W3M Conference

„ For Wetlands: Monitoring, Modelling and Management”

22-25 September 2005

Numerical modeling of material fluxes on the floodplain wetland of Pilica River, Poland

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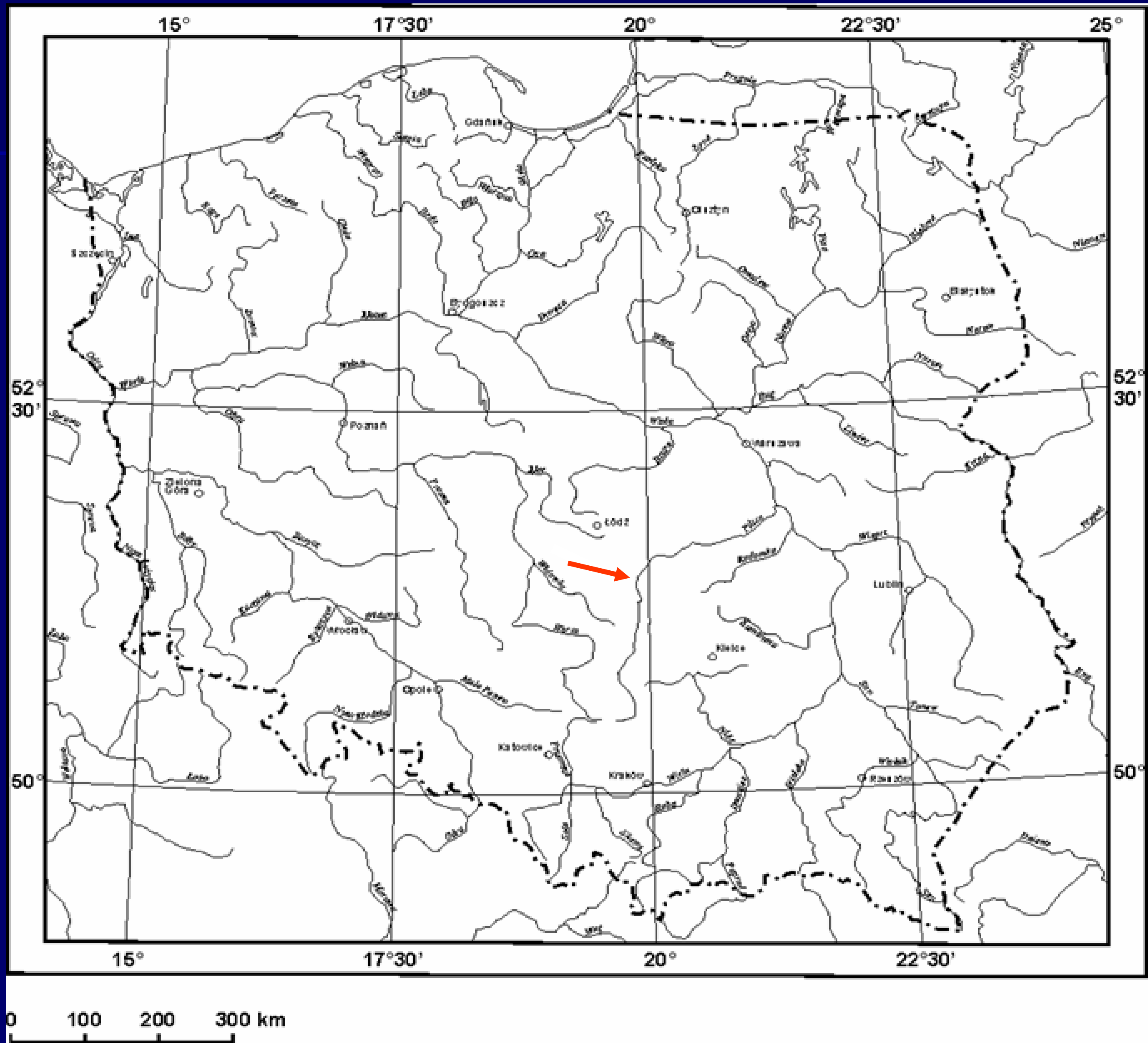
LOCATION OF THE PILICA RIVER

Sulejow gauge

A=3909 km^2

MQ=27.6 m^3/s

HQ=161 m^3/s



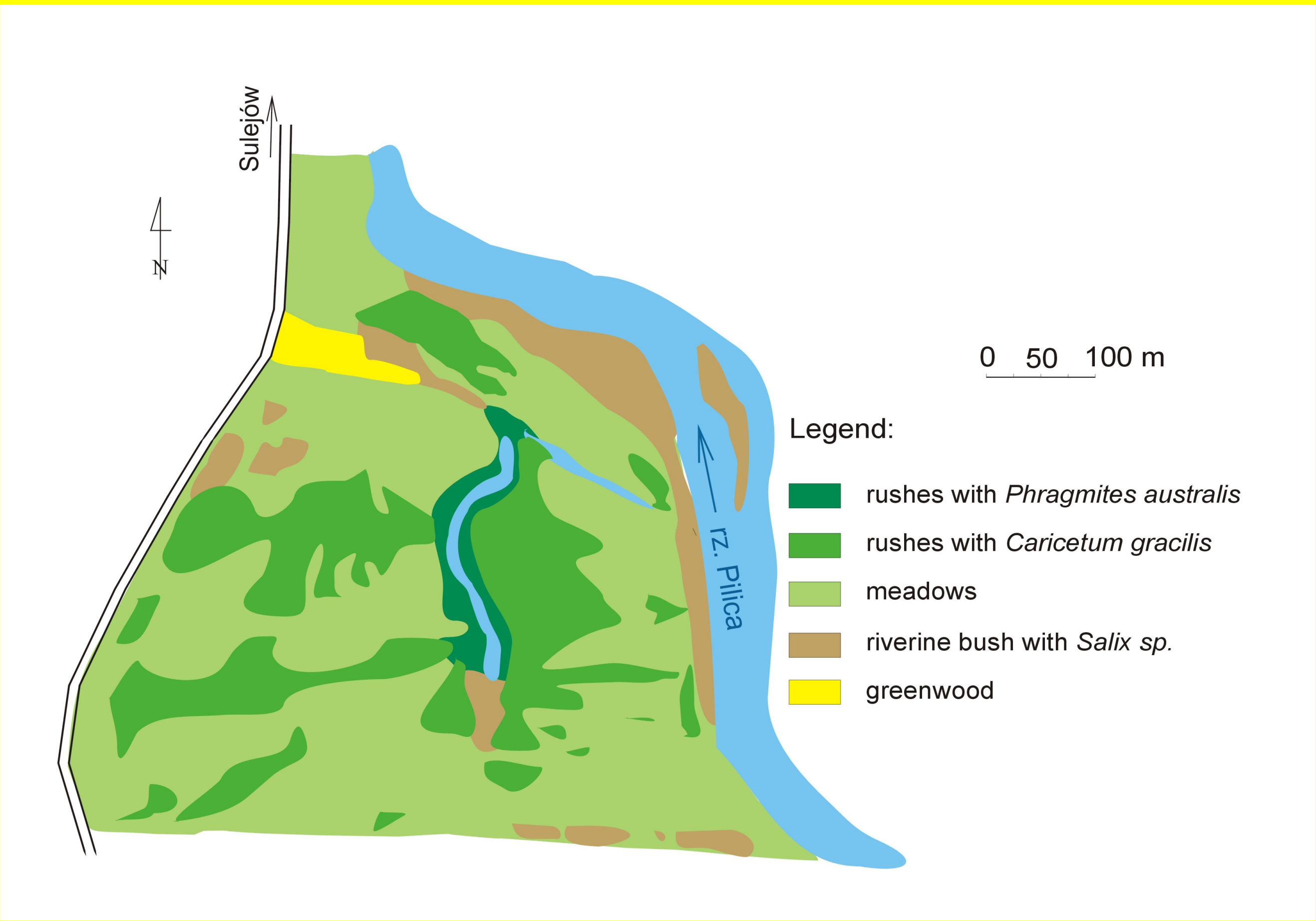
LOCATION OF THE PILICA RIVER FLOODPLAIN

Pilica River Floodplain

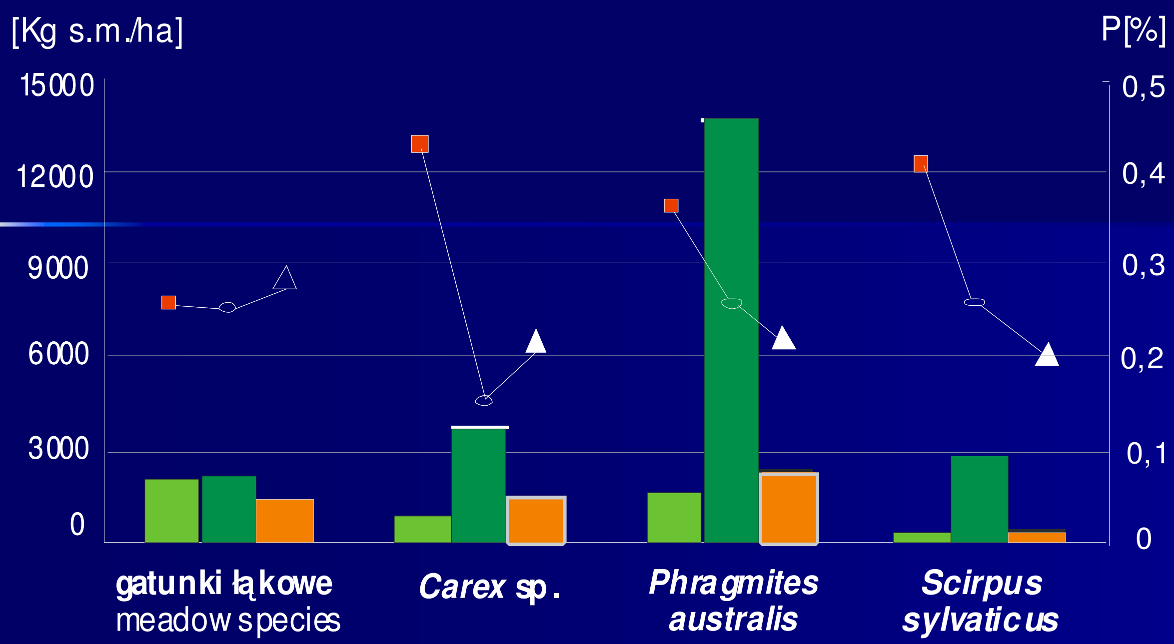
2005-10-26


Study
area

PLANT COMMUNITIES ON THE FLOODPLAIN



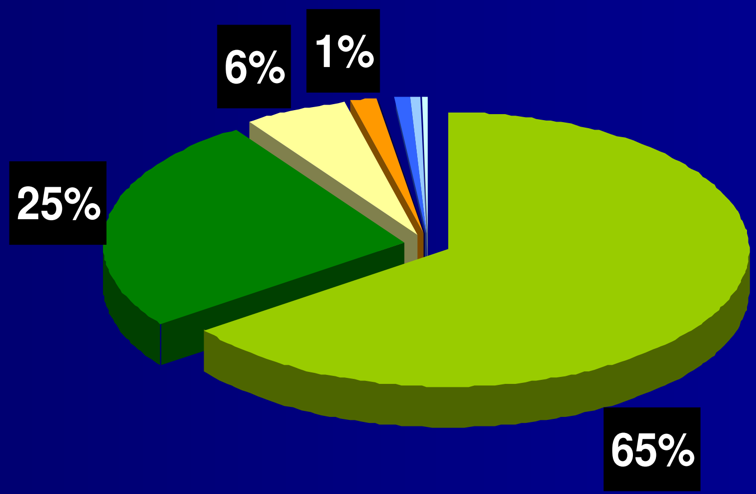
ABILITY TO PHOSPHORUS ASSIMILATION BY NATIVE SPECIES



