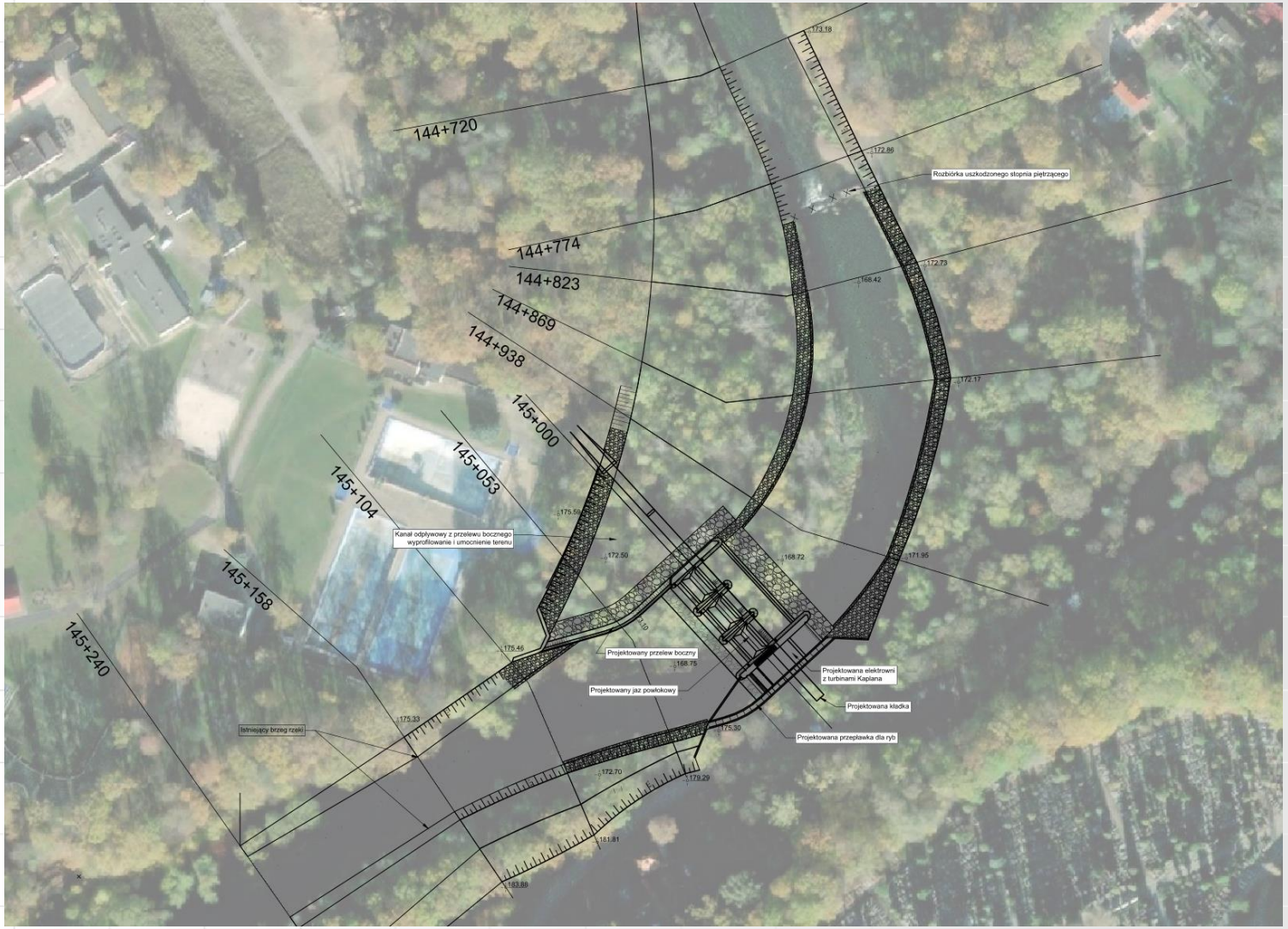
