XXXVI INTERNATIONAL SCHOOL OF HYDRAULICS

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The deflectors impact on sediment transport processes on the basis of modelling and simulations

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[2] Institute of Meteorology and Water Management, Flood and Drought Modeling Center
[3] University of Agriculture in Krakow, Department of Hydraulics Engineering and Geotechnic
[4] Cracow University of Technology, Institute of Structural Mechanics, Faculty of Civil Engineering

Jachranka, 23rd– 26th May 2017

OUTLINE

- *Introduction*
- *Study area*
- *Materials*
- *Methods*
- *Results*
- *Conclusions*

INTRODUCTION

Aim of the study

- *To investigate how deflectors impact on sediment transport processes*

Motivation

- *Deflectors are popular structures used in river restoration*
- *Utility of modeling in prediction of changes within the channel*
- *Verification of changes in flood risk caused by the river restoration*

STUDY AREA (1)

Flinta River

province: Wielkopolska

tributary of the Wełna River (outlet in Rożnowo-Młyn)

source in the Nature Reserve „Źródliska Flinty"

total length	*27 km*
catchment area :	*345 km²*
water gauge:	*Ryczywół*

Fig. 1 Location of the Flinta River.

STUDY AREA (2)

Flinta River

sandy lowland stream (WFD typology)

slope	*0.75‰*
velocity	*0.2 m/s*
analyzed reach	*2 km*
catchment area to analyzed cross-section :	*251 km²*

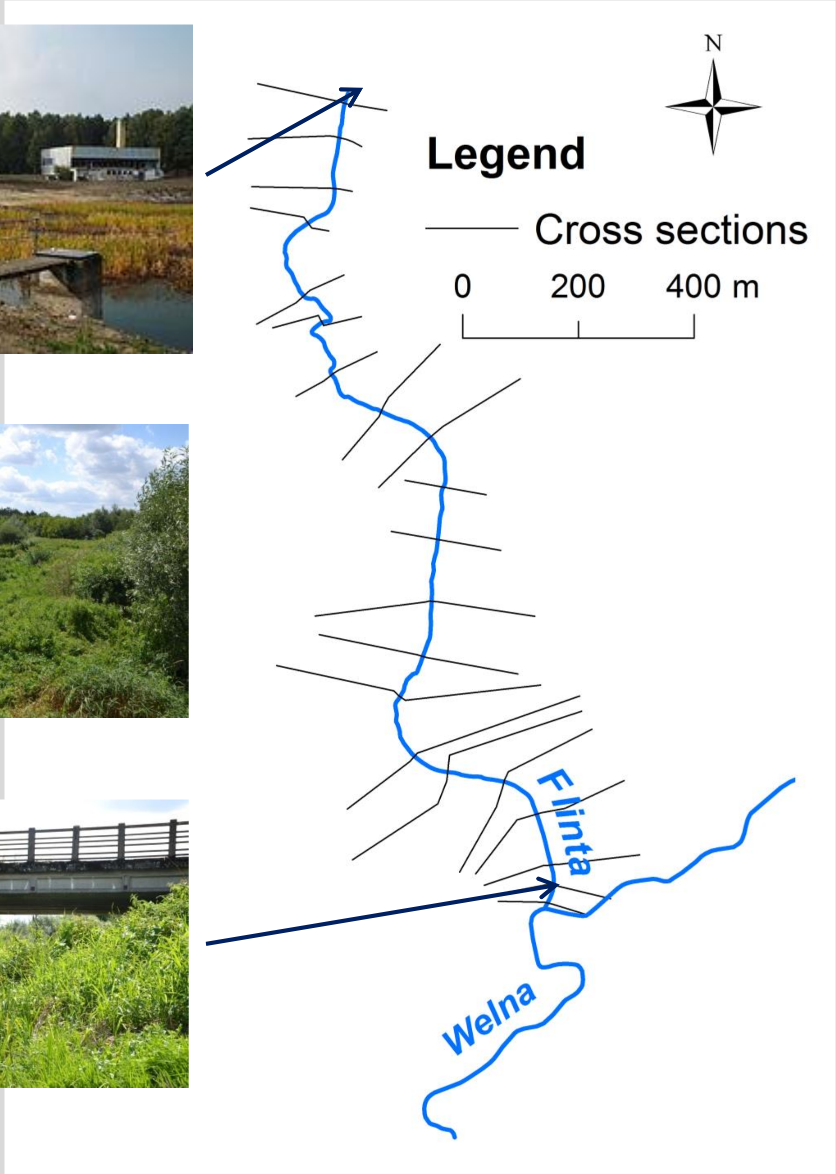


Fig. 2 Analysed reach of the Flinta River.

MATERIALS

Aquired data

Hydrological data

DEM

Digital maps

Cross sections

Sediment sample

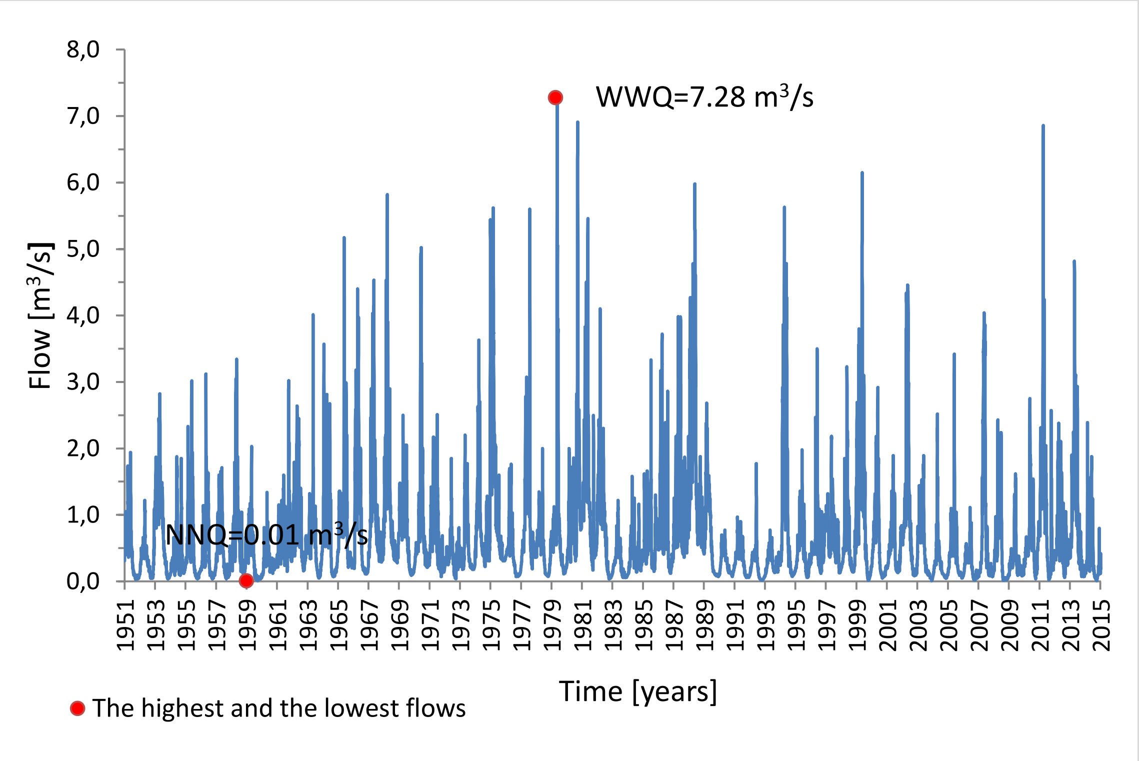


Fig. 5 A daily flow hydrograph for period 1951-2015 for water gauge Ryczywół.