The seasonal change of biomass and phosphorus content

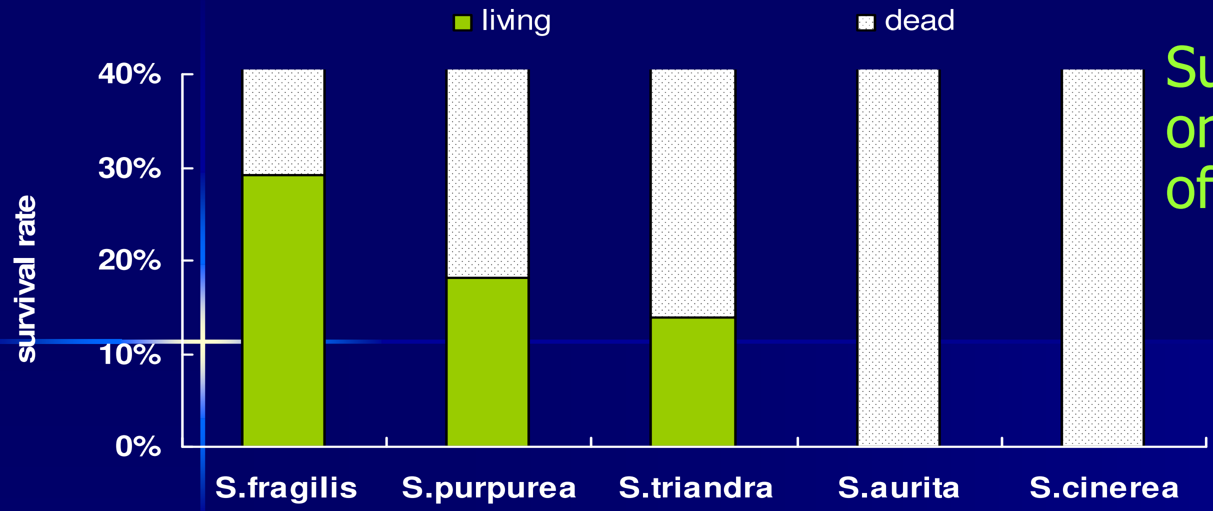
	wiosna spring	lato summer	jesień autumn
Biomasa biomass	■	■	■
zawartość P[%] P content [%]	■	⬭	▲

Plants cover



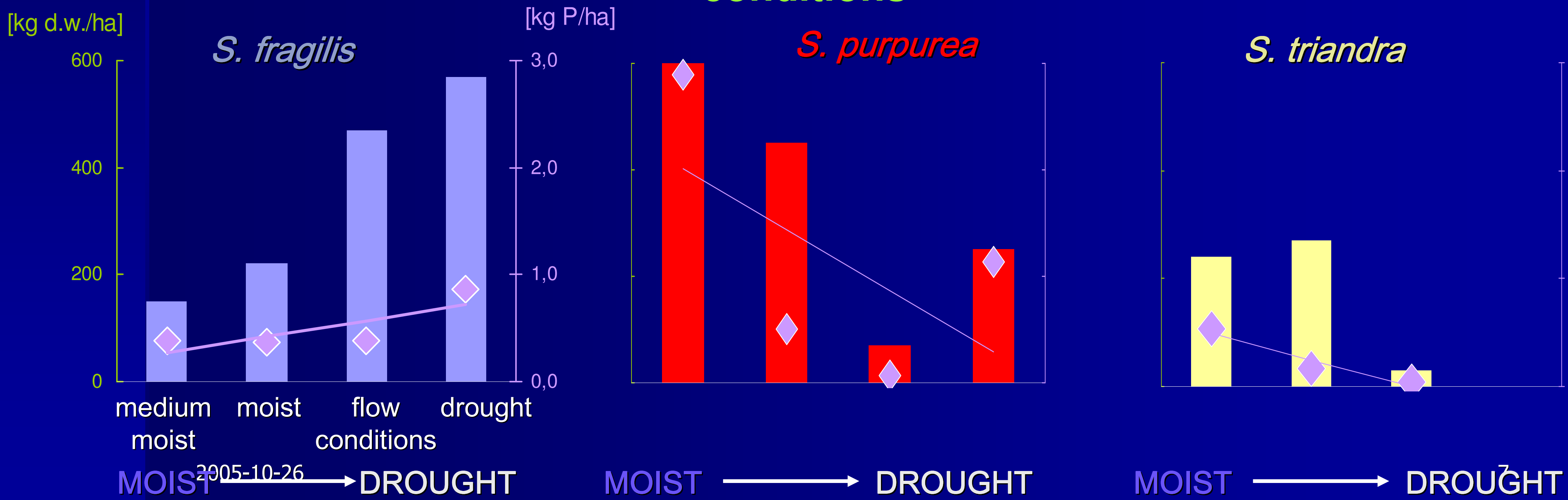
- gatunki łąkowe
- *Carex gracilis i vesicaria*
- *Phragmites australis*
- *Scirpus sylvaticus*

ABILITY TO PHOSPHORUS ASSIMILATION BY WILLOWS



Survival rate of autochtonic *Salix sp.* on the experimental study area of the floodplain

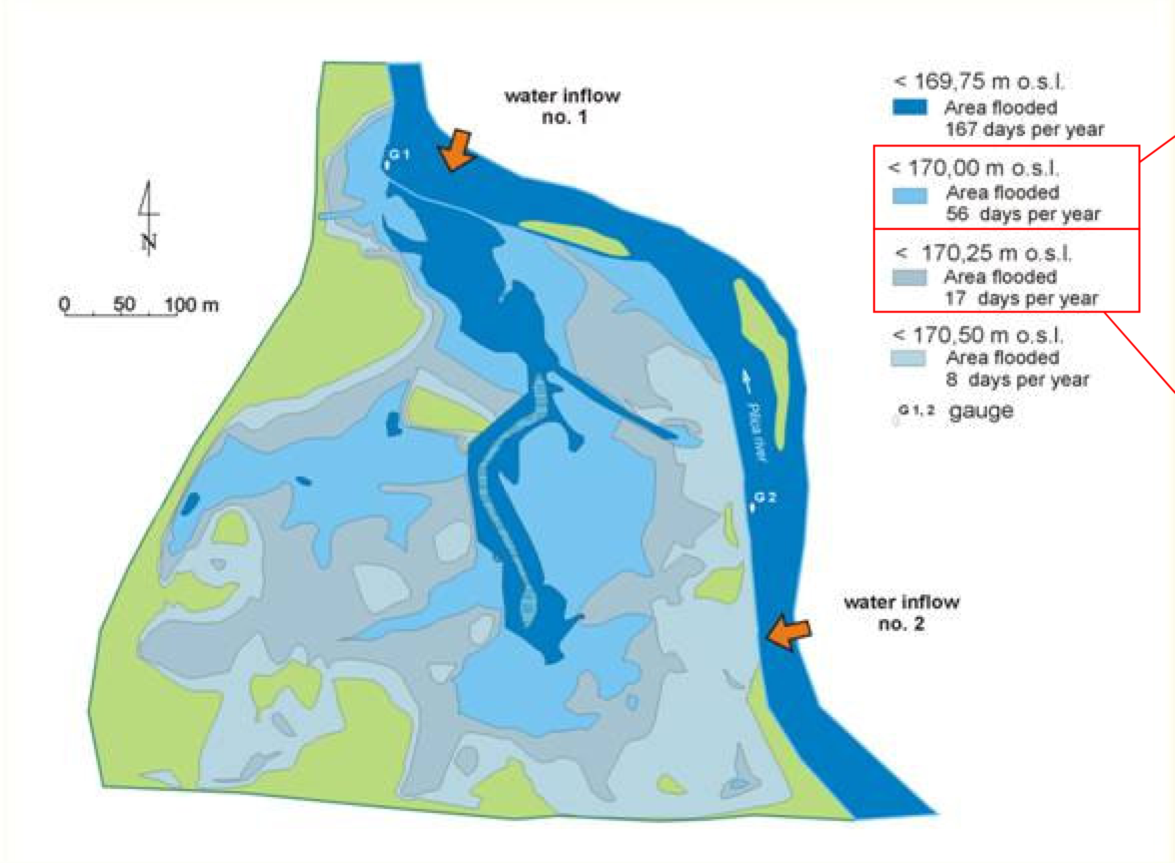
Biomass and phosphorus content of *Salix sp.* in different hydrological habitat conditions



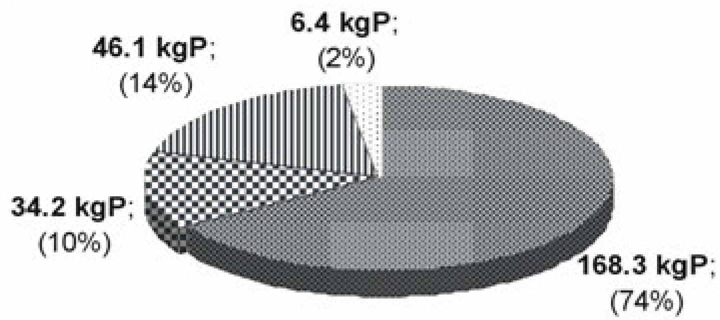
Łukasz Michalak, 2003

TOTAL PHOSPHORUS ACCUMULATION IN FLOODPLAIN BIOMASS

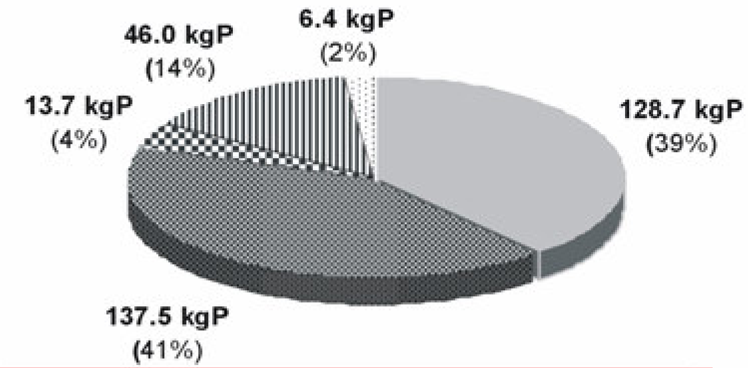
ENHANCEMENT OF ABSORBING CAPACITY OF FLOODPLAIN
for nutrients trapping



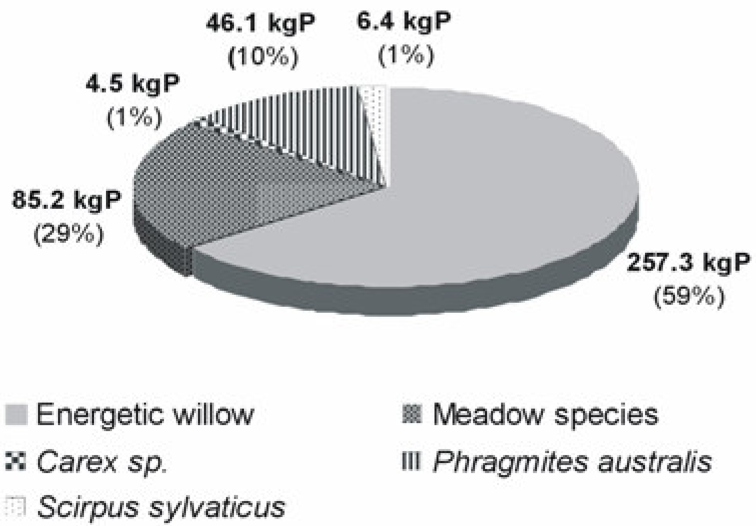
SCENARIO "0"
Accumulation of phosphorus 255.0 kg/floodplain



