Hydraulic Modelling of wetland flow

Data collection and problem solving

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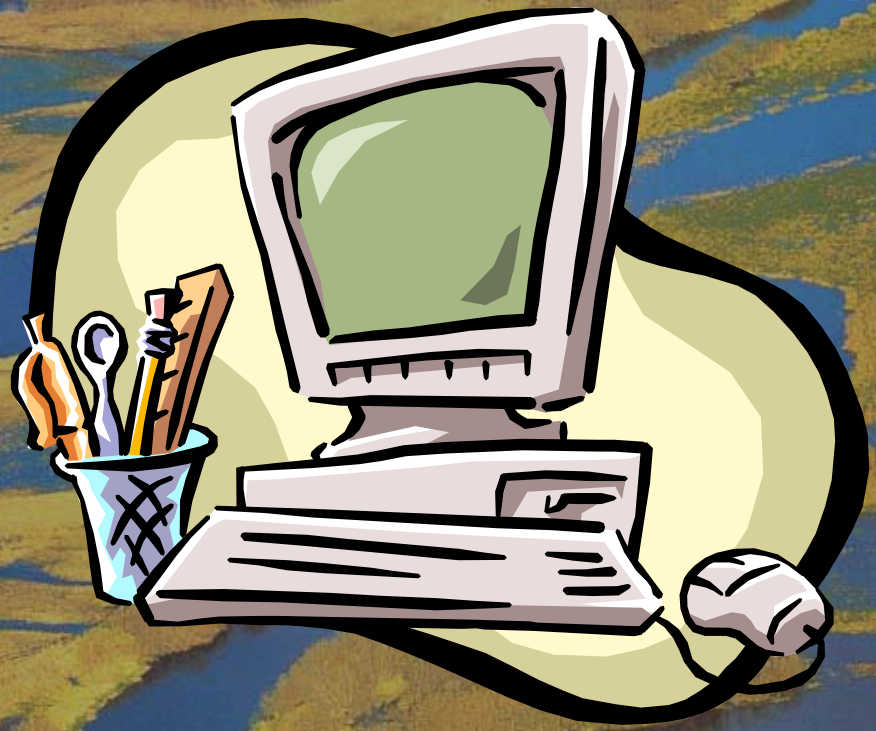
WETHYDRO WORKSHOP – 13 – 14 June 2003

Hydraulic Modelling of wetland flow

- Introduction
- Hydraulic modelling of open channel flow
- Extension to wetlands
- Data collection – problems, questions, solutions
- Input data – problems, questions, solutions
- Conclusions - questions

Introduction



Engineer >>
translates reality
into formula

Deterministic approach is what he likes: $p = \rho g h$

Stochastic representation is what he needs to live with

Introduction

Hydraulic Modelling of open Channel Flow

Supositions

- Uniform velocity distribution: $Q = A \cdot U$
- Prismatic bed – constant cross-section
- Hydrostatic cross sections
- Constant bottom slope
- Constant friction factor

Hydraulic Modelling of open Channel Flow

Steady state

Continuity:

$$Q = A \cdot U$$

Motion – Bresse equation:

$$\frac{\delta h}{\delta x} = \frac{So - Sf}{\sqrt{1 - So^2} - \frac{BQ^2}{gA^3}}$$

Uniform flow
>> Manning <<

$$U = 1/n.R^{2/3}.S_0^{1/2}$$

Hydraulic Modelling of open Channel Flow

Unsteady state

Saint Venant equations

Continuity:

$$\frac{\delta Q}{\delta x} + B\frac{\delta h}{\delta t} = 0$$

Motion:

$$\frac{\delta Q}{\delta t} + \frac{\delta}{\delta x}\left(\frac{Q^2}{A}\right) = g.A..\left(S_o - S_f - \frac{\delta h}{\delta x}\right)$$