MATERIALS

Aquired data

Hydrological data

DEM

Digital maps

Cross sections

Sediment sample

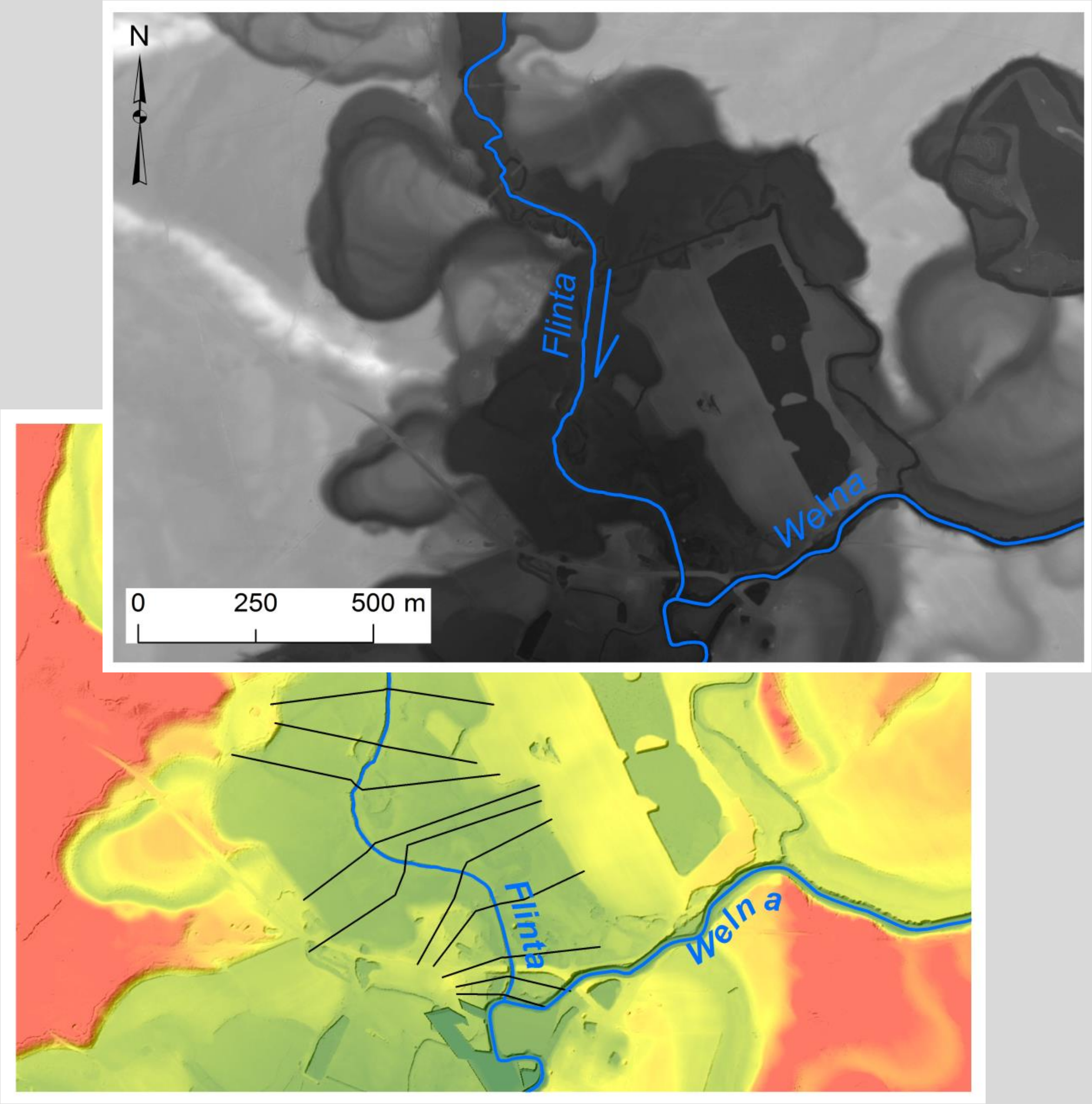


Fig. 6 Digital elevation model in the analysed area.

MATERIALS

Aquired data

Hydrological data

DEM

Digital maps

Cross sections

Sediment sample

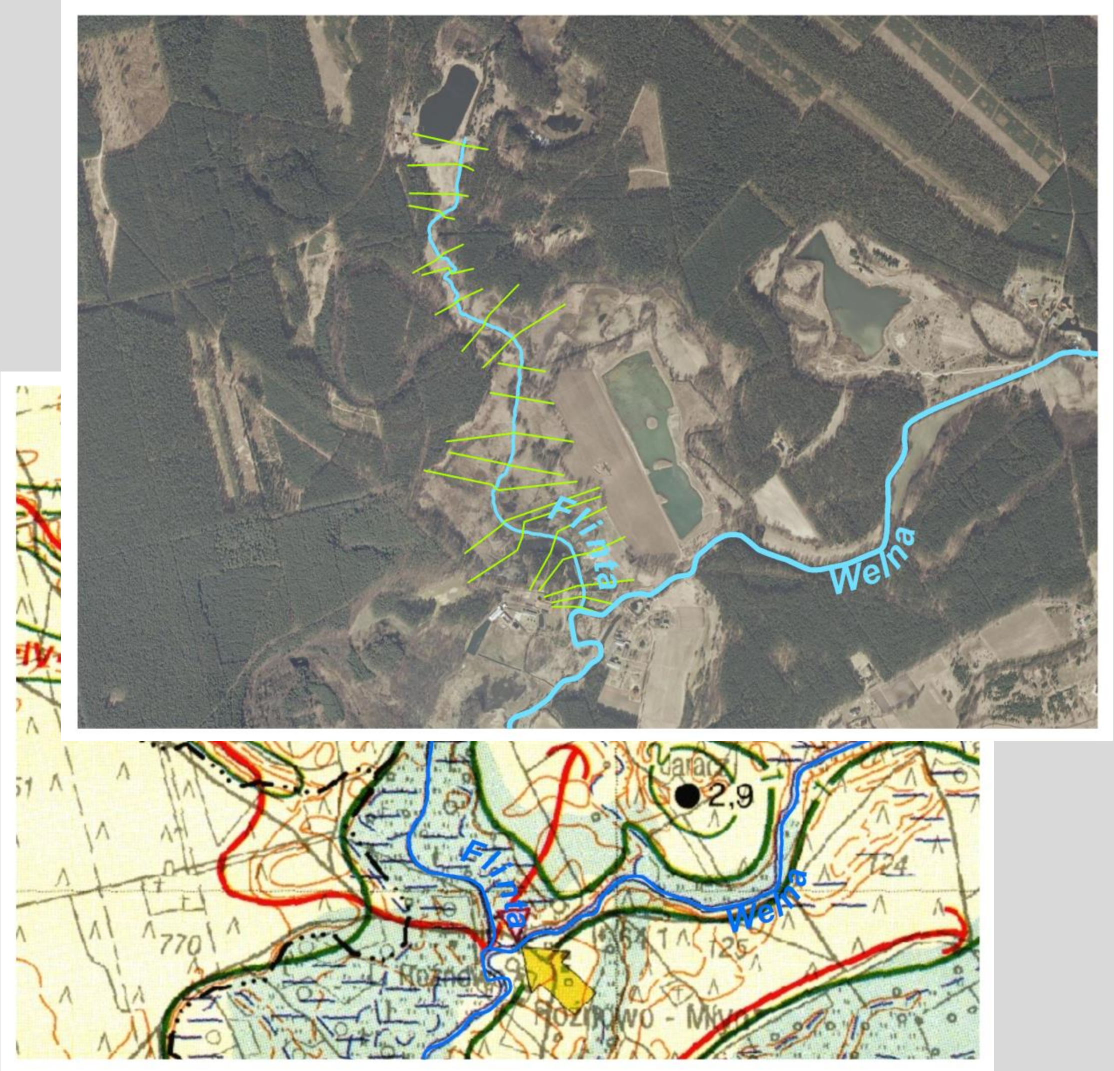


Fig. 6 Digital maps used in analysis (geoportal.gov.pl).

MATERIALS

Aquired data

Hydrological data

DEM

Digital maps

Cross sections

Sediment sample

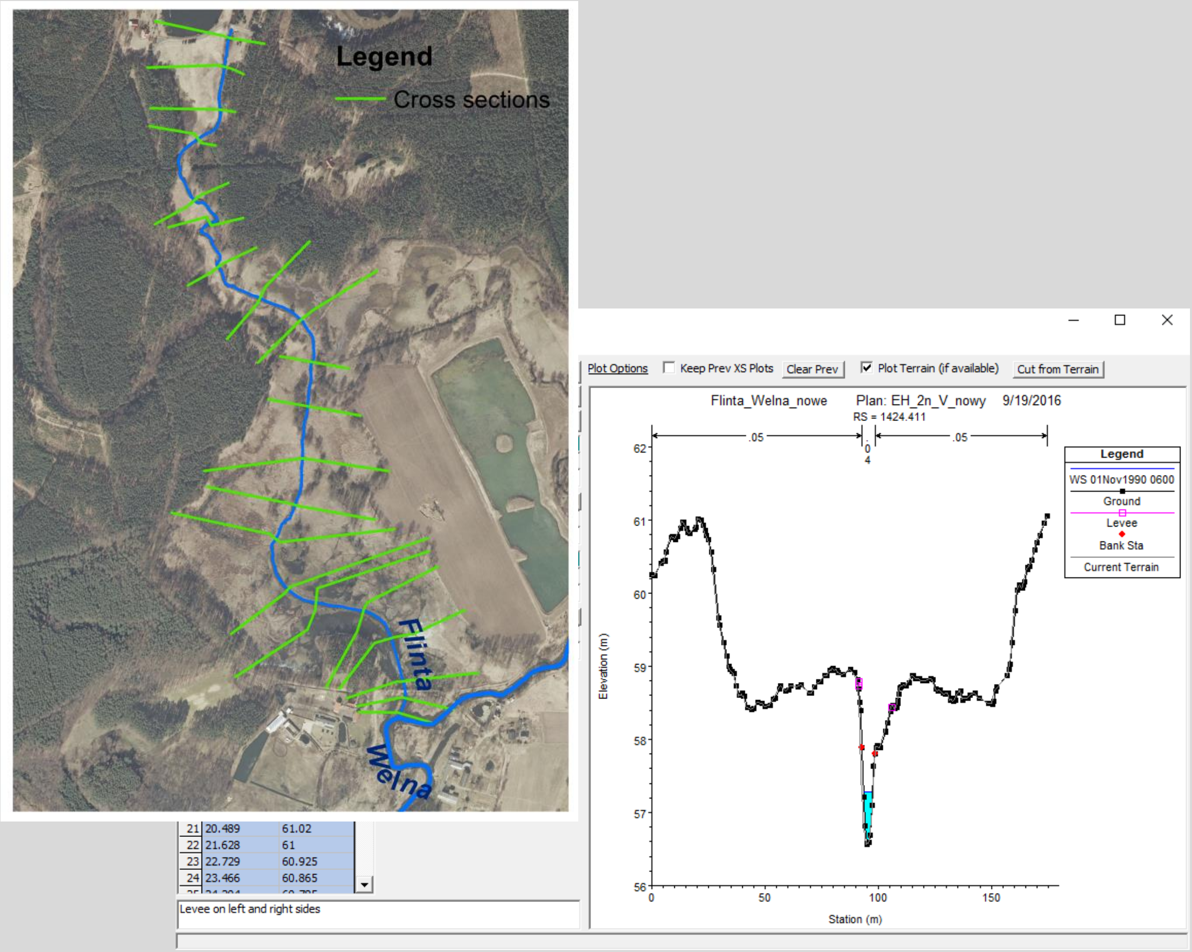


Fig. 7 Cross-sections of the Flinta River obtained from BIPROWODMEL company.