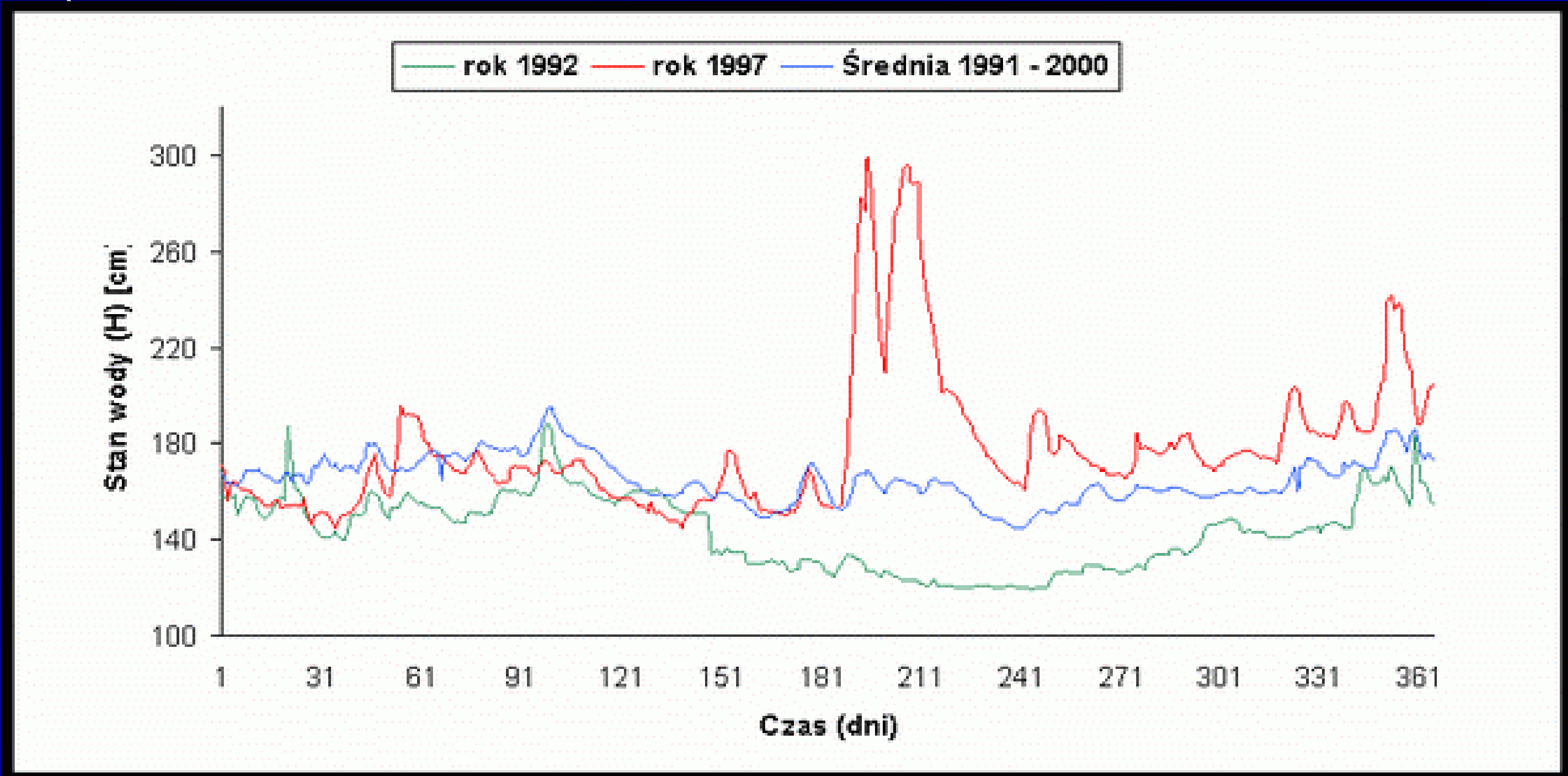
SCENARIO "24"
Accumulation of phosphorus 332.4 kg/floodplain



SCENARIO "48"
Accumulation of phosphorus 399.4 kg/floodplain



DAILY WATER STAGES
at the gauge Sulejow-Kopalnia in: a dry year (1992), wet year (1997) and averaged for a period (1991-2000)

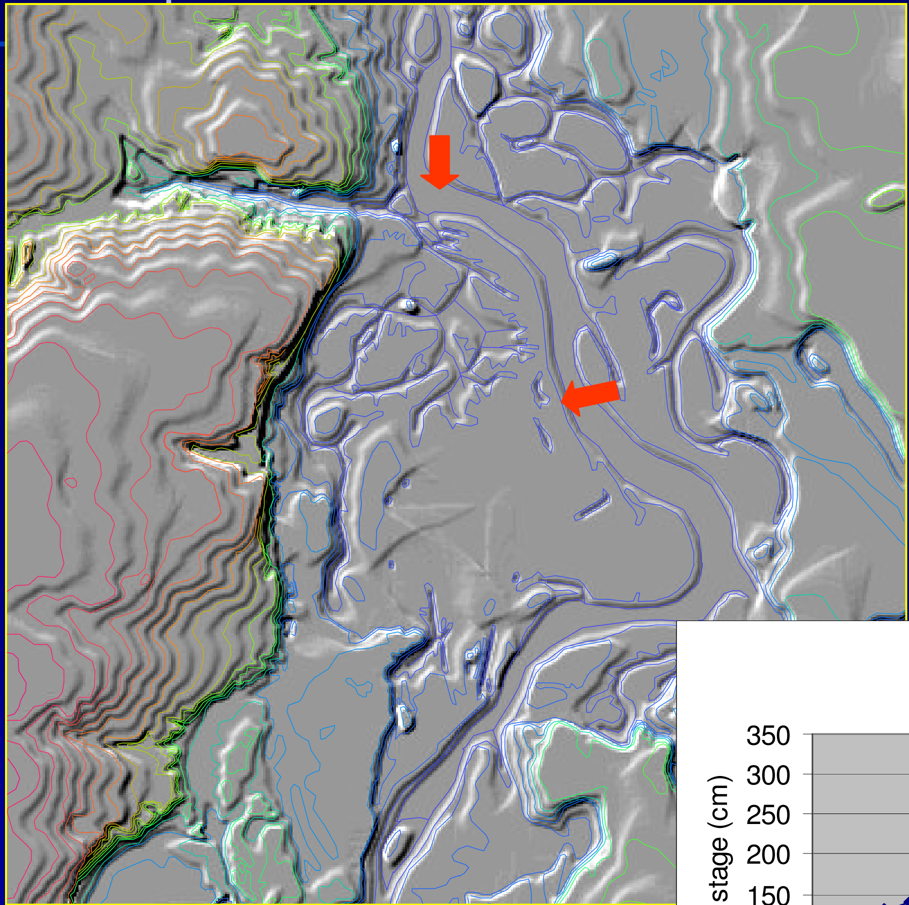


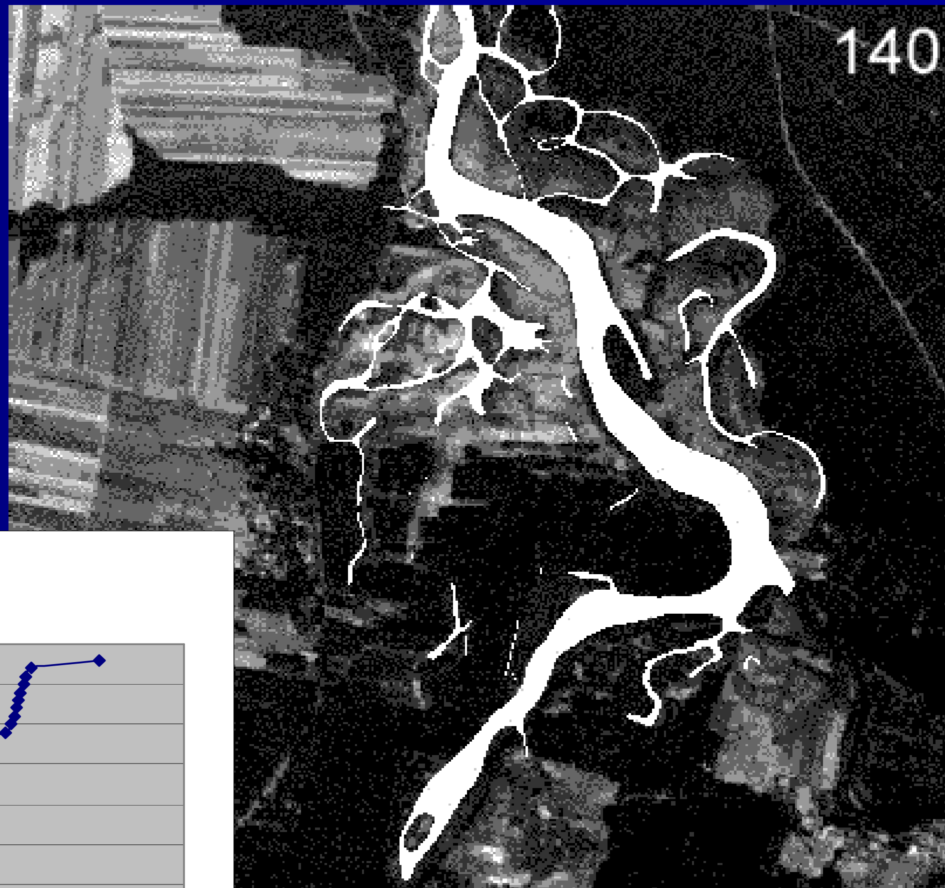
WATER LEVEL of the Pilica River – TP concentration

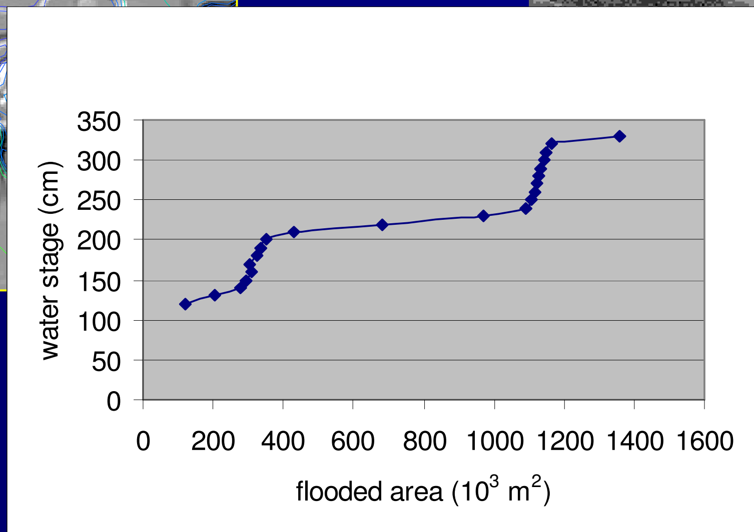
Concentration of the TP transported with the Pilica River during floods