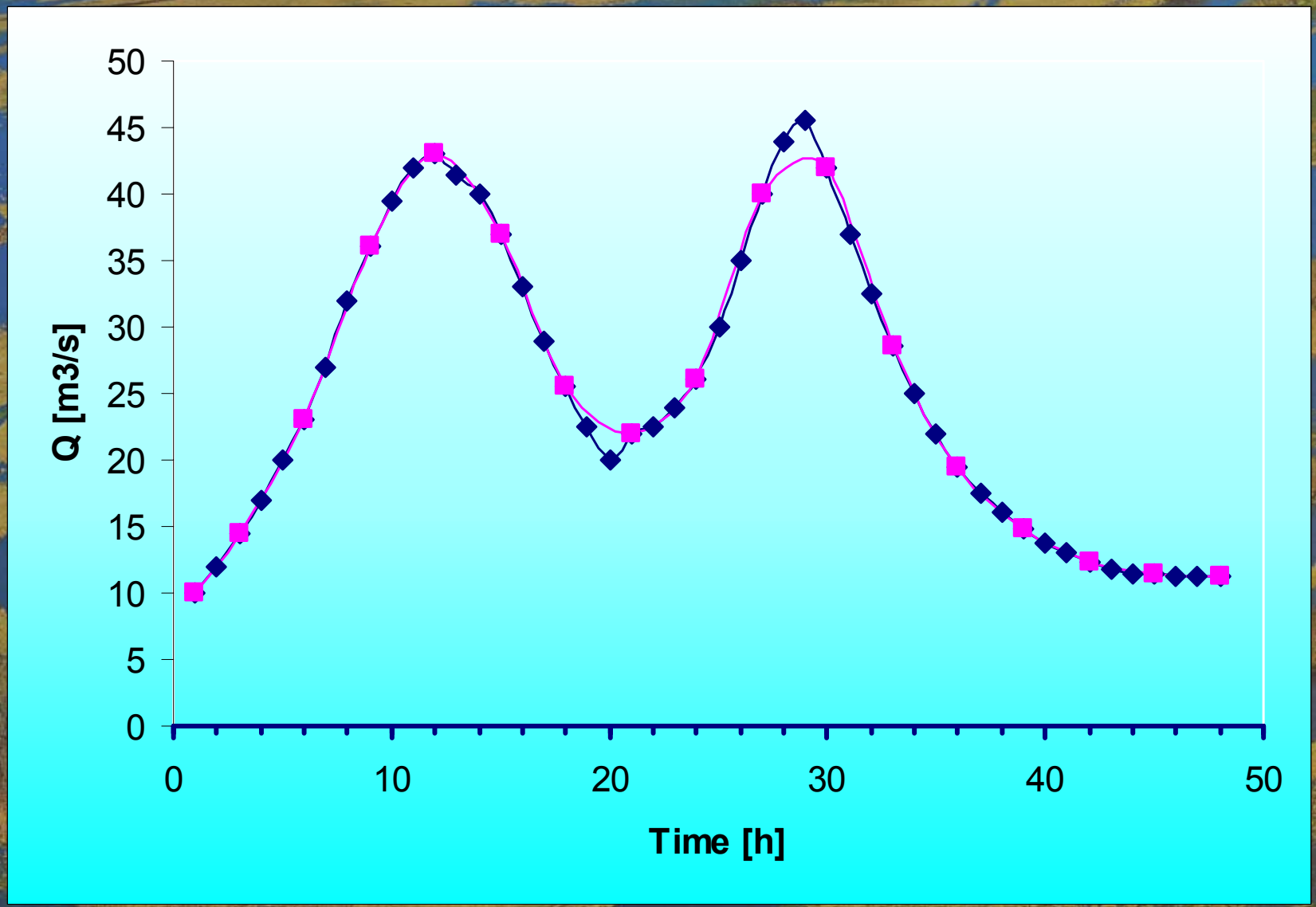
Hydraulic Modelling of open Channel Flow

Unsteady state

Saint Venant equations – solved by implicit finite difference Preismann scheme

>> choise of Θ is important > stability

>> choise of Δs and Δt also > accuracy


Q [m3/s]
50
45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
Time [h]