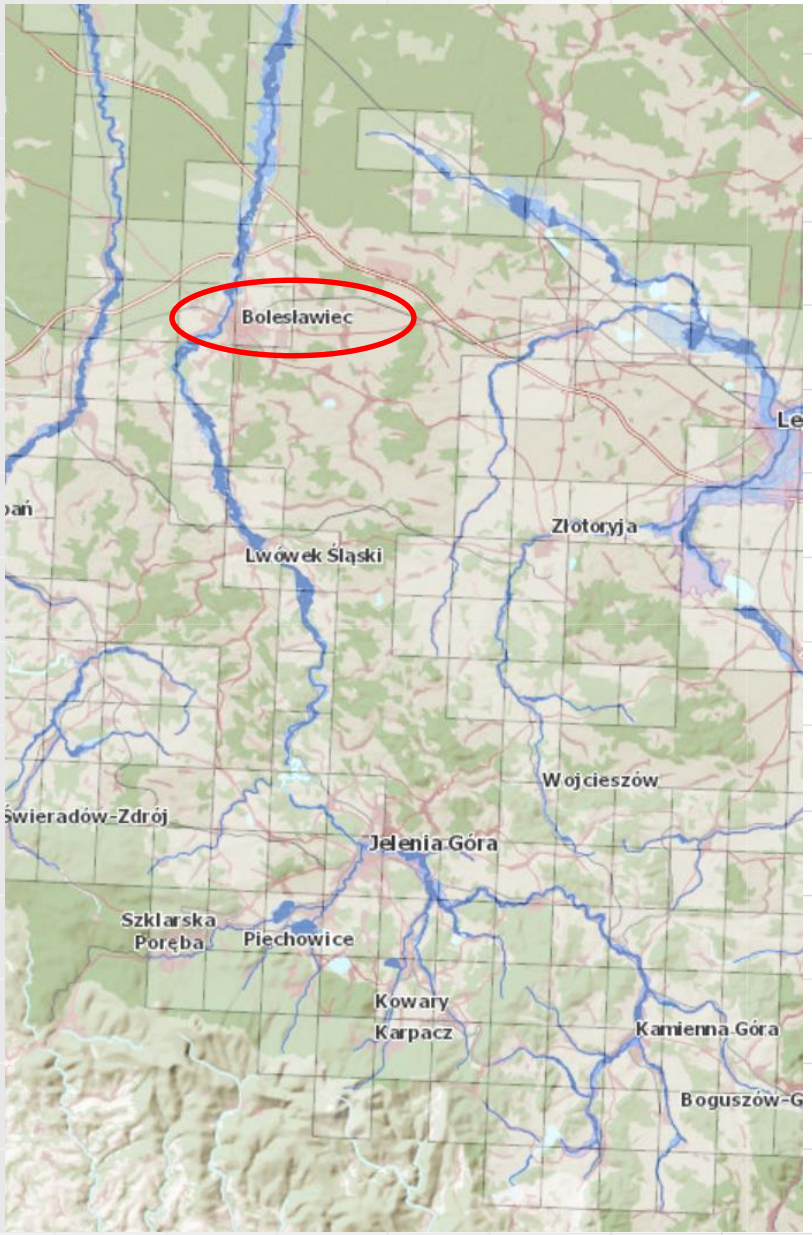
HR EXCELLENCE IN RESEARCH