DIGITAL TERRAIN MODEL

Boundary of the model based on DTM analysis







VELOCITY FIELD STRUCTURE

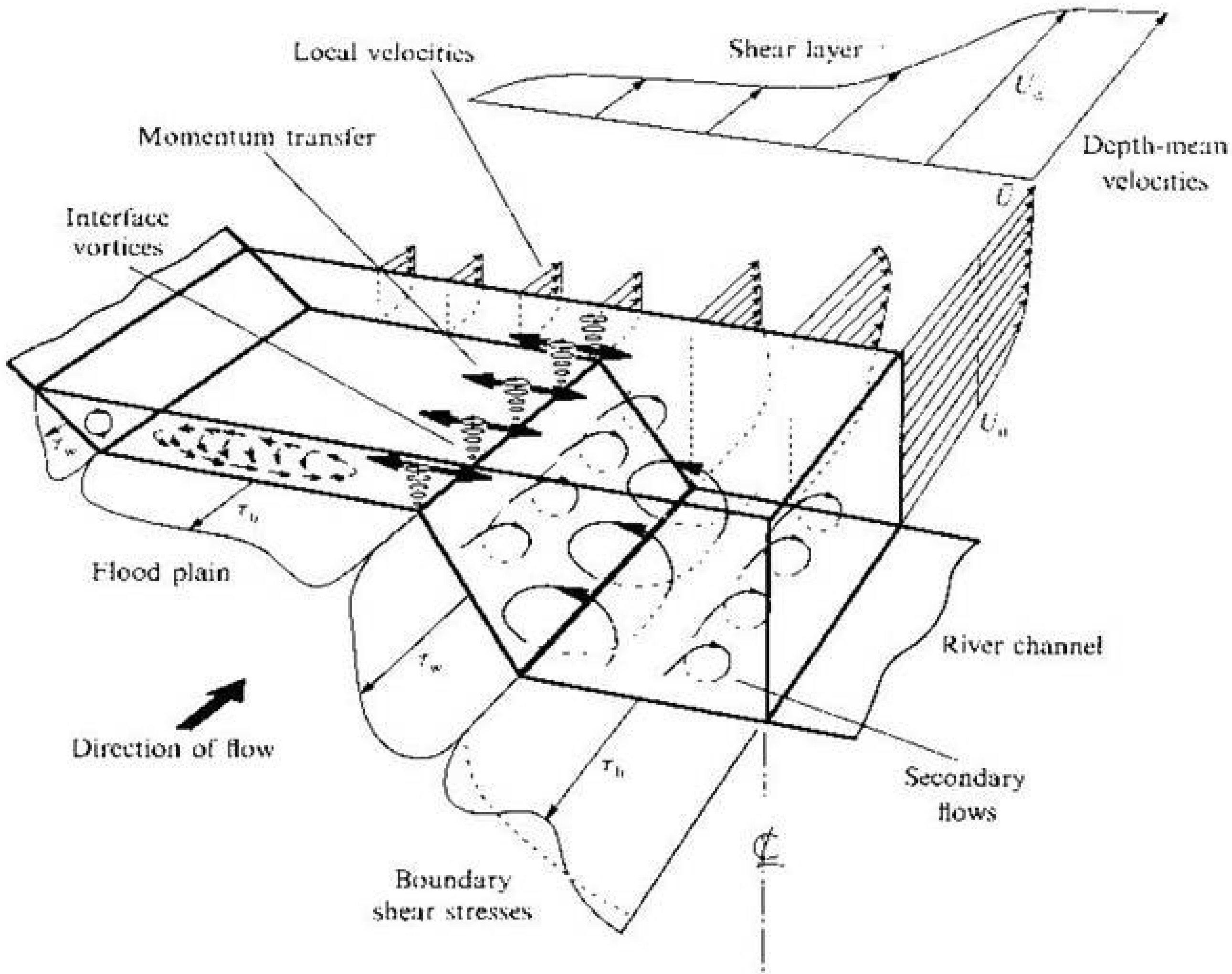
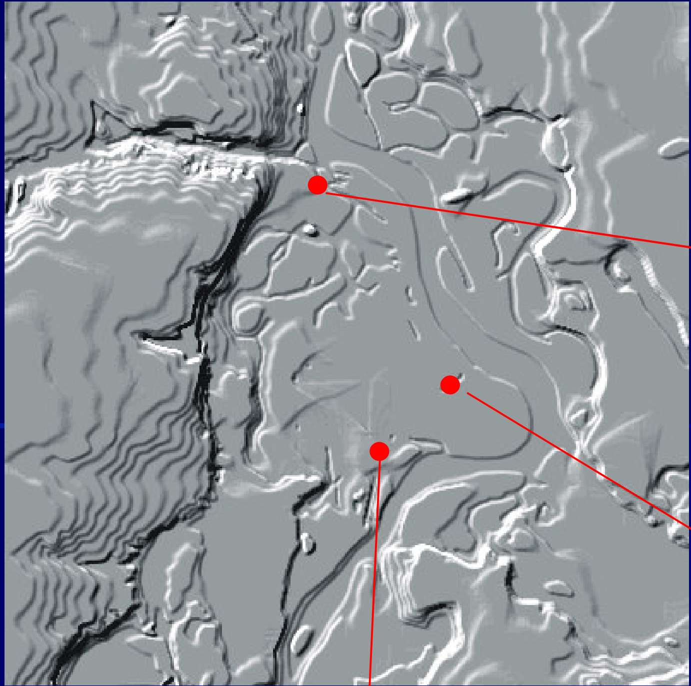


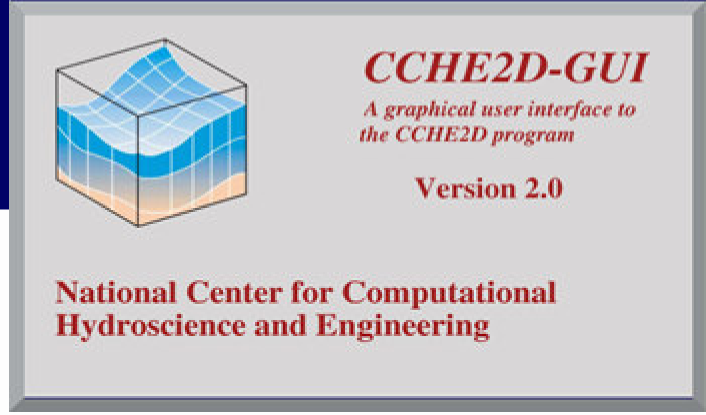
Figure 5.7 Hydraulic parameters associated with overbank flow (after Shiono and Knight, 1991)

Knight, Shiono (1996)

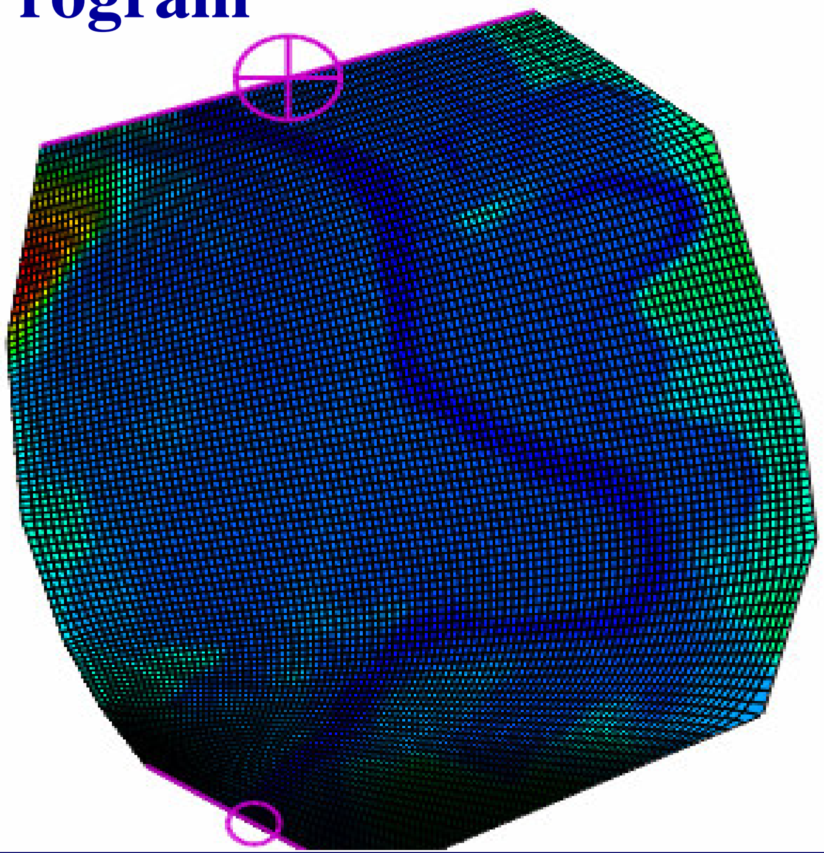
FLOODPLAIN INNUNDATION WAYS



CCHE2D MODEL DATA PREPARATION

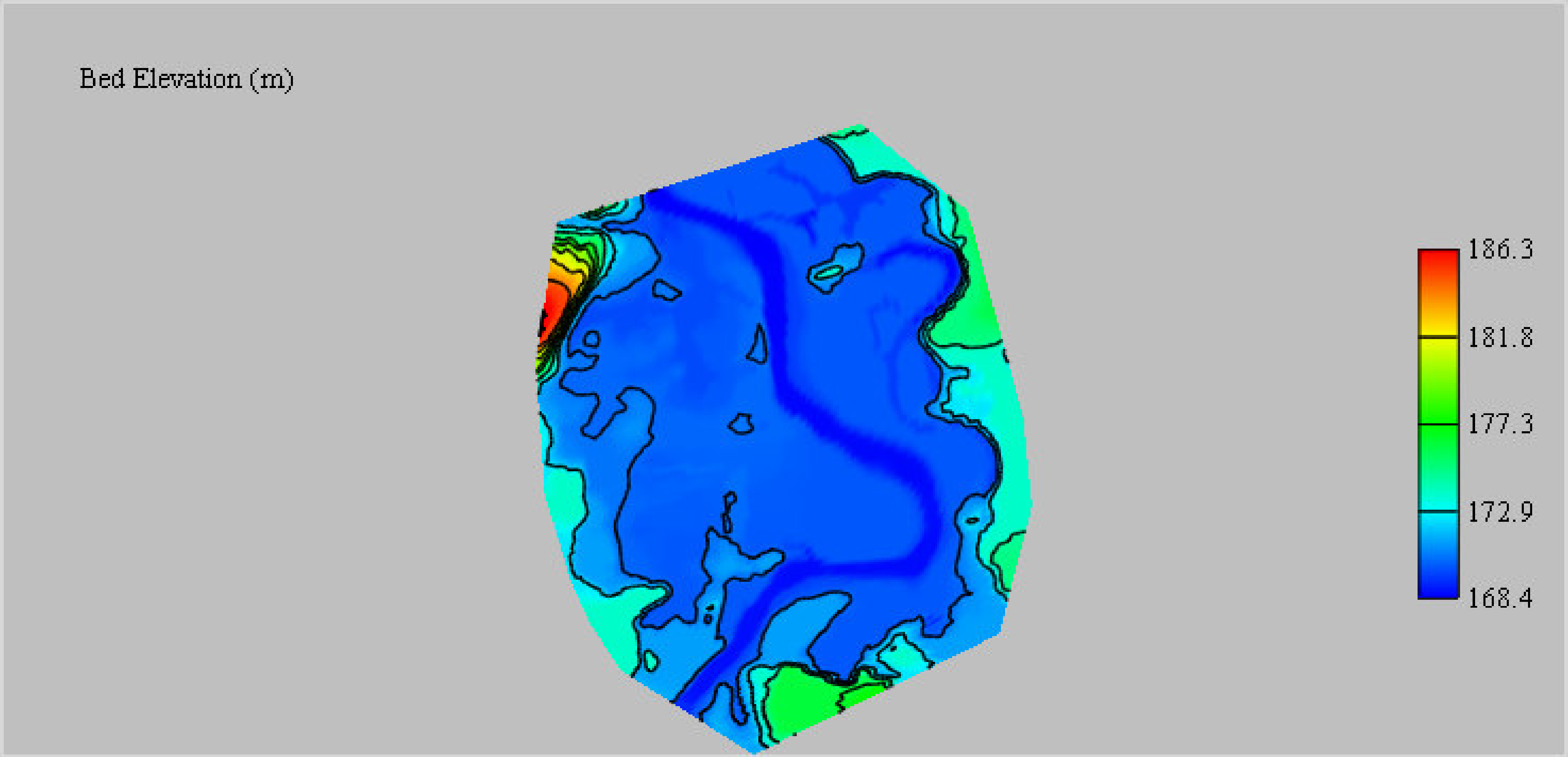


US-Poland Technology Transfer Program of US Agency for International Development (US-AID)