MATERIALS

Aquired data

Hydrological data

DEM

Digital maps

Cross sections

Sediment sample

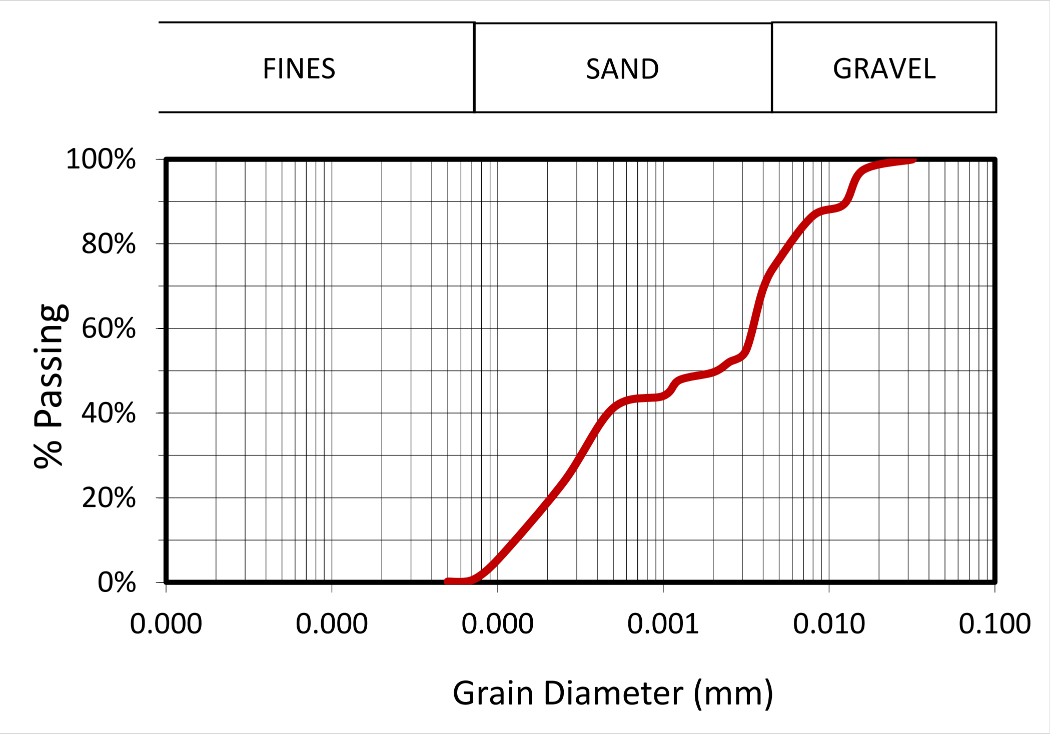


Fig. 8 Sieve curve of the sediment samples collected in the Flinta River.

METHODS (1)

Pre–processing of data

development of geometries (by spatial analysis tools and geometry tools in HEC-RAS)

Simulation model

quasi-unsteady flow, sediment transport, steady flow

Analysys of the results

Mean, max and min changes of bottom elevations for both geometries, water surface elevation

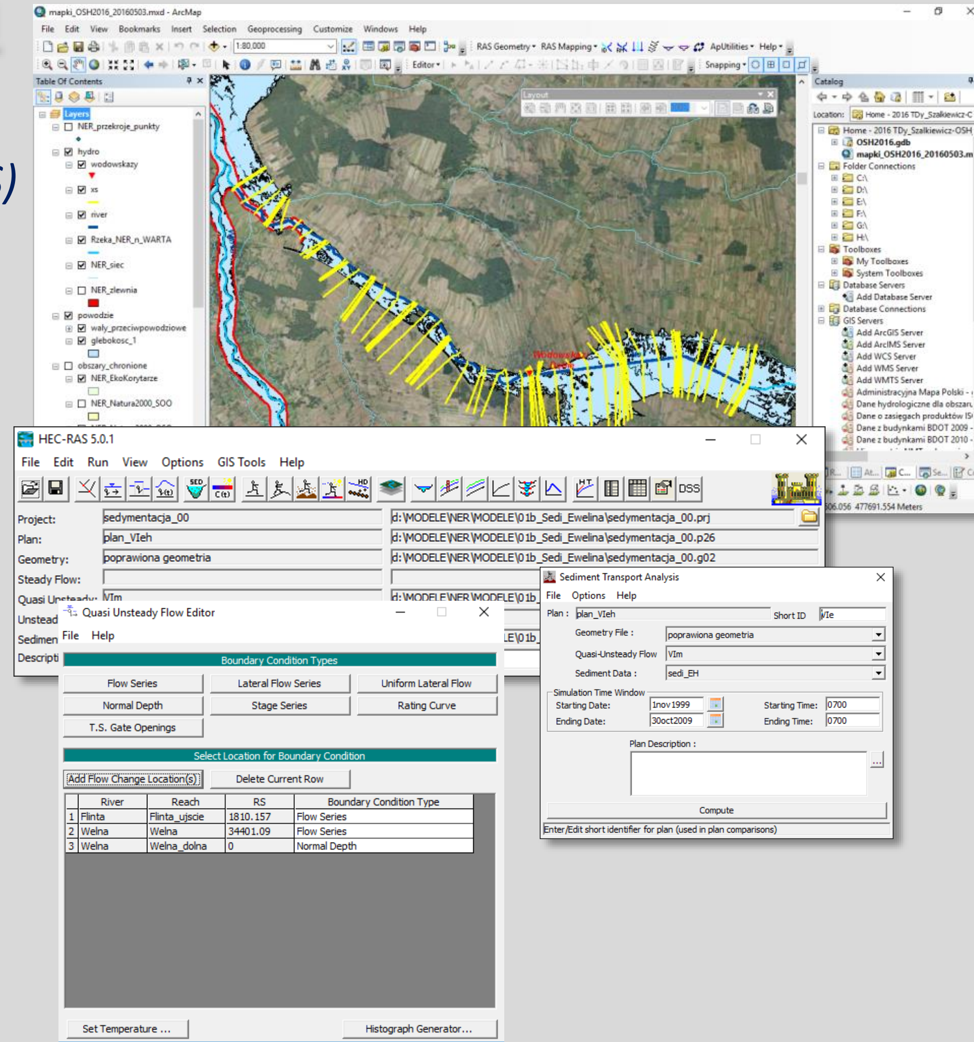


Fig. 9 Tools used to the analysis.

METHODS (1)