Technical and Economic Analysis of the Construction of a Small Hydropower Plant in Bolesławiec





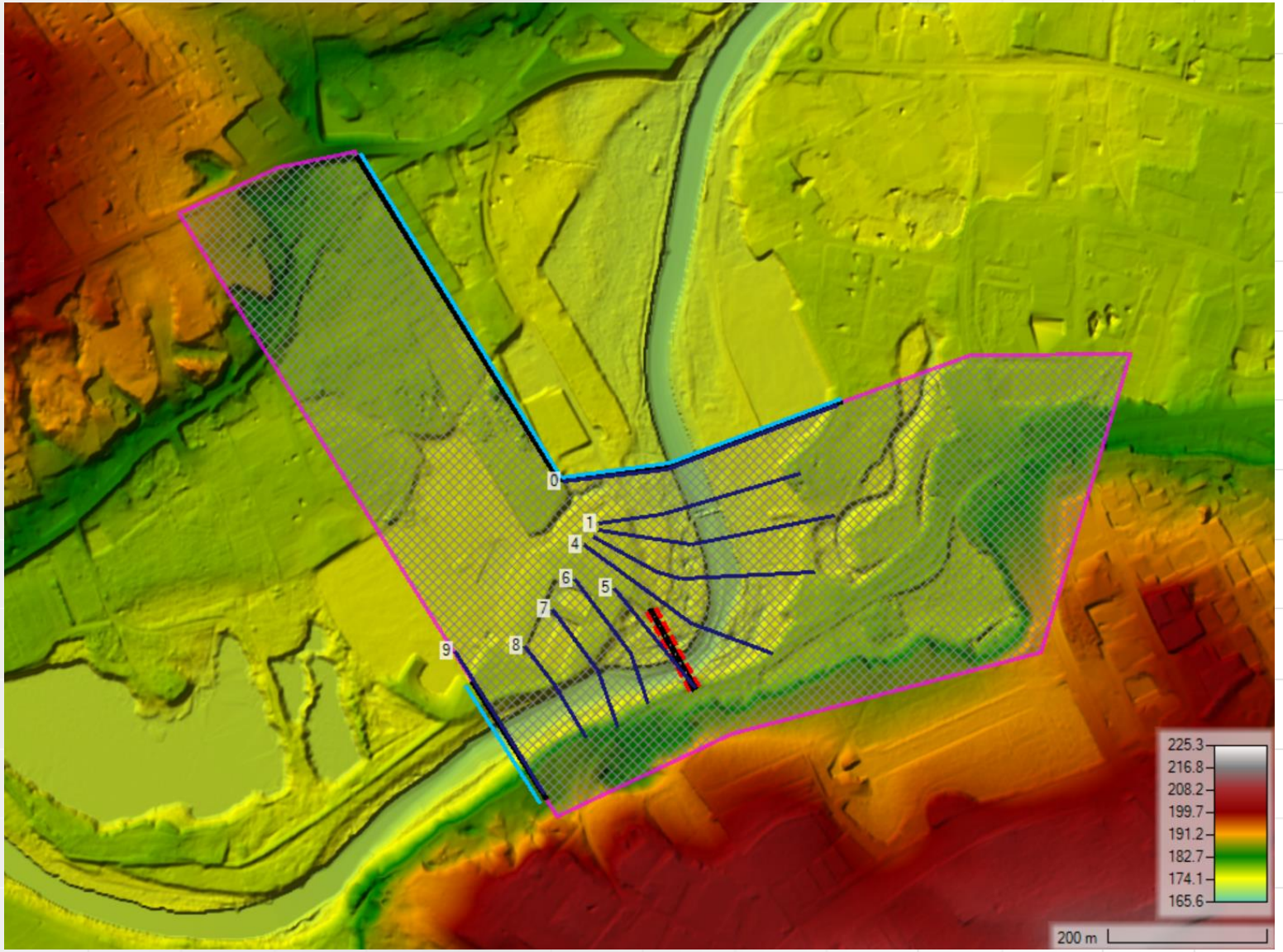
Source: Kostecki S., J. Machajski, K. Zamiar, (2024) „Analiza techniczno – ekonomiczna budowy małej elektrowni wodnej w Bolesławcu w km 145+000 biegu rzeki Bóbr", Raport series SPR nr 62/2024, Wrocław University of Science and Technology,