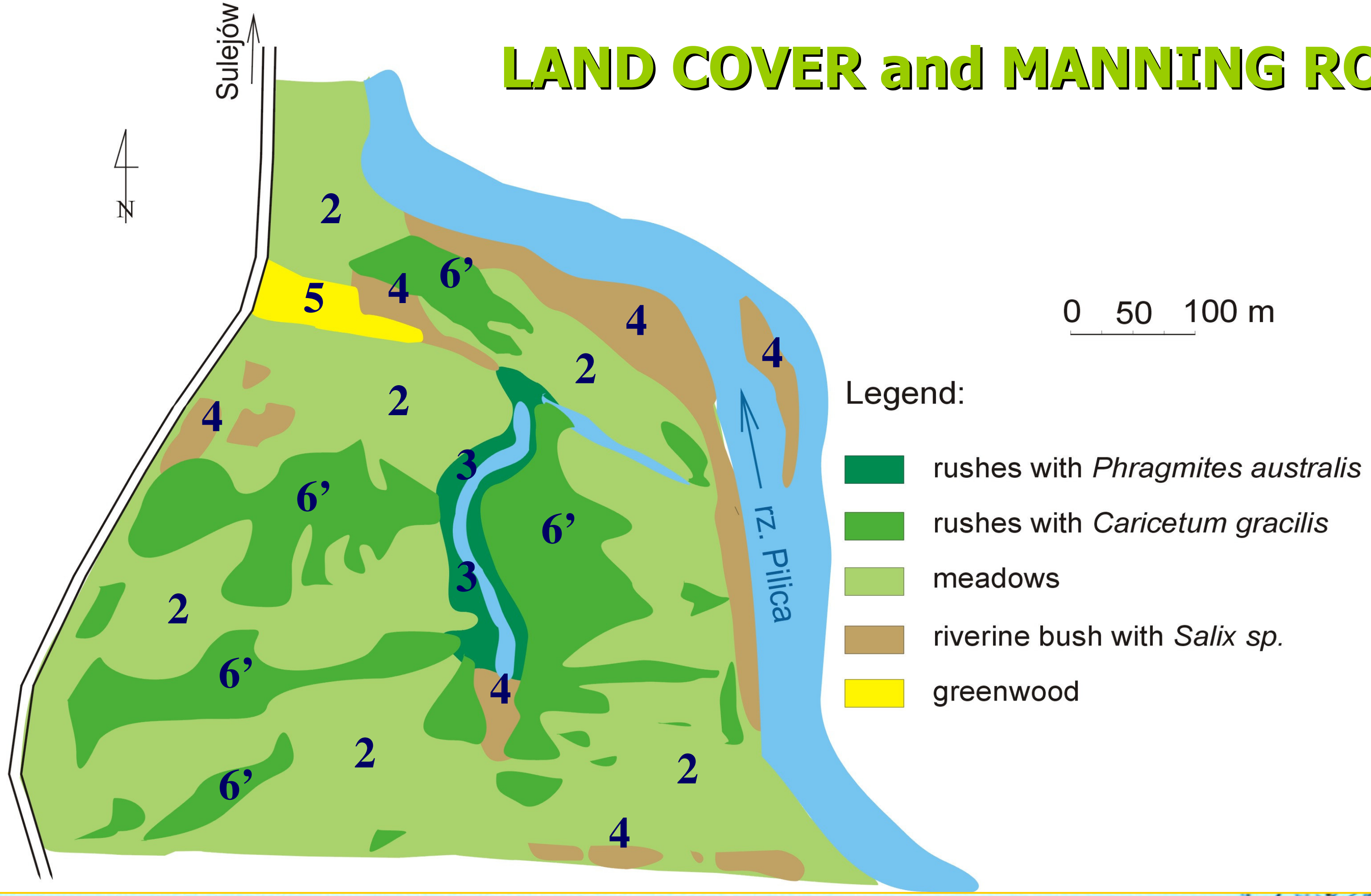
Two-dimensional depth-averaged, unsteady, flow and sediment model. It is based on depth-averaged Navier-Stokes equations. The turbulent shear stress are approximated using Boussineq's approximation and the turbulent eddy viscosity, with the use of three different closure schemes. The set of equations is solved implicitly using control volume approach and efficient element method. The sediment flow is calculated assuming non-uniform material in a non-equilibrium transport model. The equations for suspended, bedload or total load are solved using efficient element of method or exponential difference scheme.

Geometry of the Pilica river valley



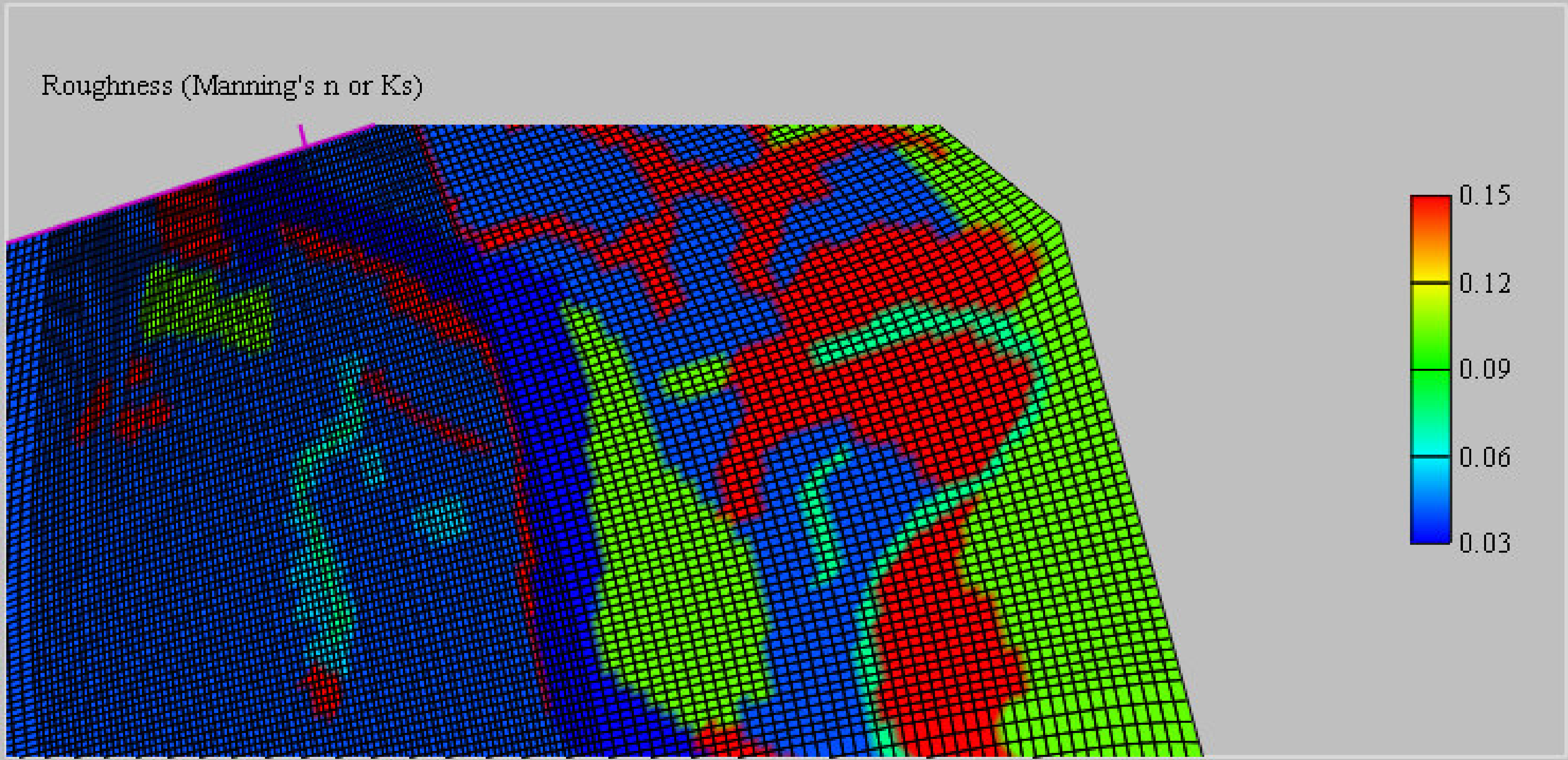
5 m spatial distance of x,y,z coordinates obtained from DTM

LAND COVER and MANNING ROUGHNESS



1-sand channel of Pilica
0.025
oxbow channel 0.070
2-grass 0.035
3-reed 0.050
4-willow 0.150
5-forest 0.100
6'–*Carex* sp. 0.042

ROUGHNESS DEFFINITION by NCCHE2D MODEL



SUSPENDED SEDIMENT

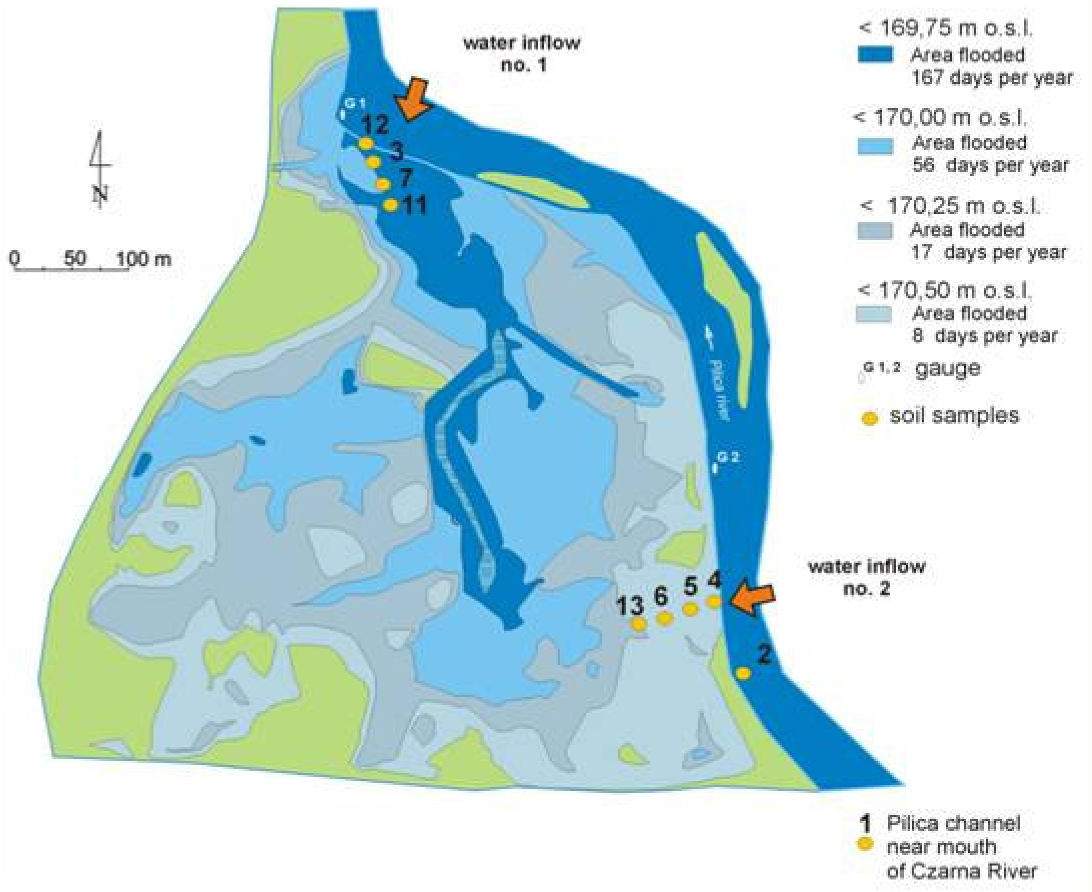
ppm=mg/l = g/m^3

Suspended sediment transport comprise 85-95 % of the total sediments transport in the mountain and upland rivers, unique is the Vistula river with **65-70 %**

Momentary sediment concentration of the Pilica river at Przedborz gauge is in the range: **1 g/m^3 – 150 g/m^3**

Monthly average sediment concentartion of the Pilica River at Przedborz is in the range: **5 g/m^3 - 41 g/m^3**