Deflectors

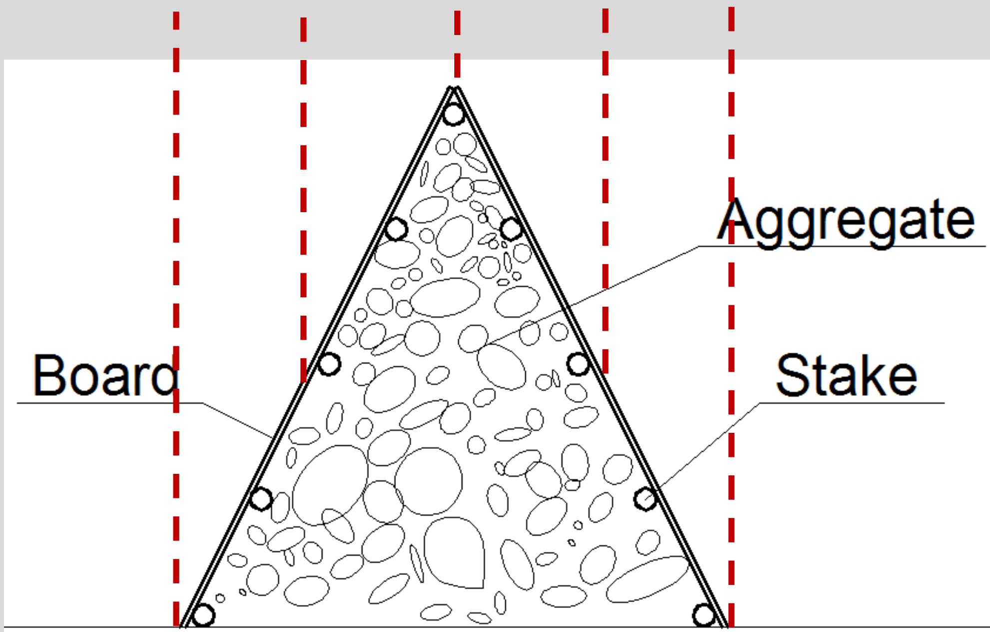
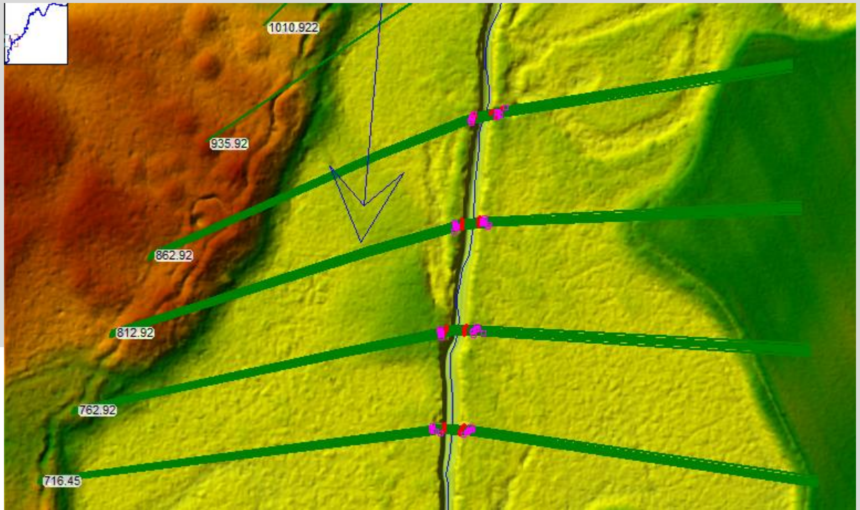
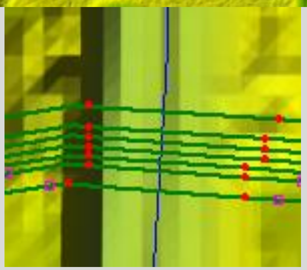
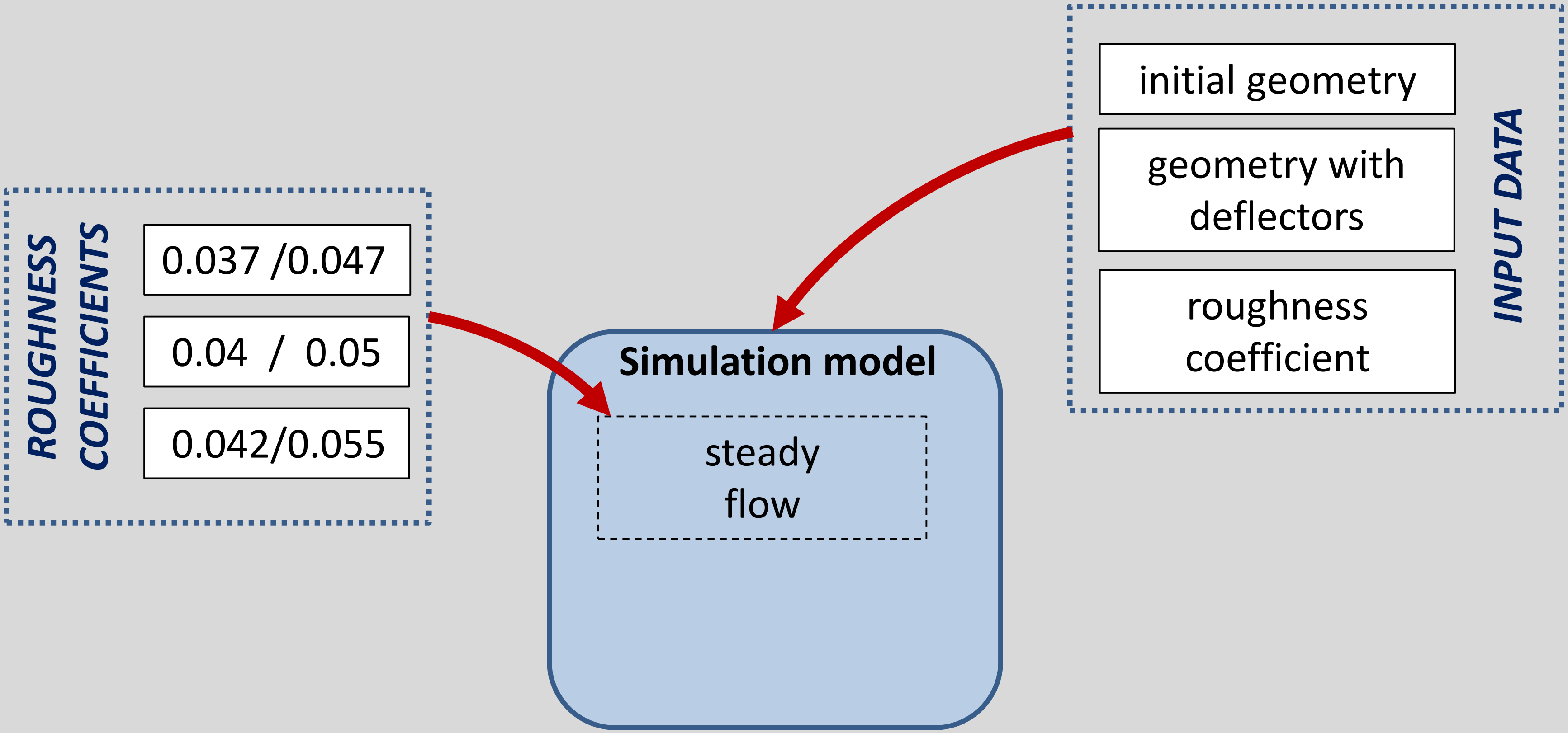


Fig. 10 Scheme of deflector.

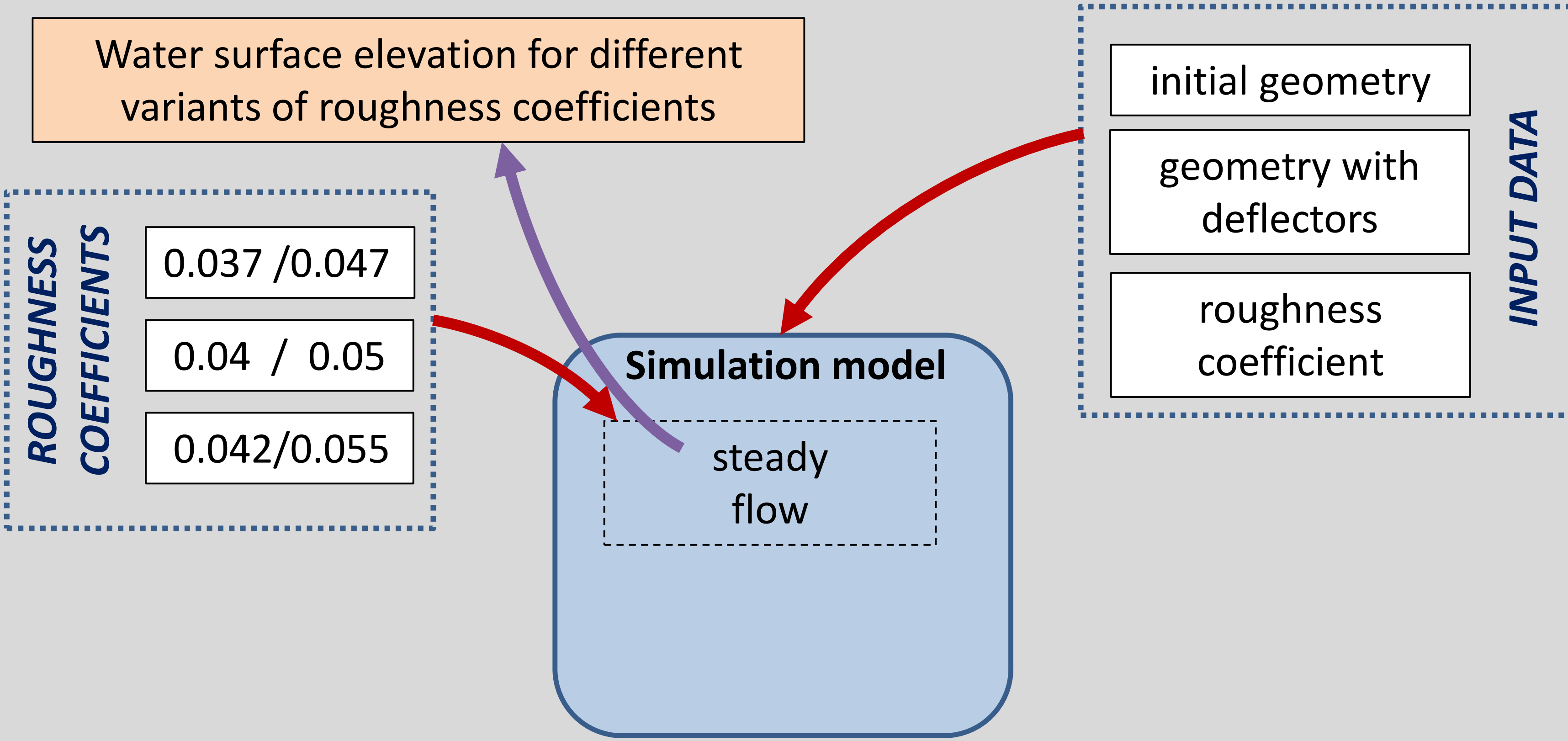




METHODS (2)