The Bóbr river

- Catchment area: 1700 km^2
- Mean flow: 19,4 m^3/s
- Q1%: 592 m^3/s

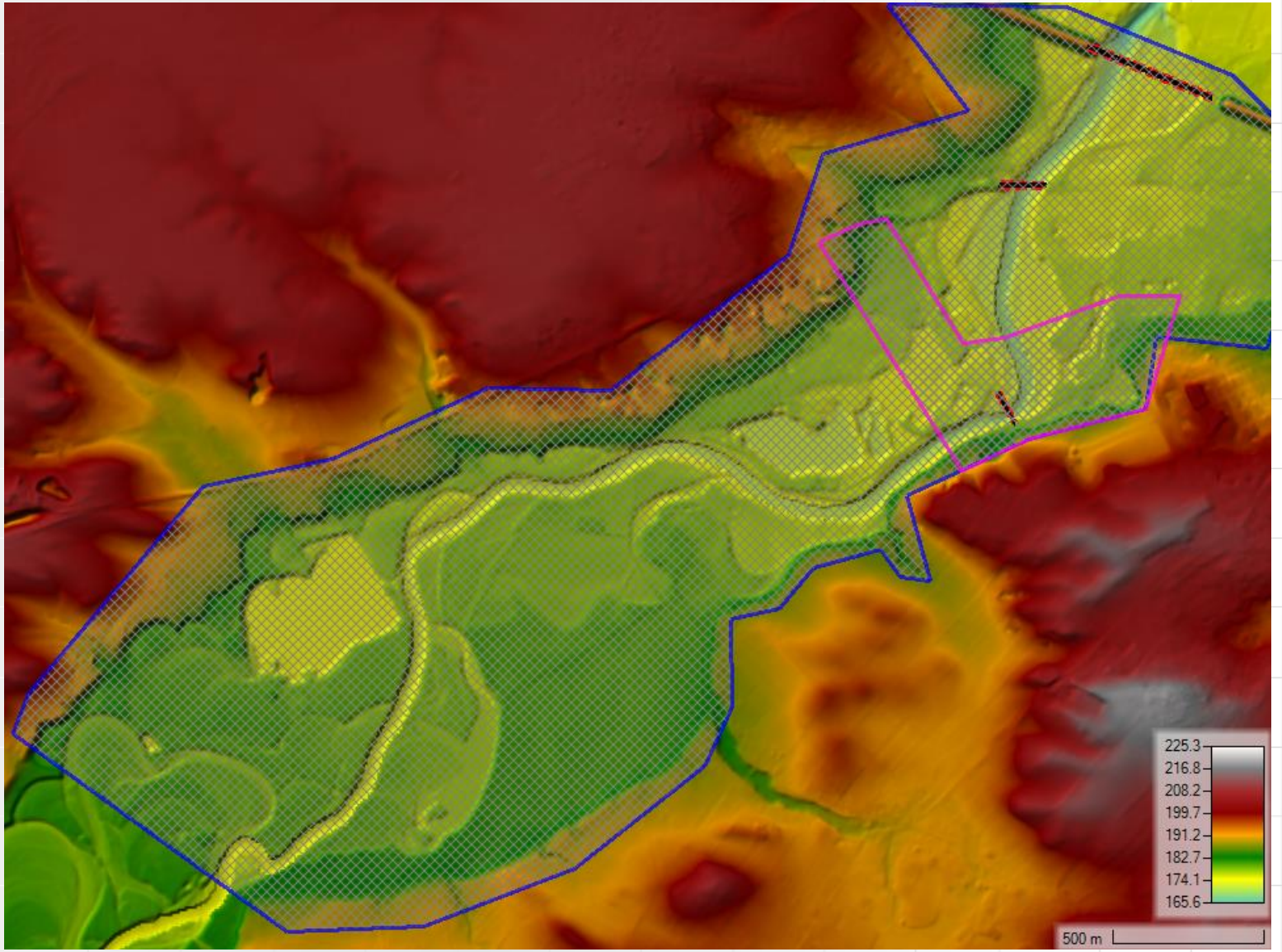
Short Model

- Range from km 144+700 to km 145+200 of the Bóbr river
- Mesh size:
  main channel: 2 m x 2 m
  floodplains: 15 m x 15 m
- Manning's n value:
  main channel: 0.035
  floodplains: 0.120
- Boundary conditions:
  upstream: Flow hydrograph
  downstream: Normal depth