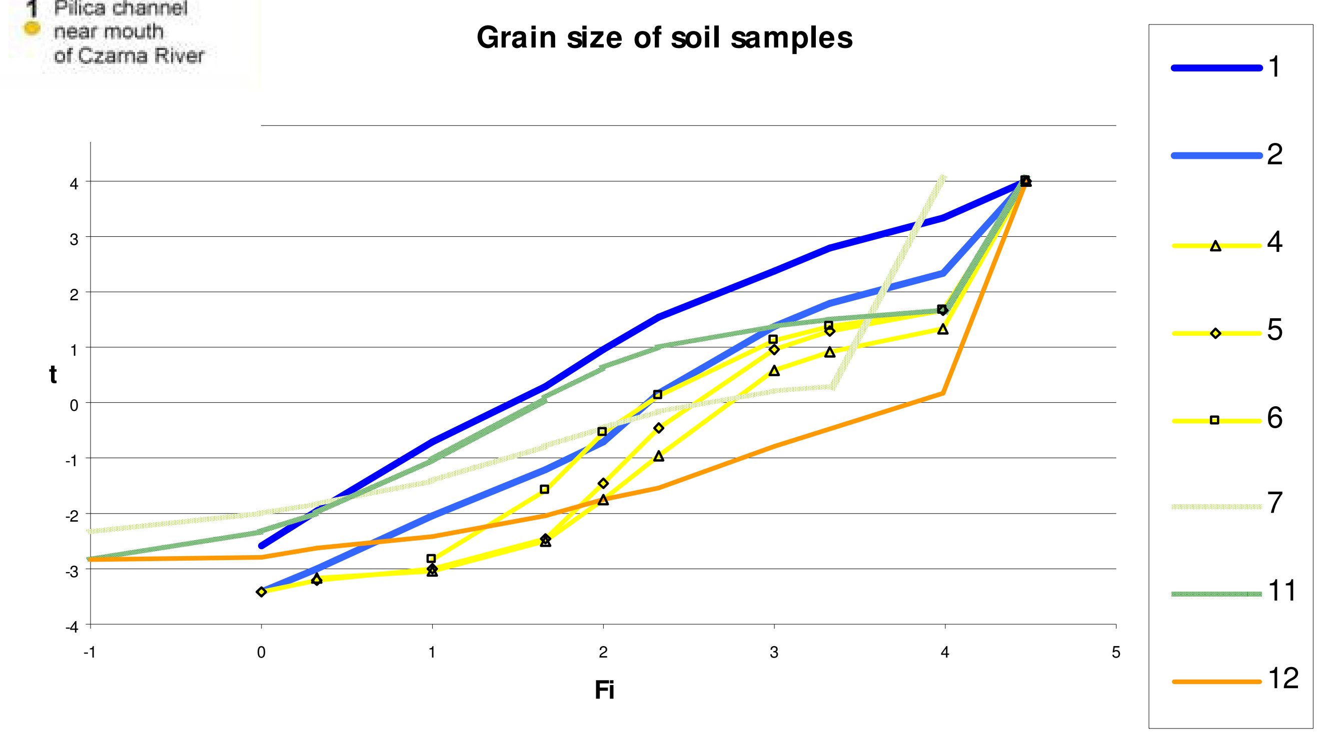
LOCATION OF THE SOIL SAMPLES



river channel deposits (samples 1, 2)
d_{50}= 0.205-0.368 mm

bank deposits (samples 4, 5, 6)
d_{50}=0.137-0.197 mm

wetland (samples 3 and 7)
d_{50}=0.108-0.176 mm

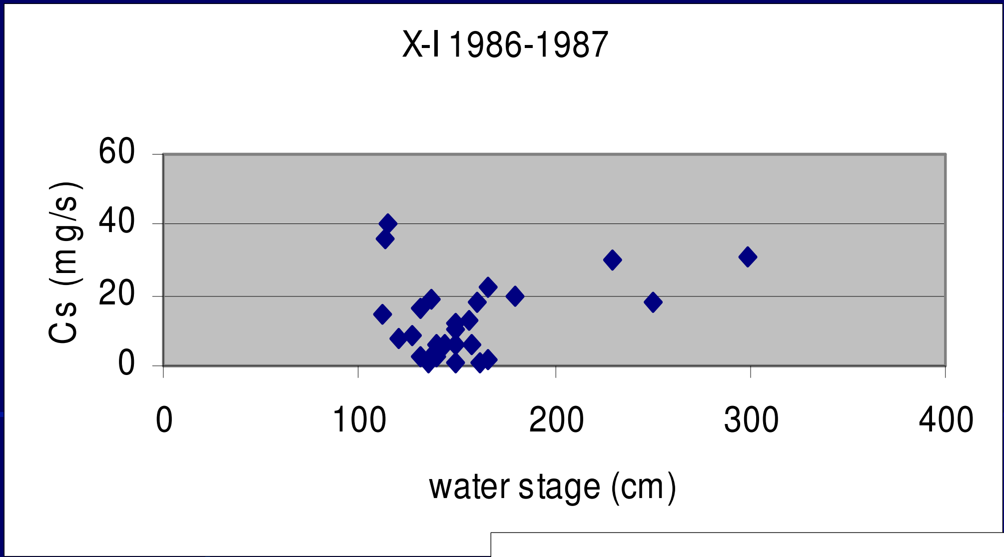


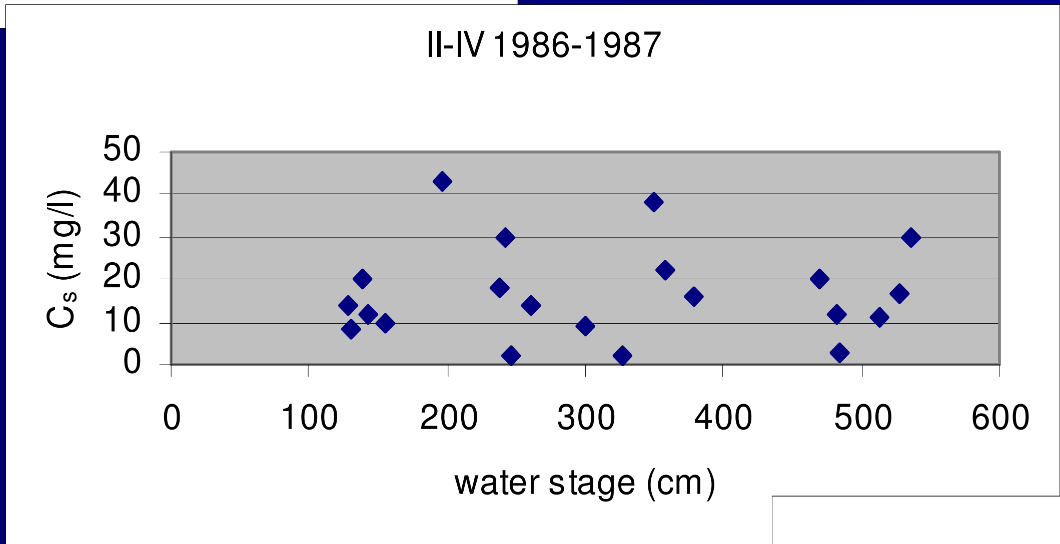
PIHM bedload sampler
d_{50} = 0.55 mm

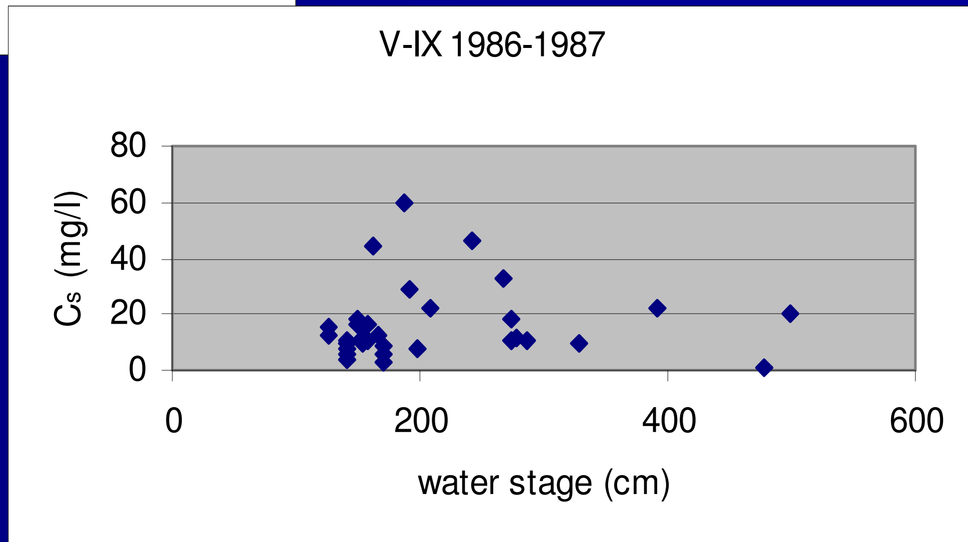
river suspended sediments
d_{50} = 0.0195 mm

2005-10-26

WATER STAGE – SEDIMENTS RELATIONSHIP







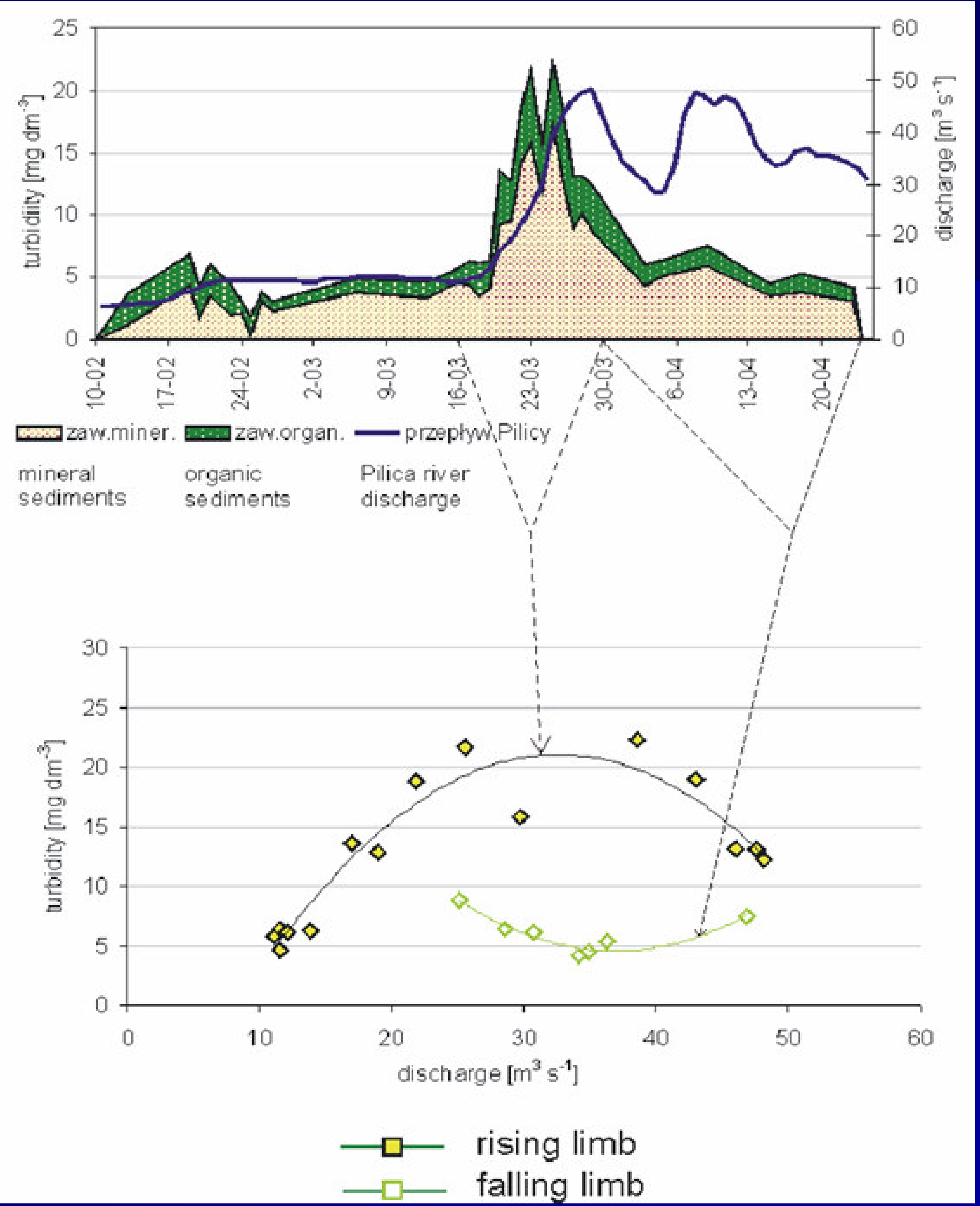
Sulejow gauge (H) and Przedborz gauge (Cs)