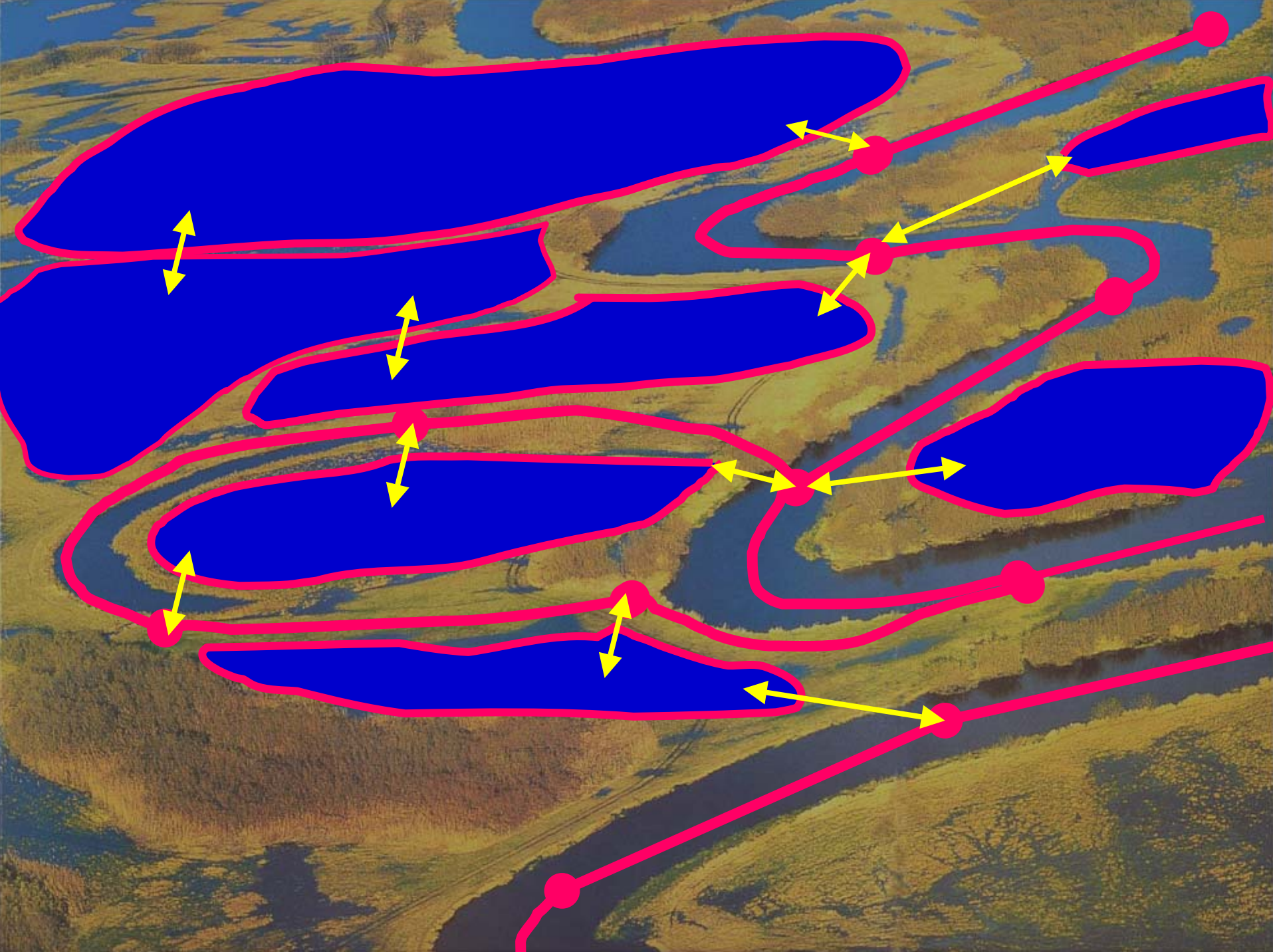
Extension to wetlands

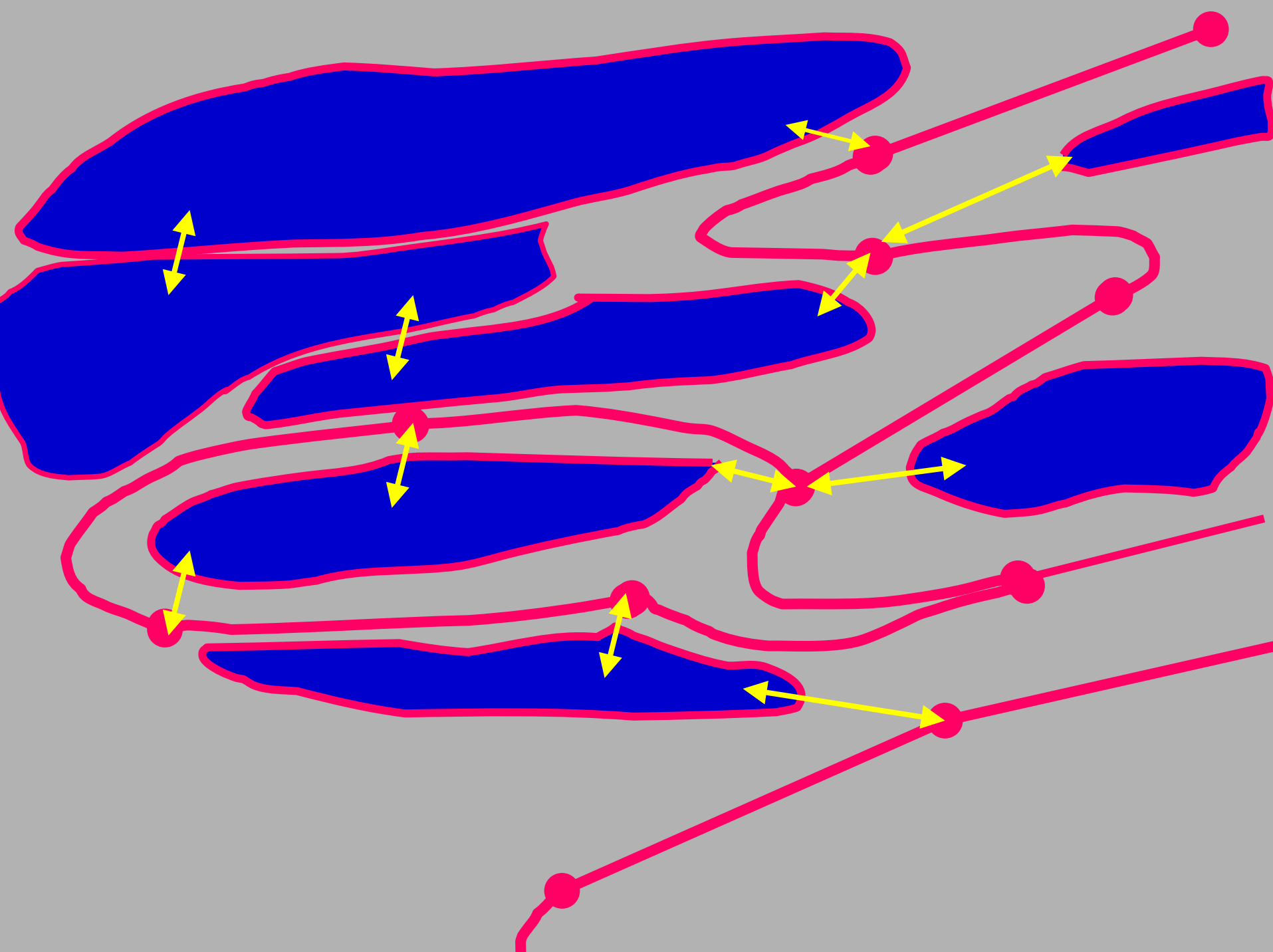
Quasi 2D modelling

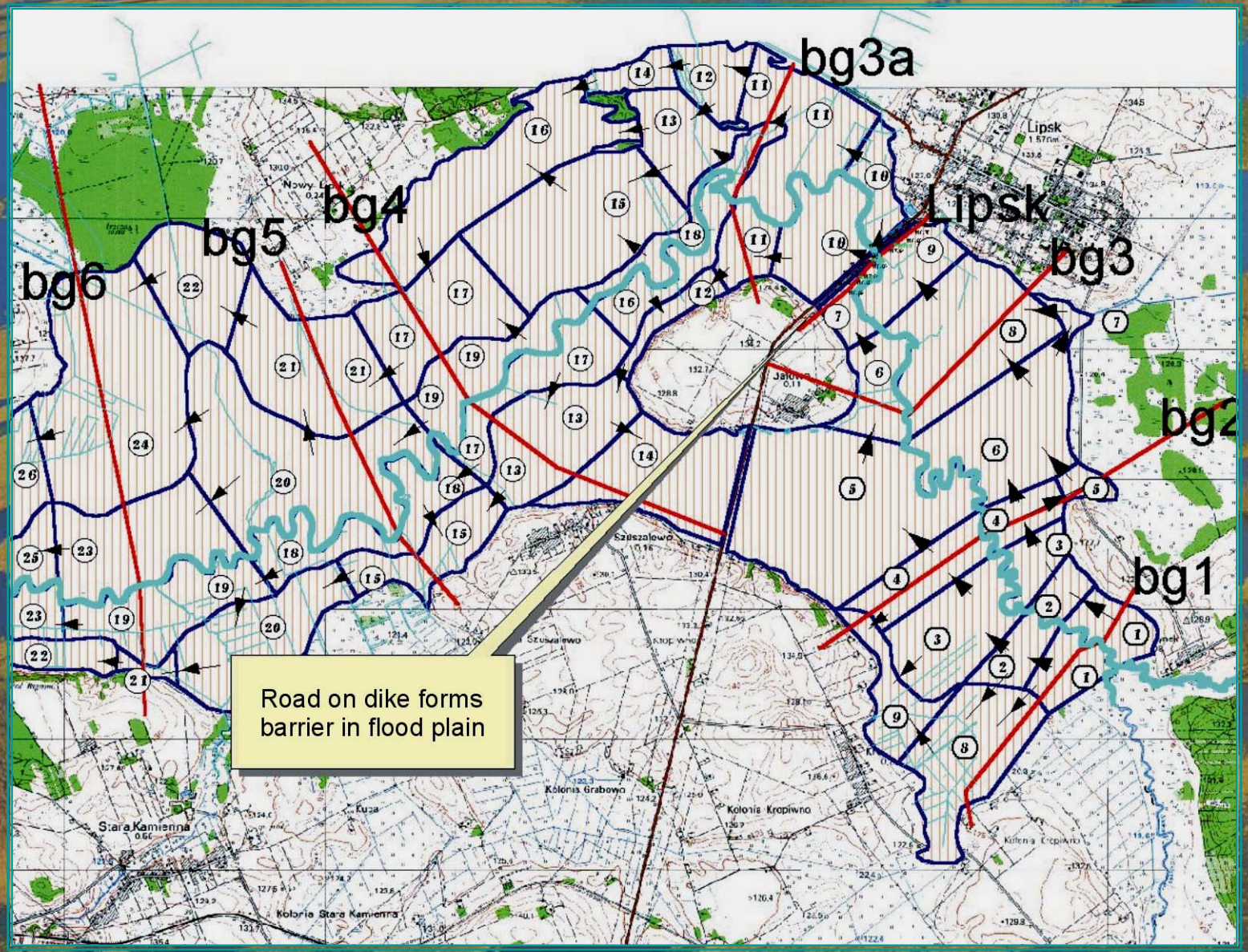
>> Network structure - flow

>> Cells - exchange of volumes

>> Combination - what to choose?






bg3a
bg4
bg5
bg6
Lipsk
bg3
bg2
bg1
Road on dike forms barrier in flood plain

Input data – what do we need?