ROUGHNESS COEFFICIENTS
0.037 /0.047
0.04 / 0.05
0.042/0.055
Simulation model
steady flow
initial geometry
geometry with deflectors
roughness coefficient
INPUT DATA

METHODS (2)


Water surface elevation for different variants of roughness coefficients
ROUGHNESS COEFFICIENTS
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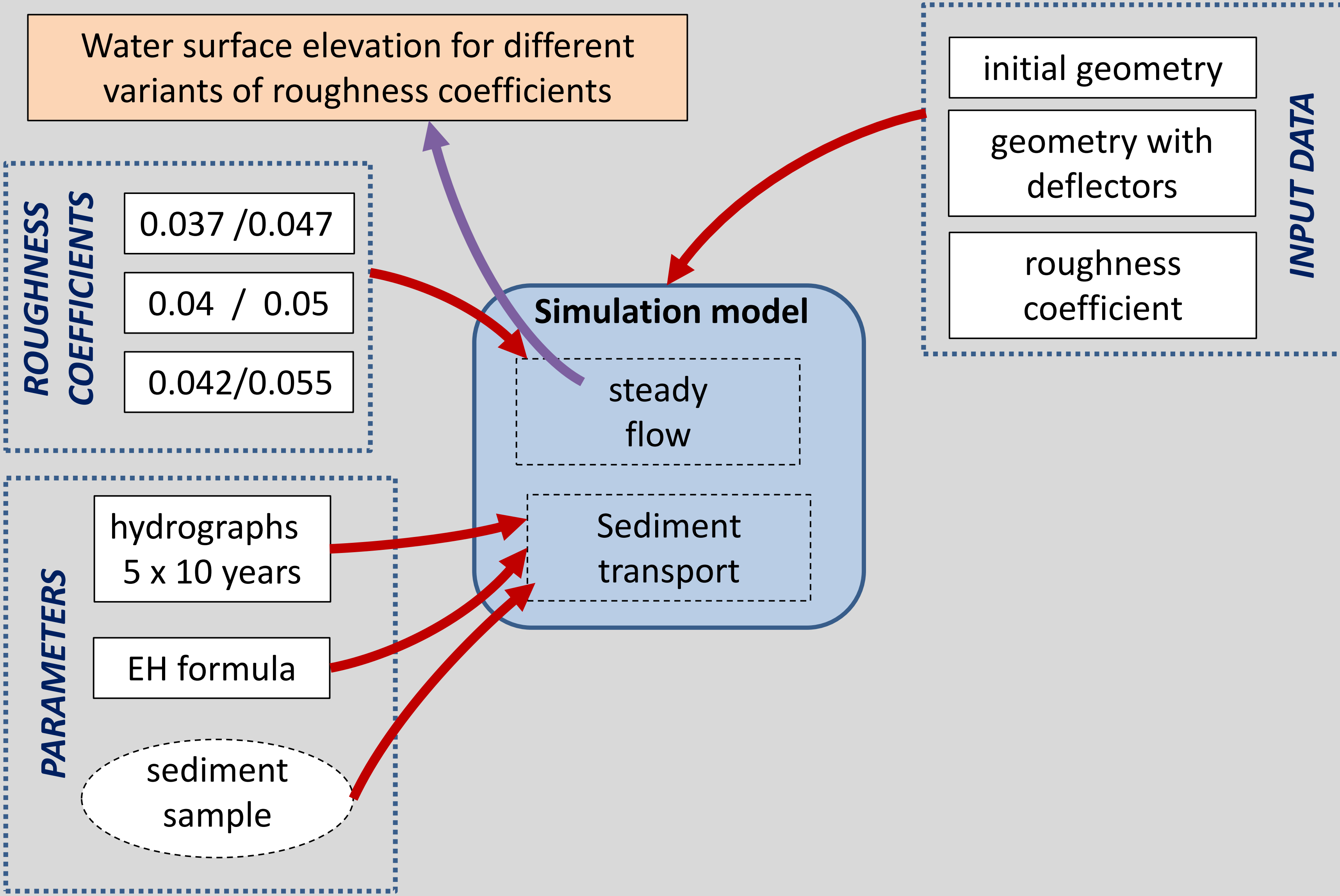

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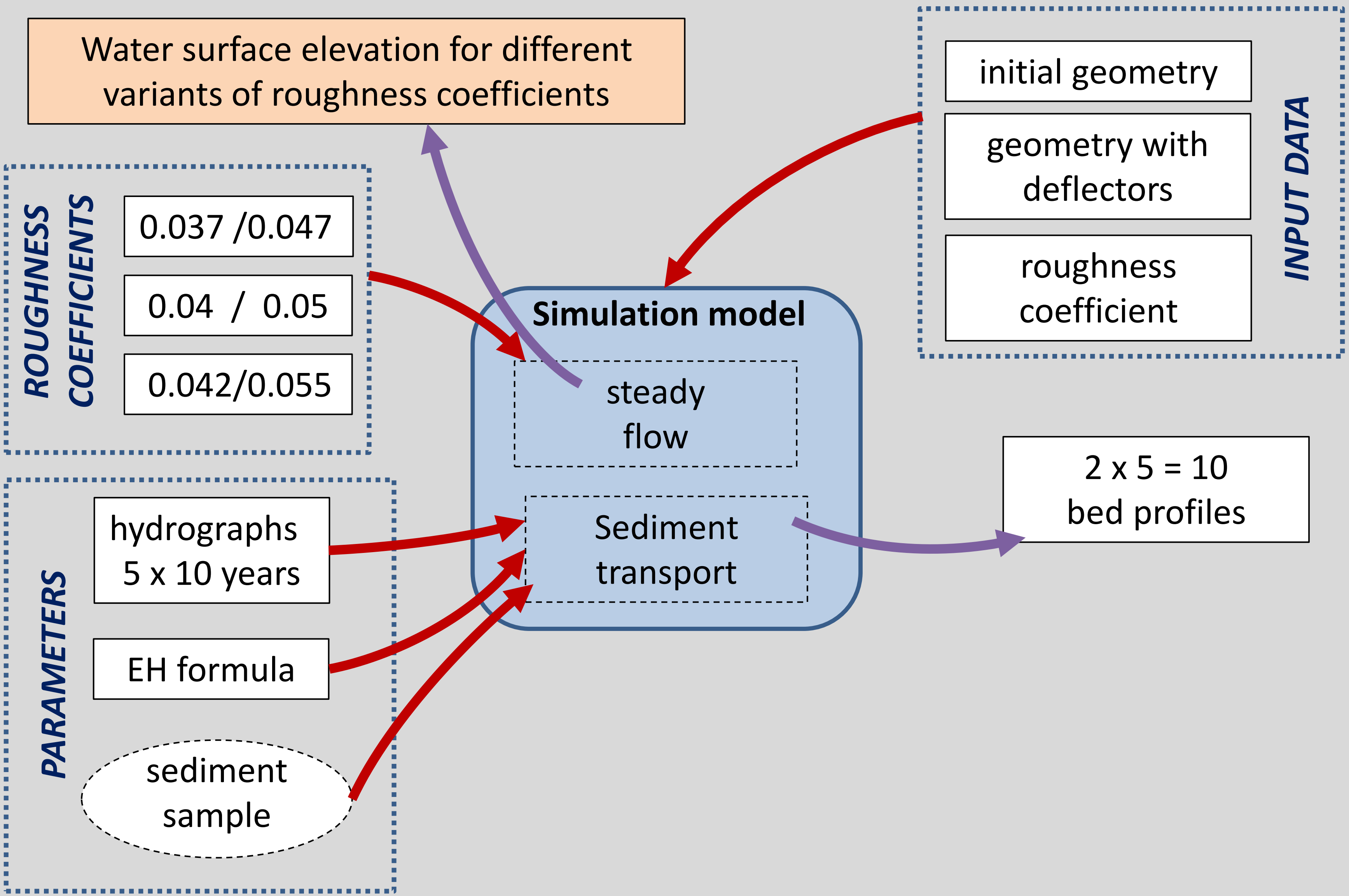
Simulation model
steady flow
Sediment transport
PARAMETERS
hydrographs 5 x 10 years
EH formula
sediment sample