SUSPENDED SEDIMENT CONCENTRATION AND DISCHARGE

minor flood after the lowflows period

1996 03 16 – 1996 03 30 Sulejow gauge

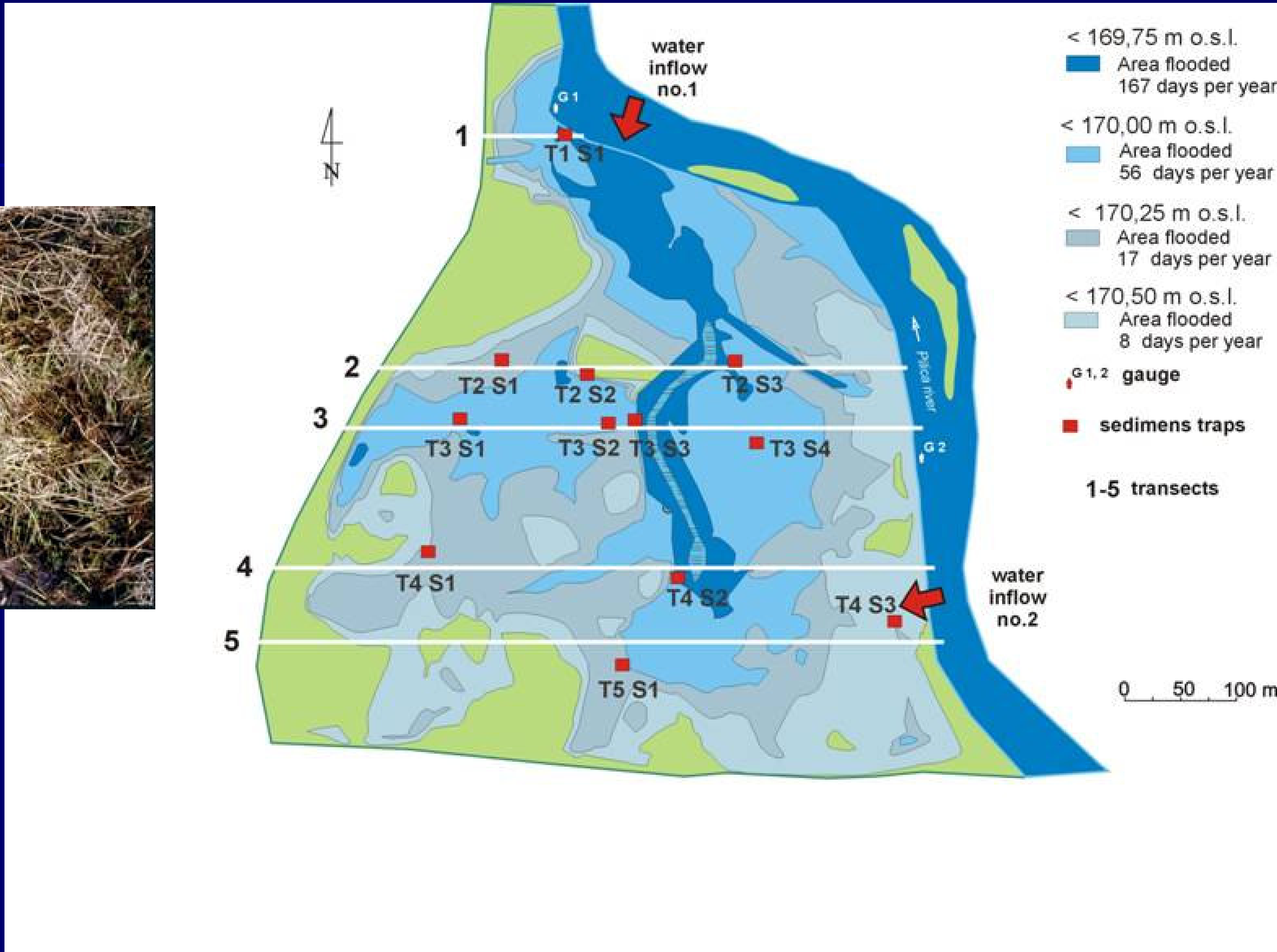
C_s = 22 mg/dm^3 has been observed 4 days in advance before Q_{max}= 48 m^3/s



2005-10-26

SEDIMENTS TRAPS

front door plastic mats 45 x 50 cm



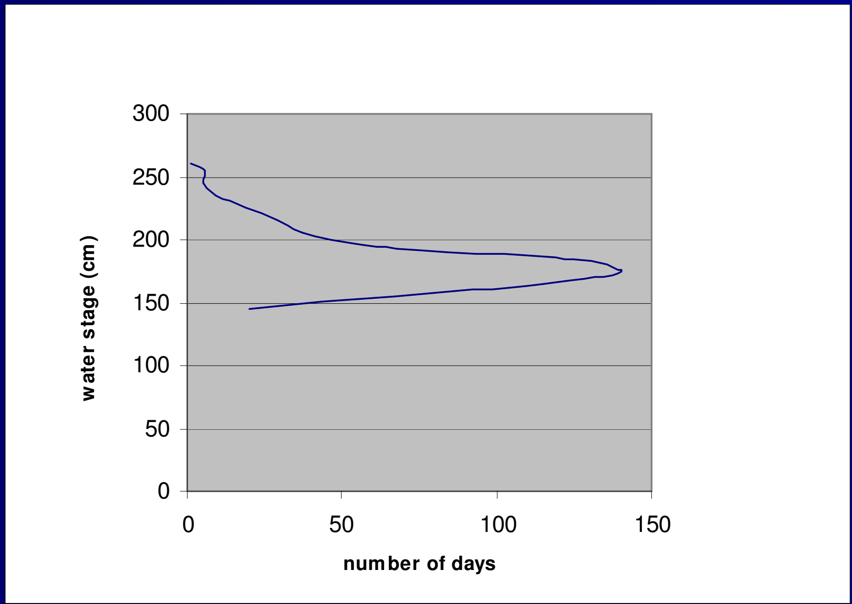
12 sediments traps in 5 transects

SEDIMENTS TRAPS EXPOSITION

- exposition time 634 days (2002 11 01 – 2003 07 29).

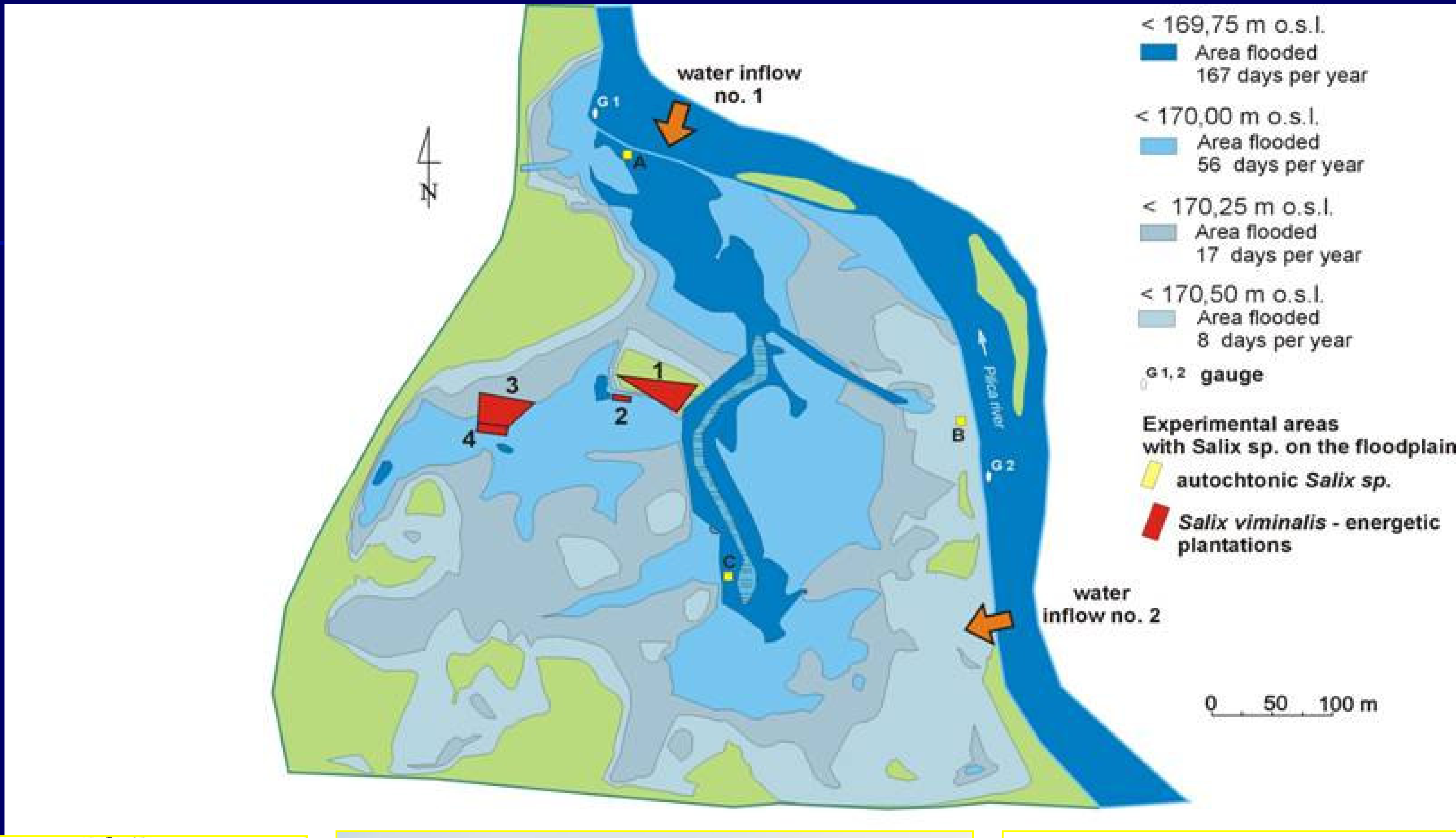
- the highest stage was 260 cm, the most frequent were stages 170-180 cm

- long term average stage of the Pilica river at Sulejow gauge is 171 cm corresponding to mean discharge of 23.3 m^3/s.



plantation no. 1 (900 m^2)
plantation no. 3 (1225 m^2)

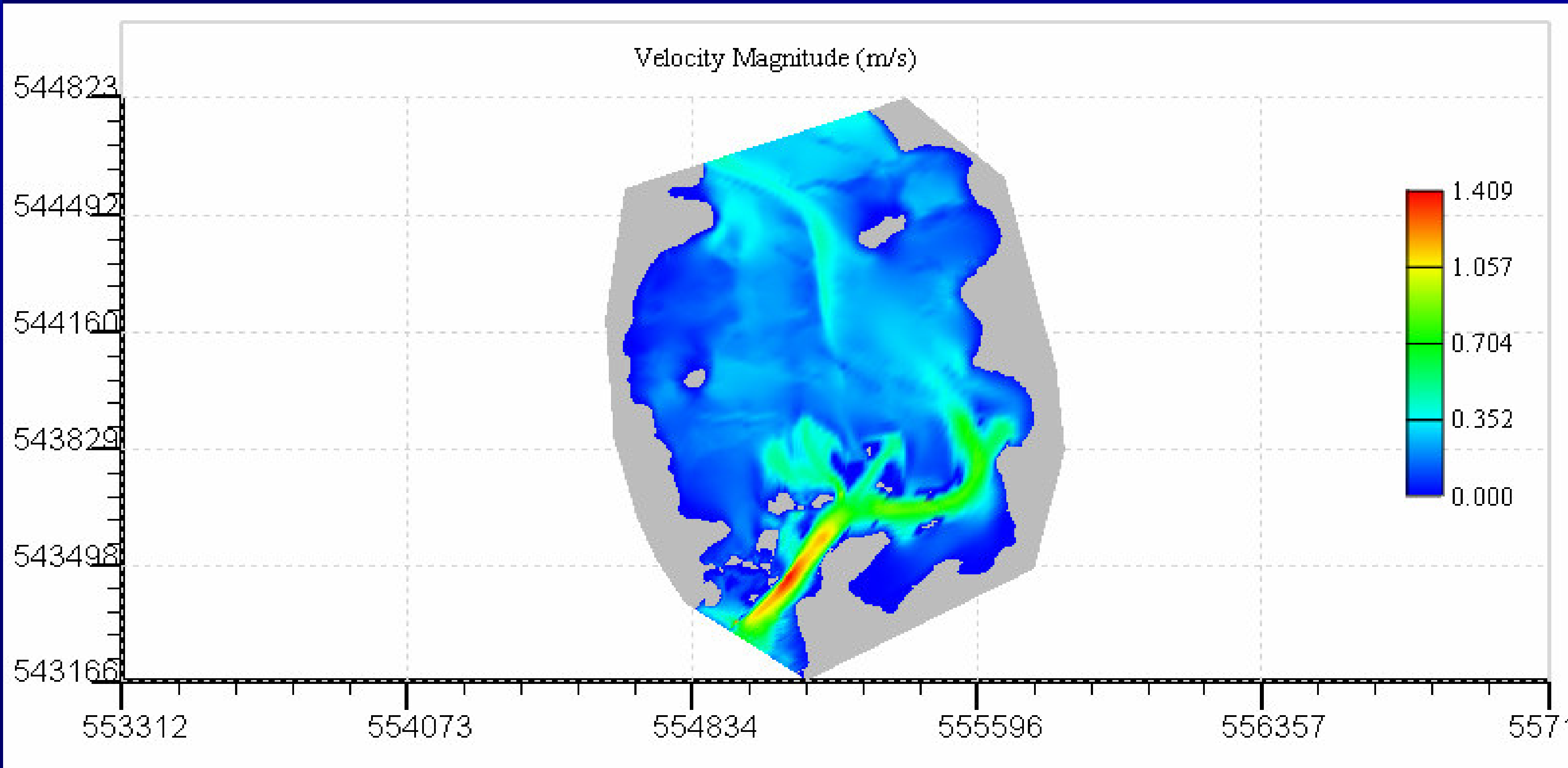
WILLOW PLANTATIONS



NCCHE2D MODEL VELOCITY FIELD SIMULATION

-simulation range: H=210÷300 cm with 10 cm interval.