Topographical

- Cross-sections of river and floodplain
- Longitudinal profile (Thalweg)
- Water levels (f(t))

Hydraulic

- Discharge (f(t)) – lateral discharges
- Friction coefficients
- Sediment transport (bottom / suspended)

Data collection

Topographical

- ? Distance between 2 cross-sections
- ? Boundaries of flood plains
- Altitude measurements should be the most accurate ones
- Accuracy of measurements is influenced by:
  - mud
  - vegetation
  - obstacles in cross-section
  - soft bottom

Data collection

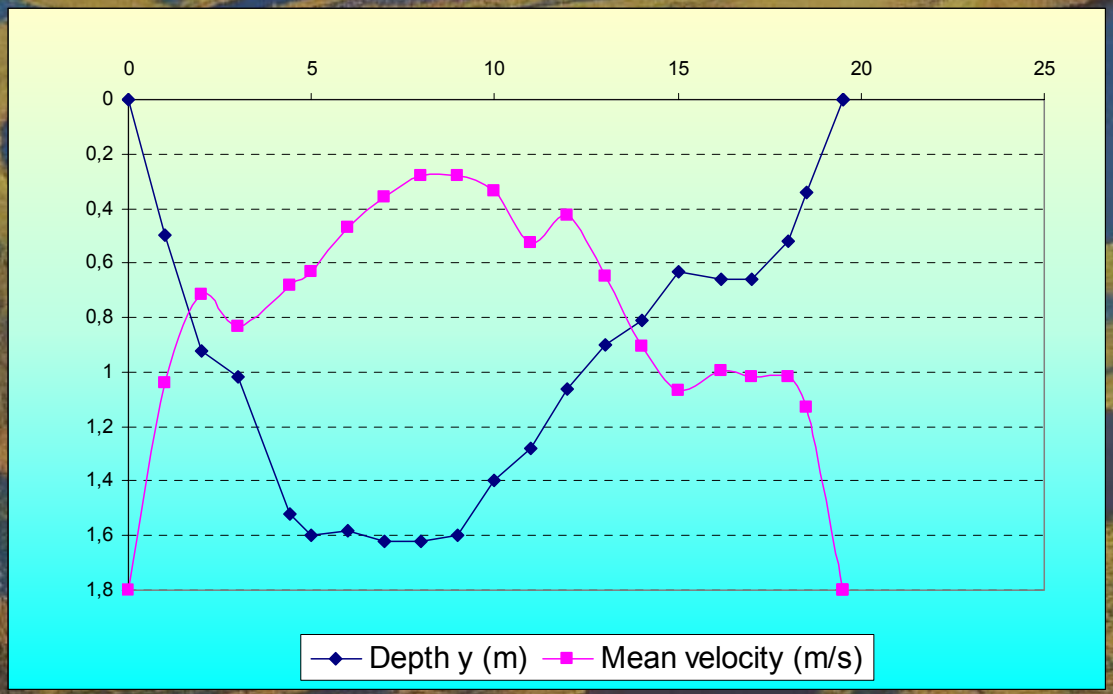
Hydraulic data – discharge measurements

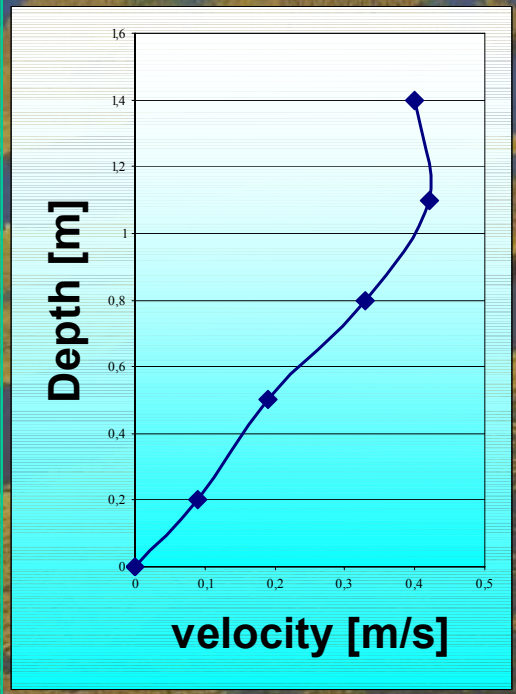
- Integration of velocity field over cross-section
- Propeller meter or electromagnetic, acoustic velocity meter
- From bridge or from boat