METHODS (2)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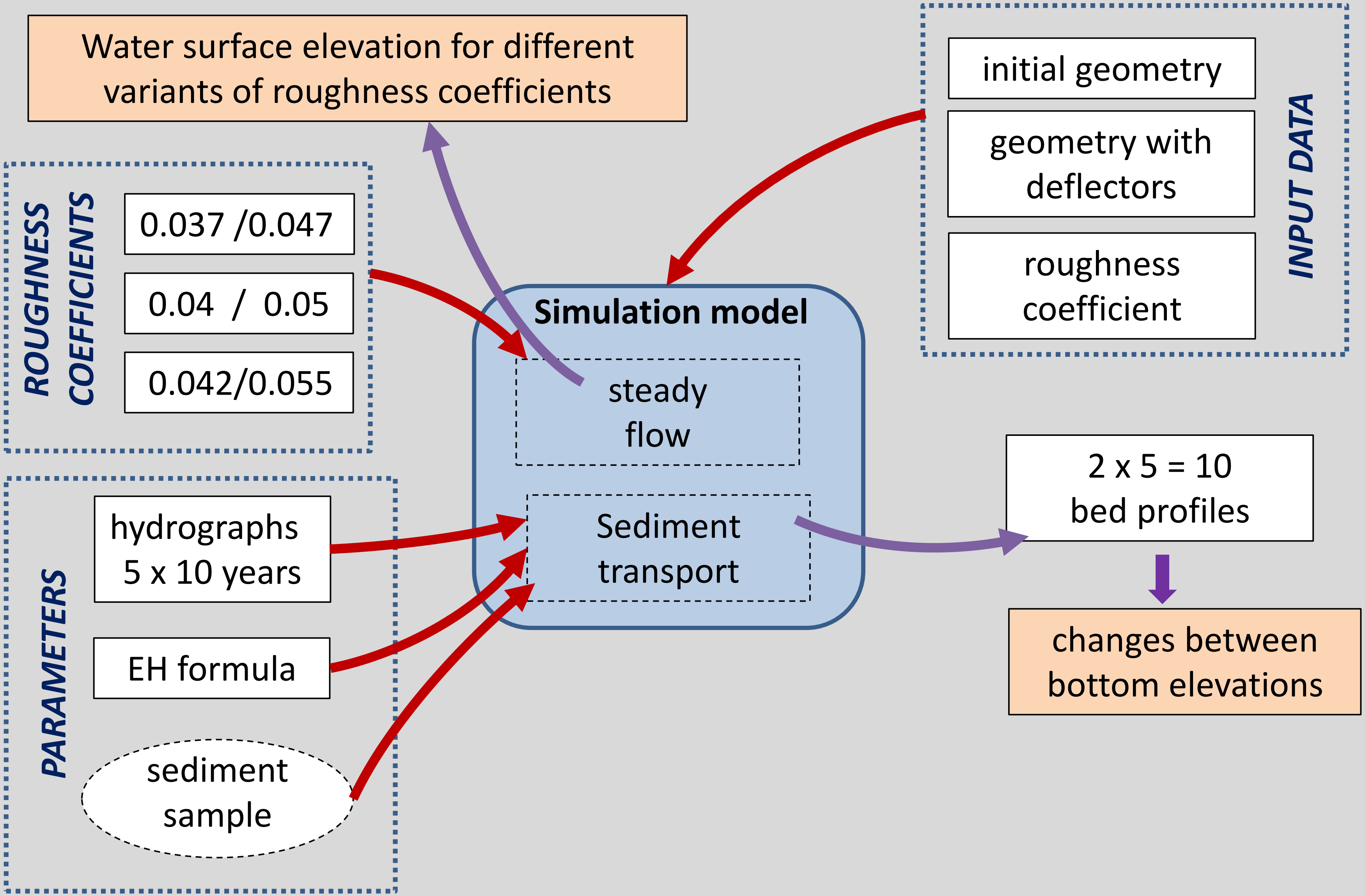
roughness coefficient
2 x 5 = 10 bed profiles

METHODS (2)


Water surface elevation for different variants of roughness coefficients
ROUGHNESS COEFFICIENTS
0.037 /0.047
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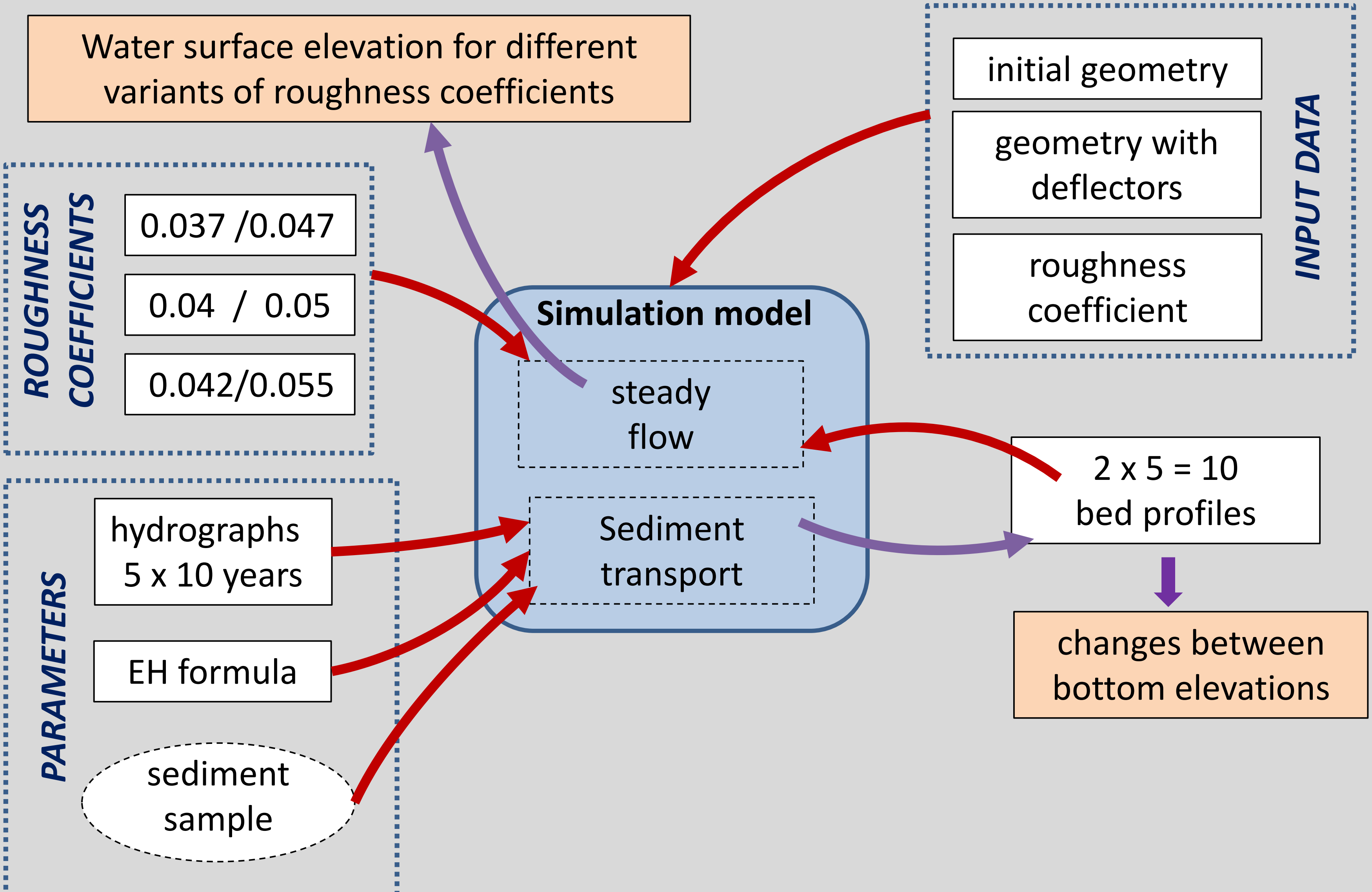
Simulation model
steady flow
Sediment transport
INPUT DATA
initial geometry
geometry with deflectors
roughness coefficient
2 x 5 = 10 bed profiles
changes between bottom elevations
PARAMETERS
hydrographs 5 x 10 years
EH formula
sediment sample

METHODS (2)