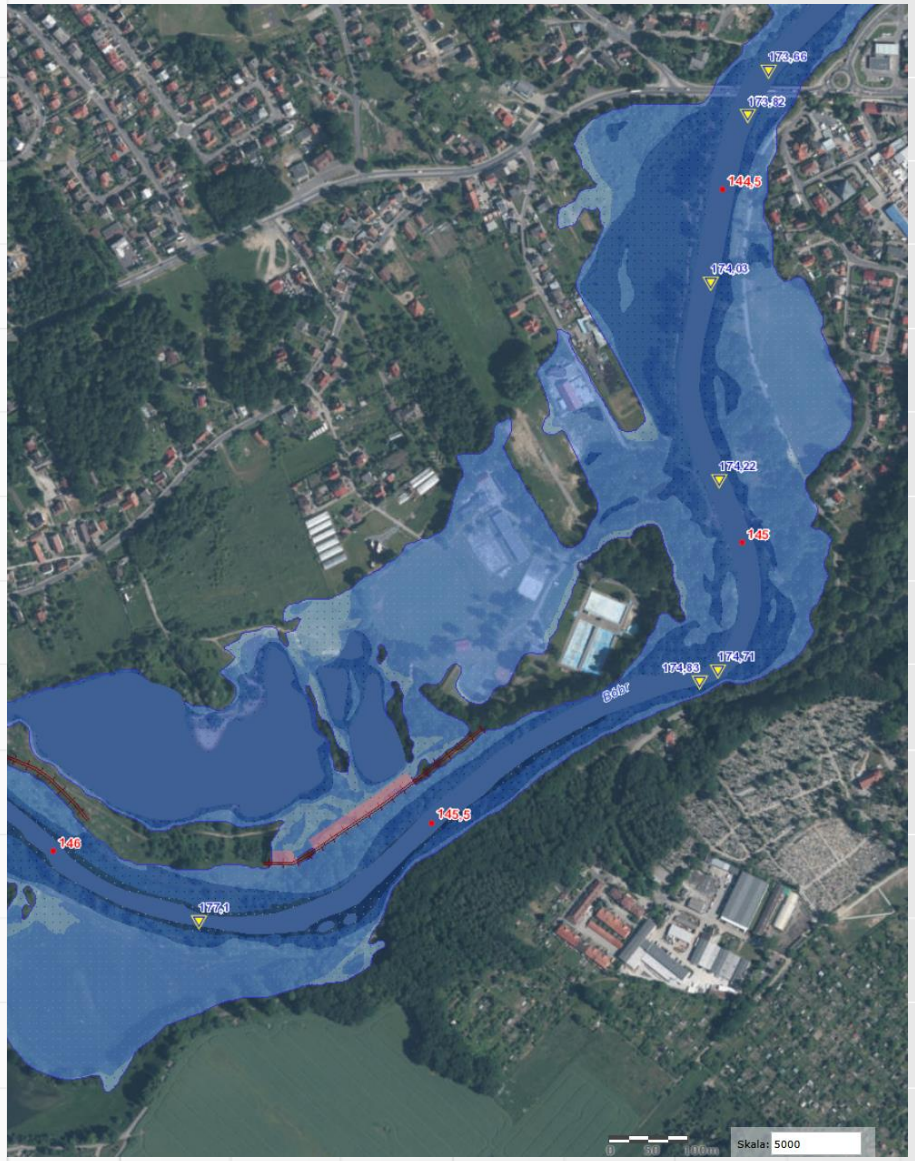
Full Model

- Range from km 143+800 to km 148+000 of the Bóbr river
- Mesh size:
  main channel: 2 m x 2 m
  floodplains: 15 m x 15 m
- Manning's n value:
  main channel: 0.035
  floodplains: 0.120
- Boundary conditions:
  upstream: Flow hydrograph
  downstream: Normal depth



Calibration

ISOK flood hazard map $Q_{1\%}$



Full model HEC-RAS $Q_{1\%}$

Calibration configurations and results

Two different downstream boundary condition values were tested: normal depth 0.001 and normal depth 0.002