- average velocity in the verticals in two scenarios has been compared using two monitoring points located in the centers of largest plantations no. 1 and 3.



H=300 cm, natural conditions

VELOCITY CHANGE IN WILLOW PLANTATIONS calculated by NCCHE2D model

H (cm)	Q (m^3/s)	MP1		MP2	
		Scenario 0 v_h (m/s)	Scenario 1 v_h (m/s)	Scenario 0 v_h (m/s)	Scenario 1 v_h (m/s)
210	50.0	0	0	0	0
220	59.0	0	0	0	0
230	68.0	0	0	0.00308	0.00135
240	79.0	0	0	0.00173	0.00215
250	90.0	0	0	0.00521	0.00496
260	102	0	0	0.0121	0.00910
270	117	0	0	0.0181	0.0152
280	133	0.247	0.0670	0.0397	0.0256
290	149	0.291	0.0667	0.0577	0.0255
300	166	0.328	0.0852	0.0687	0.0384

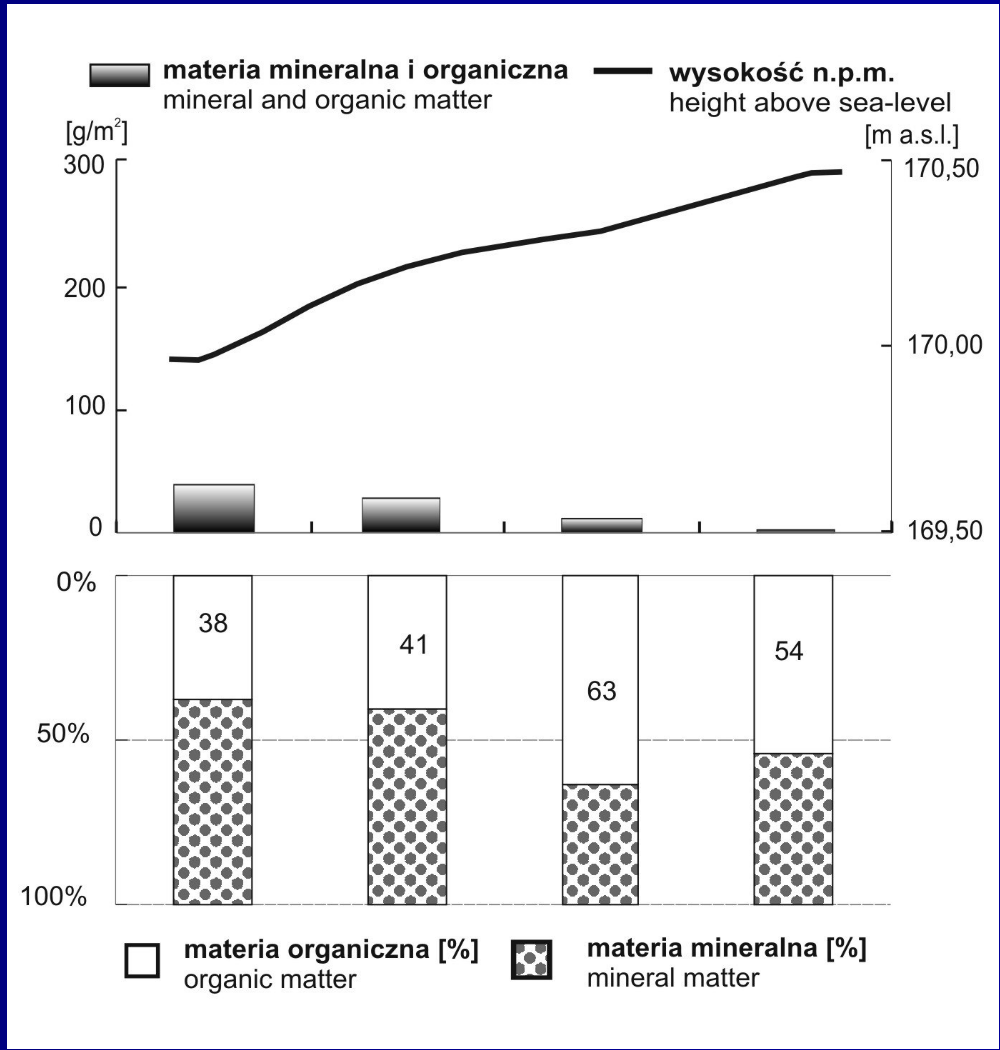
Plantation 1 (MP1) is located on a higher terrace, and is inundated only at the stages 280 cm (113 m^3/s) and higher. Plantation 3 (MP2) is located on the elevation which flooded on average 10 days per year.

SEDIMENTATION DISTRIBUTION

- there is a weak negative correlation (r=-0,309) between total mass of sedimentation and elevation of the measuring point.

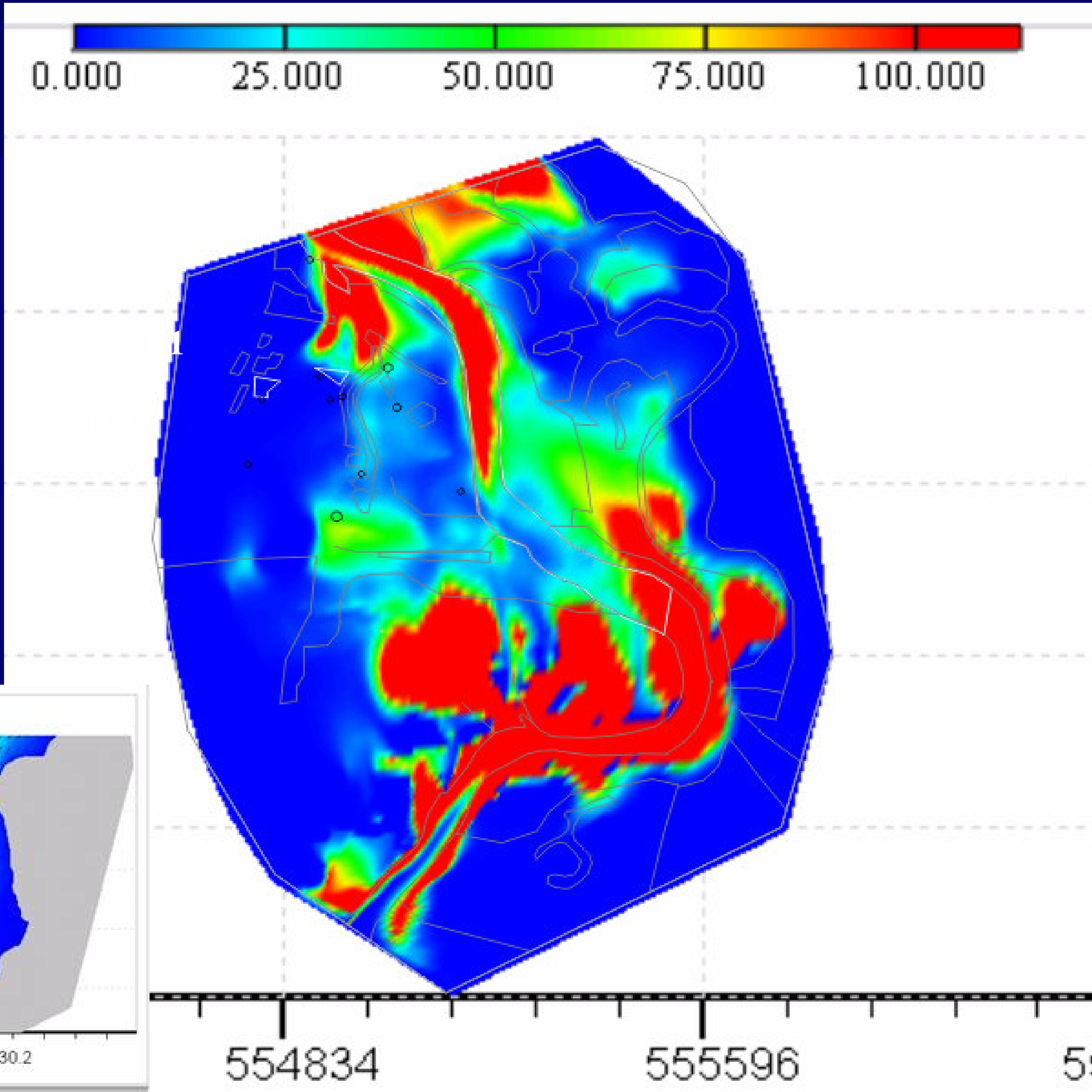
- in a higher parts of floodplain (170,5 m a.s.l.) covered by meadows - the dry mass is 3,5 g/m^2, with 54 % contribution of organic mass.

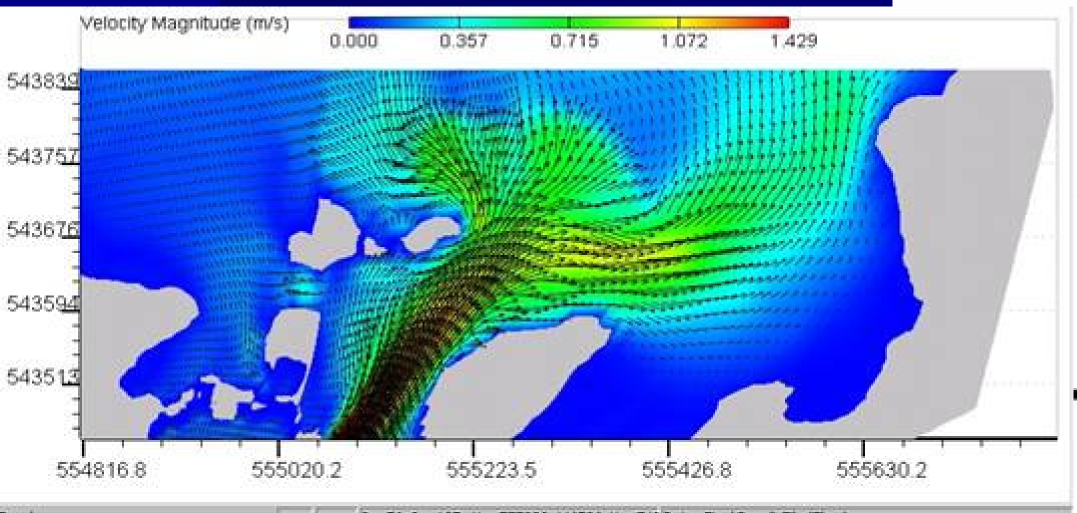
- on the posts located 50 cm lower (170 m a.s.l.) covered by wetland grass the amount of deposited sediments is close to 41 g/m^2 , with 38% contribution of organic matter



NCCHE2D
SEDIMENTATION SIMULATION RESULTS and VERIFICATION

sedimentation
transport intensity
at H=300 cm stage





CONCLUSIONS

- there is positive influence of plantations on improving sedimentation conditions. Increase of sediment transport indicates the better chance for sedimentation, which is confirmed also by the positive bed elevation change. Model shows small increase of average vertical velocity, bed shear, and lowering of water depth.

  - the results of NCCHE2D suspended sediments transport during the Pilica river floodplain inundation are giving the good indication of potential sedimentation at the study site. The spatial distribution of this parameter can serve as a good tool for planing the optimal location of the willow plantations.

- both willow plantations no. 1 and 3 are located at the edge of high sediment transport and sedimentation area. This location is a compromise between moderate sedimentation potential, proper moisture conditions at the willows root zone, available space for performing experiment (land ownership). Location at the place of highest floodplain sedimentation is questionable due to a risk of high sediments accumulation but also erosion.

CONCLUSIONS

- the sediments transport pattern obtained from the NCCHE2D model has shown that suspended sediment concentration declines with the distance from the main channel, but exhibits the plumes behavior along major flow paths. This is in accordance of Nicholas (2003) findings, who suggests that suspended sediments transport on the natural floodplains is dominated by advection.

- interesting is high contribution of organic matter in suspended sediment. Droppo (2003) states that suspended sediment is not made of discrete sediments particles, but rather flocks with an active biological community. Flocks have high porosity and low density close to water which influence the sedimentation velocity

LITERATURE

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