Water surface elevation for different variants of roughness coefficients
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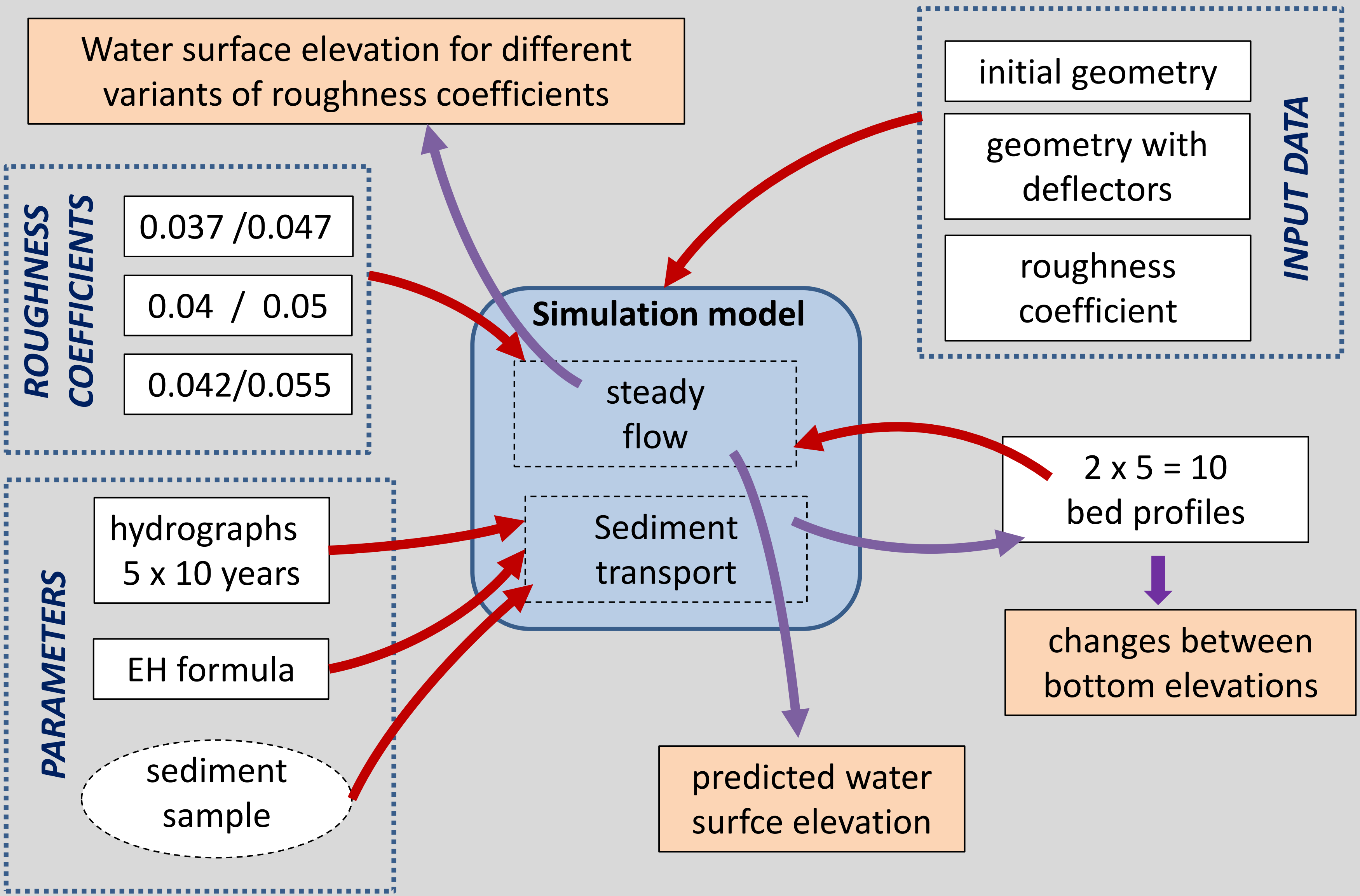
Simulation model
steady flow
Sediment transport
INPUT DATA
initial geometry
geometry with deflectors
roughness coefficient
2 x 5 = 10 bed profiles
changes between bottom elevations

METHODS (2)



Water surface elevation for different variants of roughness coefficients
initial geometry
geometry with deflectors
roughness coefficient
INPUT DATA
ROUGHNESS COEFFICIENTS
0.037 /0.047
0.04 / 0.05
0.042/0.055
Simulation model
steady flow
Sediment transport
2 x 5 = 10 bed profiles
changes between bottom elevations
PARAMETERS
hydrographs 5 x 10 years
EH formula
sediment sample
predicted water surfce elevation

RESULTS (1)

Cross-section [m]	Differences between variants [m]		
	I - II	II - III	I – III
41	0.17	0.05	0.11
712	0.03	0.04	0.07
760	0.04	0.04	0.08
936	0.02	0.04	0.06

Tab. 3 Maximum differences in water surface elevation after calculations for three variants of Manning's coefficient.

RESULTS (2)

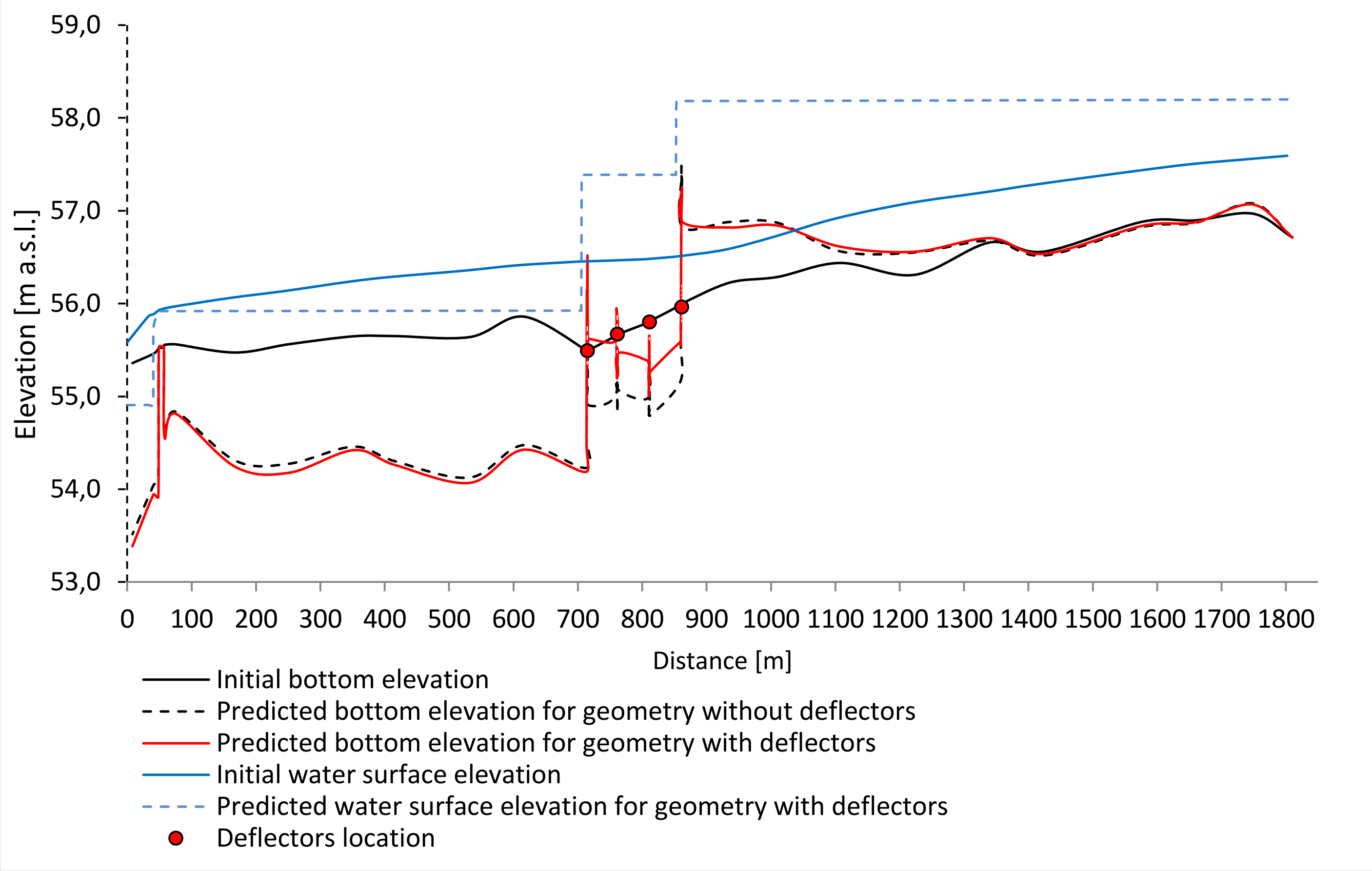


Fig. 11 Changes in bottom elevation after simulations for geometry with and without deflectors calculated assuming the Engelund-Hansen formula.

RESULTS (2)