Data collection

Hydraulic data – discharge measurements
> Problems <

- **Velocity distribution – horizontal / vertical**



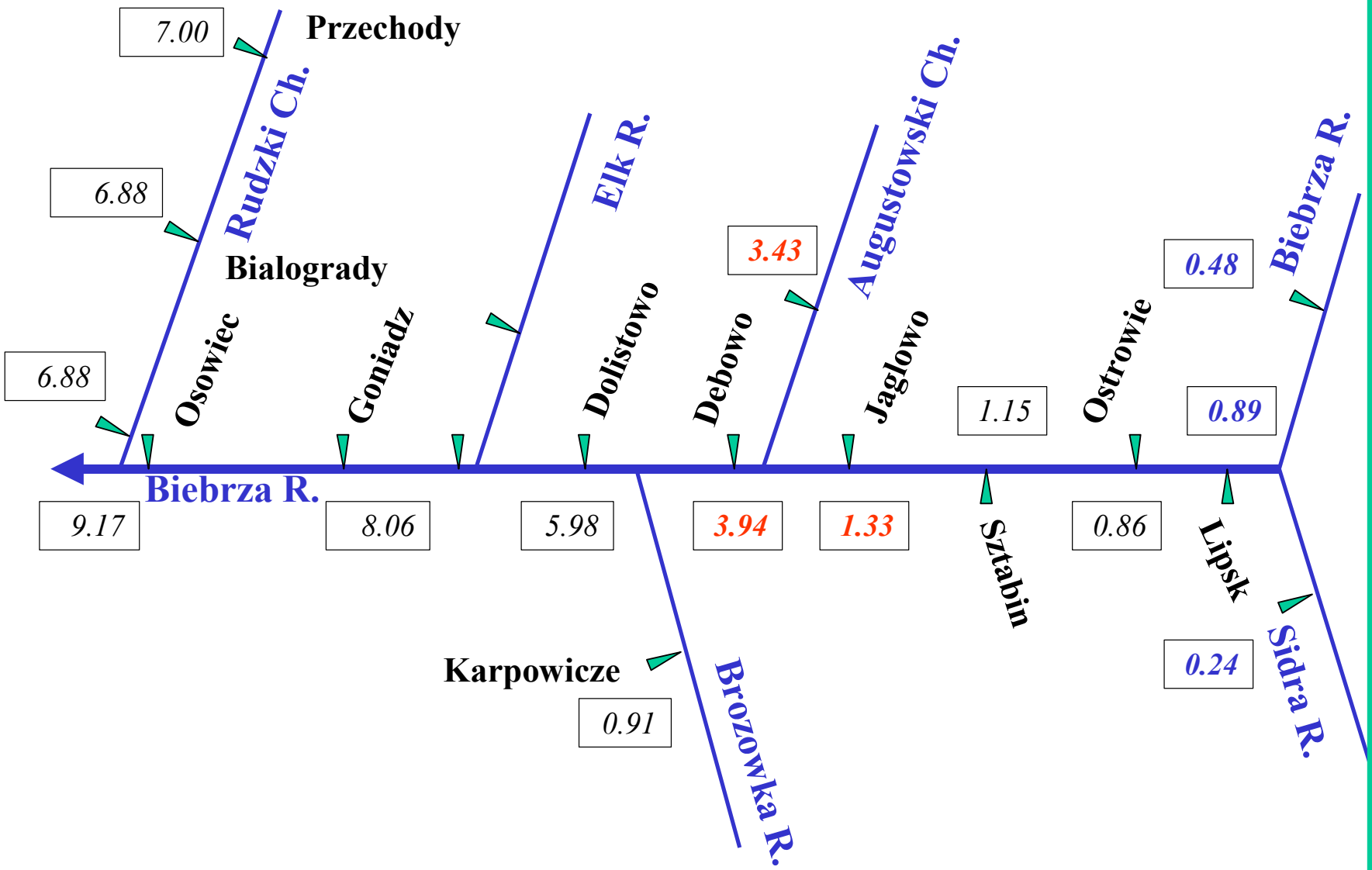


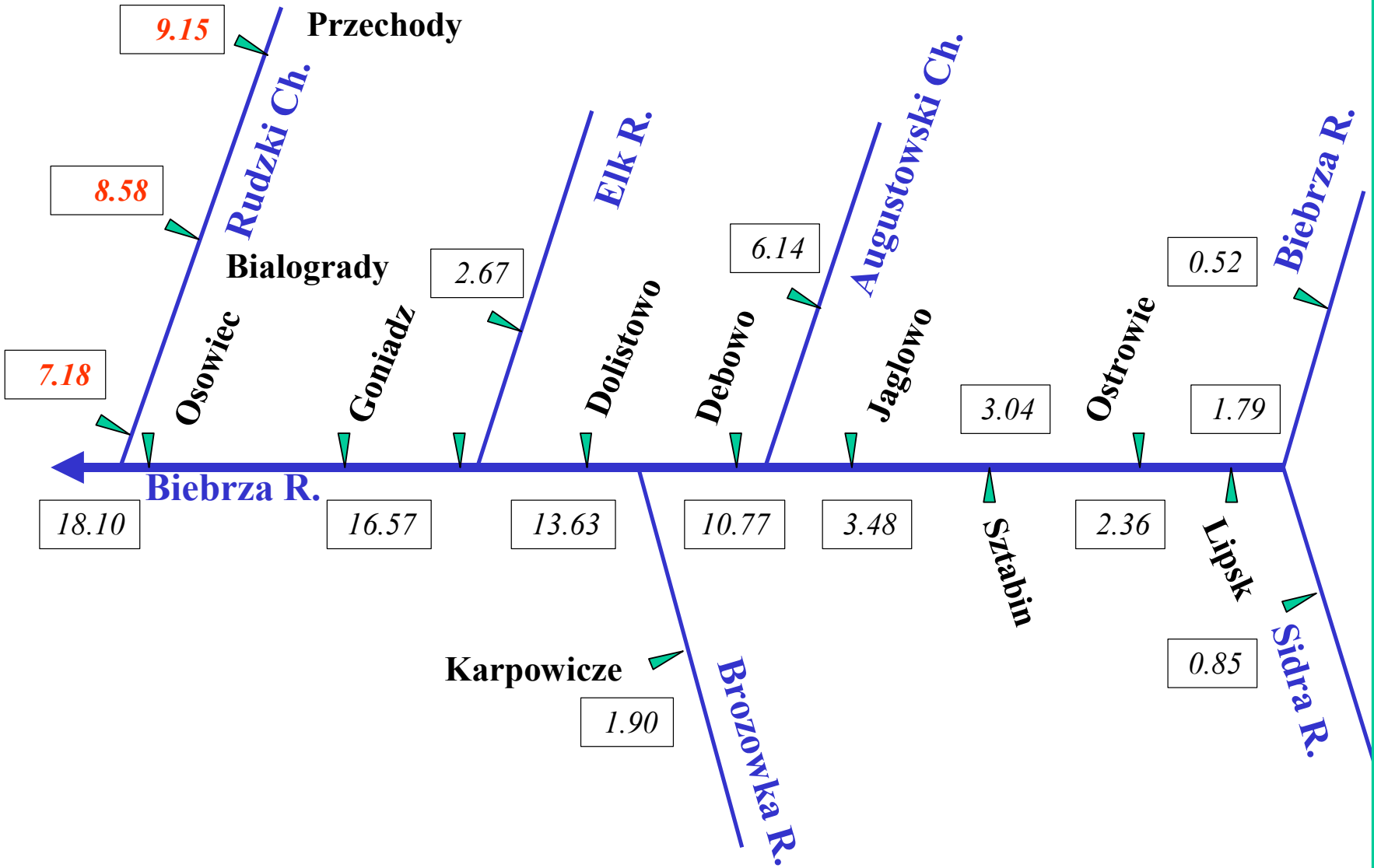
Data collection

Hydraulic data – discharge measurements
> Problems <

Influence of

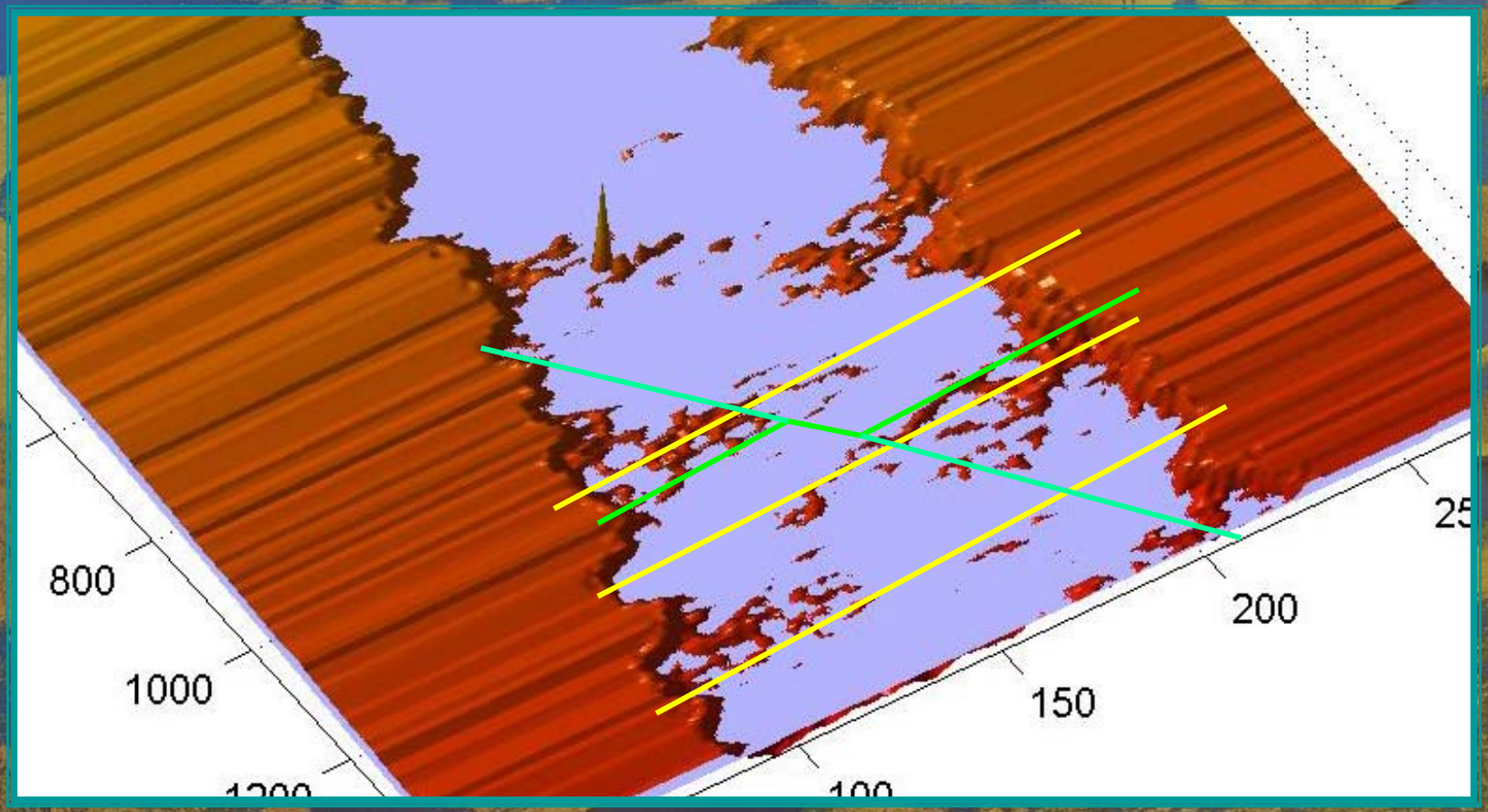
- Vegetation
  - velocity fluctuation as a function of time
  - slowing down propeller