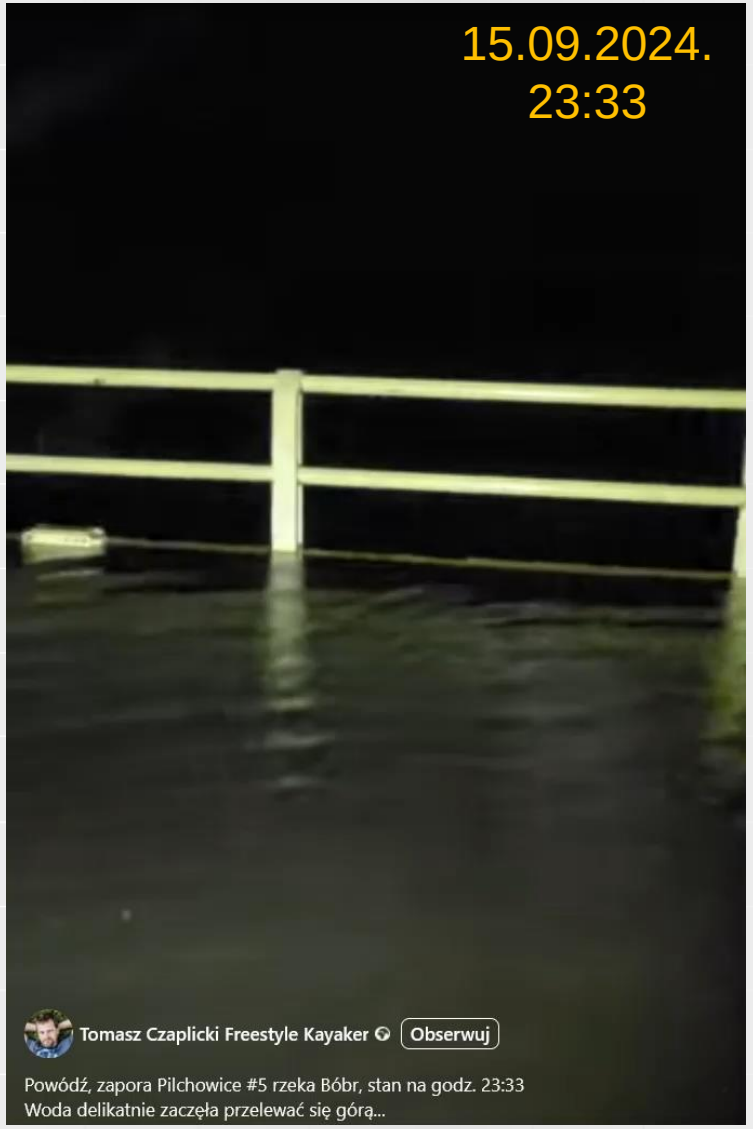
Two different sets of equations were tested: Diffusion Wave Equations (DWE) and Shallow Water Equation (SWE)

	Location (kilometer of the River Bóbr)			144+916	145+177	145+204	
Model variants	Calibration tests			Water surface elevation in meters above sea level			Δ (RMSE) [m]
0	ISOK flood hazard map Q1%			174.38	174.87	174.99	-
1	Short model	DWE	Downstream normal depth 0.002	173.669	174.314	174.926	0.52
2	Short model	DWE	Downstream normal depth 0.001	174.343	174.728	175.033	0.09
3	Short model	SWE	Downstream normal depth 0.002	173.663	174.696	175.075	0.43
4	Short model	SWE	Downstream normal depth 0.001	174.354	174.941	175.190	0.12
5	Full model	DWE	Downstream normal depth 0.002	174.408	174.768	175.080	0.08
6	**Full model**	**DWE**	**Downstream normal depth 0.001**	**174.400**	**174.764**	**175.038**	**0.07**
7	Full model	SWE	Downstream normal depth 0.002	175.254	175.538	175.746	0.77