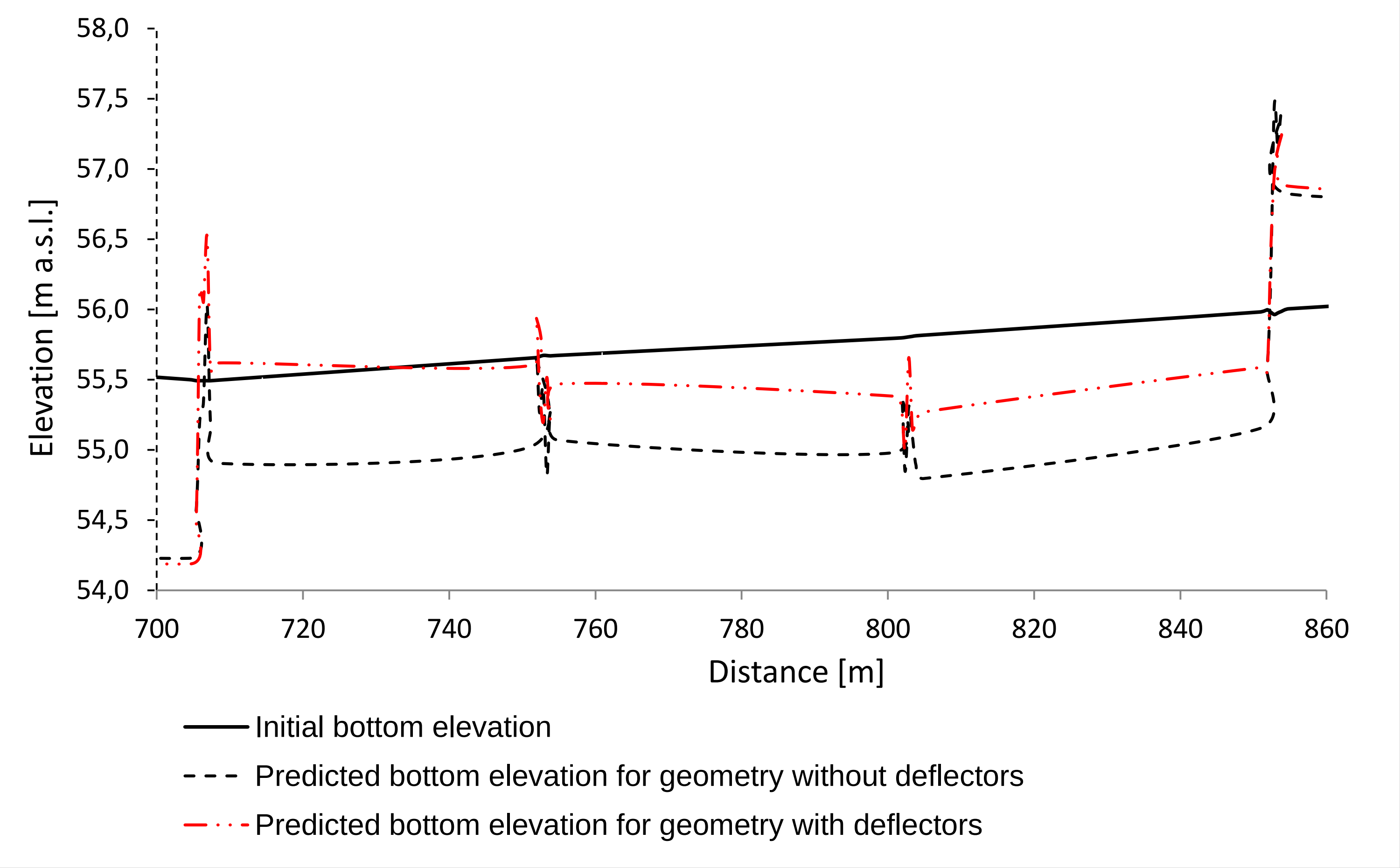


Fig. 12 Changes in bottom elevation after simulations for geometry with and without deflectors calculated assuming the Engelund-Hansen formula.

RESULTS (3)

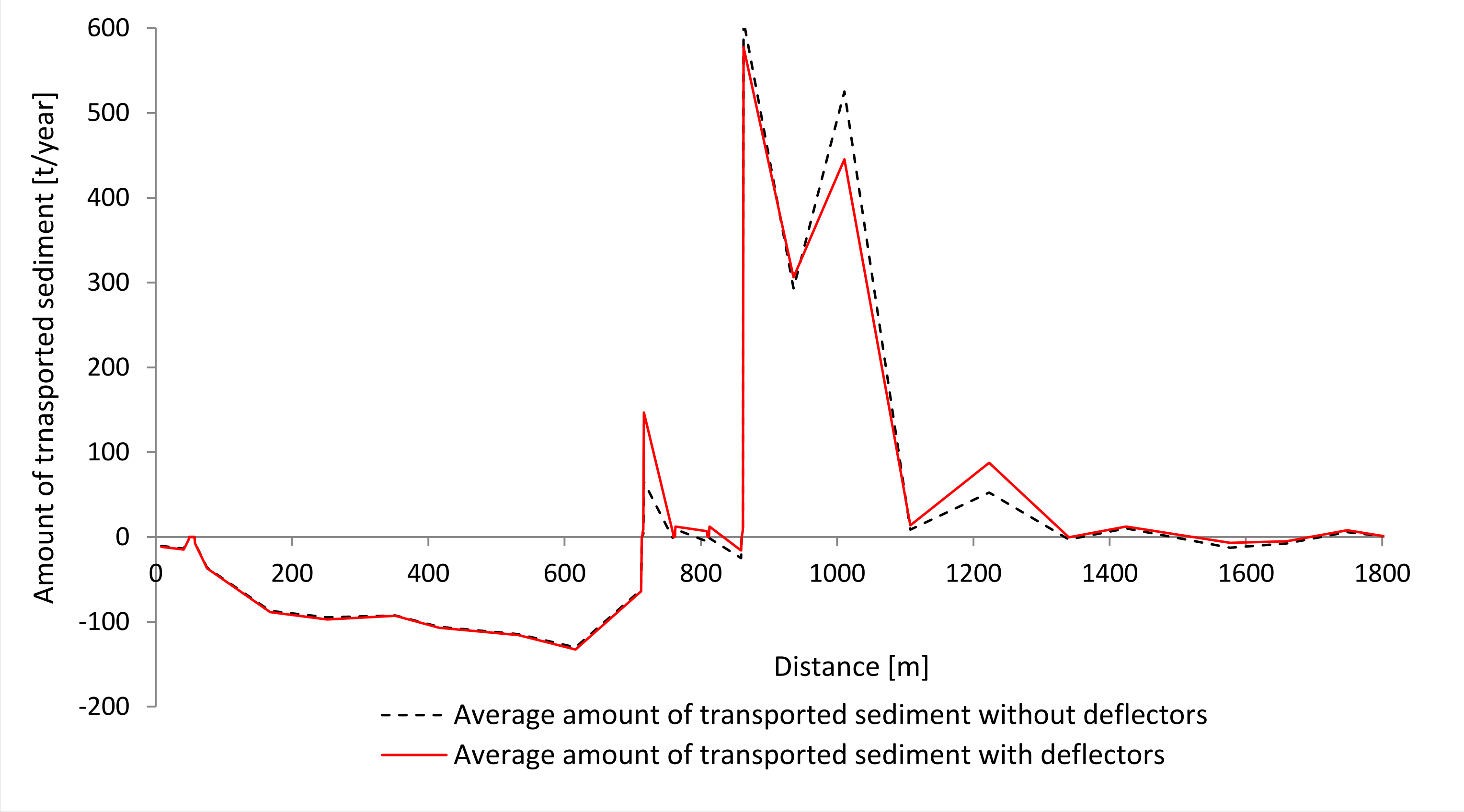


Fig. 13 Mean amount of transported sediments for variants without deflectors and with deflectors.

CONCLUSIONS

- *In the location of deflectors increased slope and depth may caused erosion*
- *Deflctors may accelerate (?) water flow what led to less erosion (?) in comparison with geometry without structures.*
- *Cascade bed profile may led to discussion about abundance of cross sections and distance between each other what is significant from the point of view of attempts to model unusual structers in 1D models.*
- *To getting more information about deflector's impact, the presented research should be tested with other formulas for intensity of sediment transport and confronted with observations in nature.*

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RÓWNANIA MODELU SYMULACYJNEGO (1)

Quasi – unsteady flow

$$H_1 + \alpha_1 \frac{u_1^2}{2g} = H_2 + \alpha_2 \frac{u_2^2}{2g} + \Delta x \bar{S}_f + C \left| \alpha_2 \frac{u_2^2}{2g} - \alpha_1 \frac{u_1^2}{2g} \right|$$

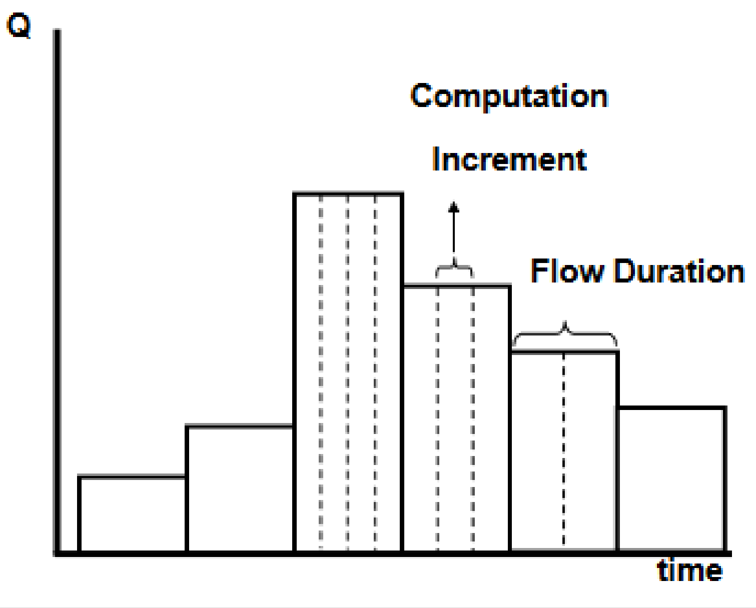

Fig. 14 A Quasi-Unsteady Flow Series with time step (Brunner 2016).

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RÓWNANIA MODELU SYMULACYJNEGO (2)

Engelunda – Hansena forumla

$$C_w = 0.05\frac{\gamma R_h S_f}{(\gamma_s-\gamma)d_s}\left(\frac{\gamma_s}{\gamma_s-\gamma}\right)\frac{uS_f}{\left[\left(\frac{\gamma_s}{\gamma}-1\right)gd_s\right]^{0.5}} \qquad \left(\frac{N_{(sed)}}{N_{(mix)}}\right)$$

$$q_v = \frac{\gamma Q C_w}{B_s[\gamma_s-(\gamma_s-\gamma)C_w]} \qquad \left(\frac{m^3}{m_{(w)}\cdot s}\right)$$

Exner's equation

$$(1-\lambda)B_s\frac{\partial z_b}{\partial t}+\frac{\partial Q_s}{\partial x}=0$$