Pilchowice reservoir: 50 km upstream of Bolesławiec

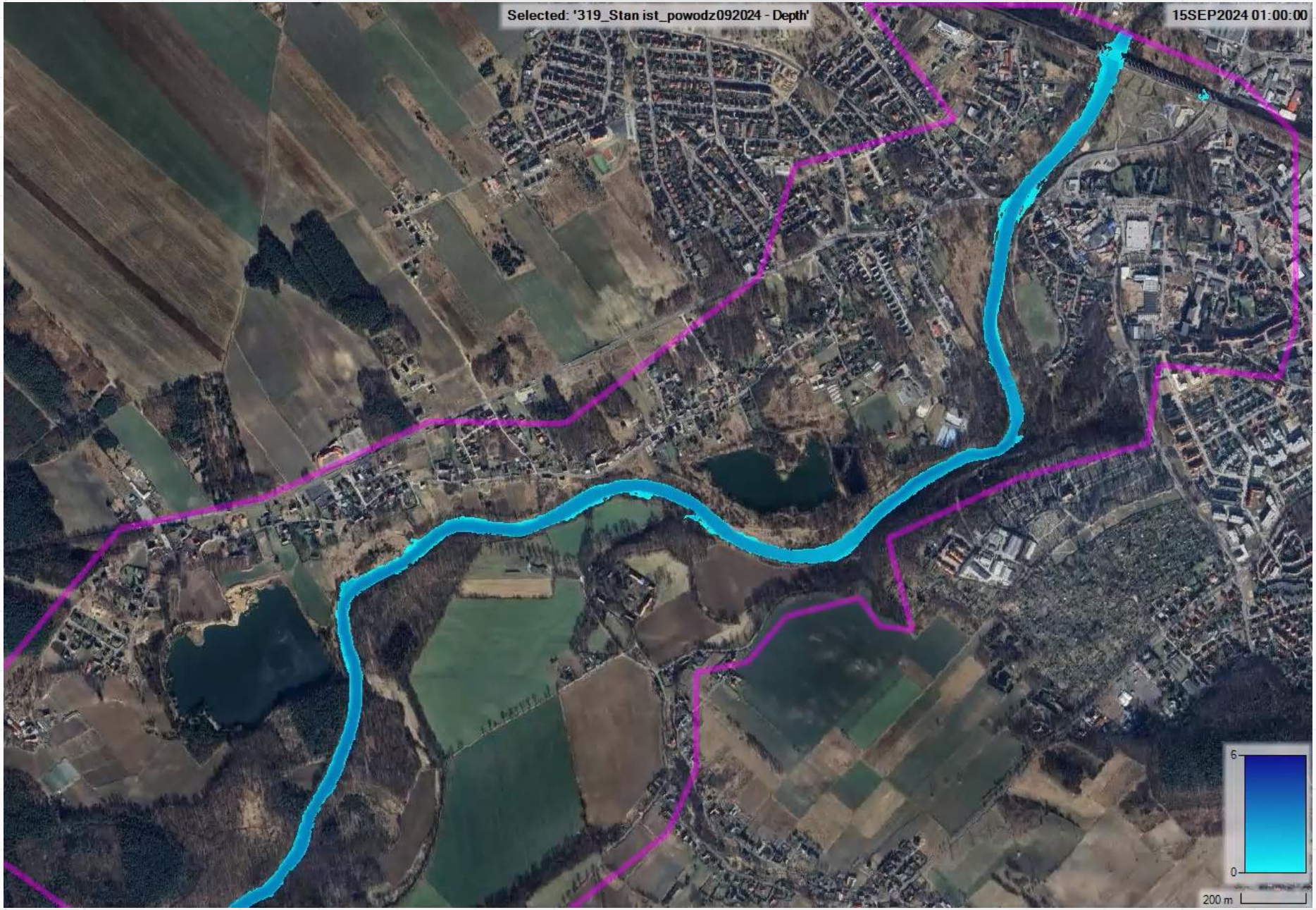
Dam height	69 m
Reservoir capacity	55 mln m^3
Maximum discharge	558 m^3/s

Source: MACHAJSKI J., RĘDOWICZ W., Ocena zdolności przepustowej stopnia wodnego Pilchowice I na rzece Bóbr, Gospodarka Wodna, nr 5/2006, 194–200.

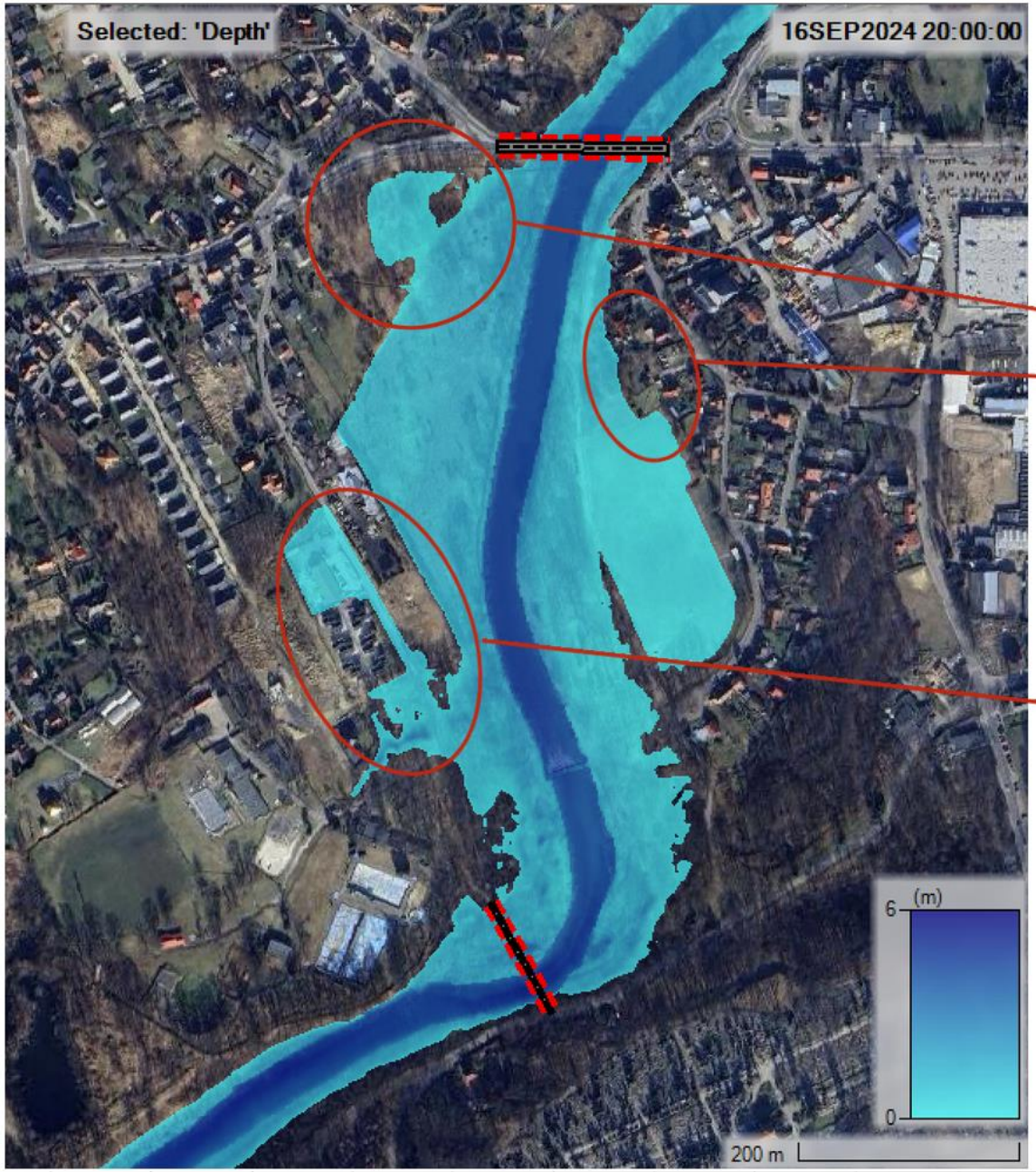


Source: Tomasz Czaplicki, https://www.facebook.com/tomekczaplicki/videos/26696282840018865

Flood event September 2024



Model and flood comparison



Photos source: Facebook profile: "Miasto Boleslawiec" 17.09.2024 https://www.facebook.com/umboleslawiec

Conclusion

- The Full Model using Diffusion Wave Equations and a downstream normal depth of 0.001 provided the best match with the ISOK Q1% flood hazard map
- Extrapolating the main channel geometry significantly reduced the sensitivity of the model to the downstream boundary condition value
- The Diffusion Wave Equation (DWE) solver proved to be significantly more efficient computationally than the Shallow Water Equation (SWE) solver, with no substantial loss of accuracy in this case
- The extrapolated and calibrated to another independent numerical source (flood hazard map $Q_{1\%}$) model proved to be satisfactorily accurate when compared with the real 2024 flood extent

Thank you for your attention

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