  - block the propeller
  - local influence on velocity meter
- Stones or rocks
- Soft bottom
- Wind while measuring from a boat
- Measuring errors


7.00
Przechody
Rudzki Ch.
6.88
Bialogrady
6.88
Osowiec
Goniadz
Elk R.
Dolistowo
3.43
Debowo
Augustowski Ch.
Jaglowo
1.15
Ostrowie
0.48
Biebrza R.
0.89
Biebrza R.
9.17
8.06
5.98
3.94
1.33
Sztabin
0.86
Lipsk
0.24
Sidra R.
Karpowicze
0.91
Brozowka R.
Measurement Campaigns: discharges in m3/s
2000


9.15
Przechody
Rudzki Ch.
8.58
Bialogrady
Osowiec
7.18
Goniadz
2.67
Elk R.
Dolistowo
6.14
Debowo
Augustowski Ch.
Jaglowo
3.04
Ostrowie
0.52
Biebrza R.
1.79
Biebrza R.
18.10
16.57
13.63
10.77
3.48
Sztabin
2.36
Lipsk
0.85
Sidra R.
Karpowicze
1.90
Brozowka R.
Measurement Campaigns: discharges in m3/s
2003

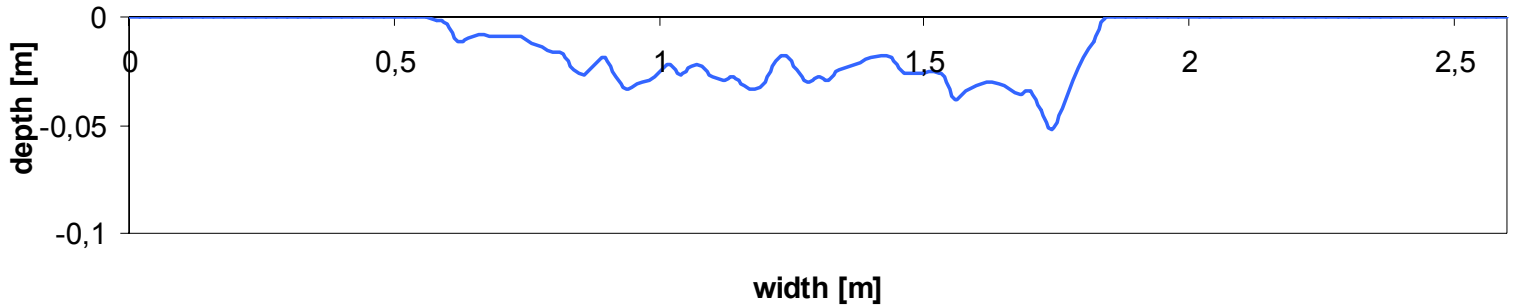
Input data

How to determine the cross-section?



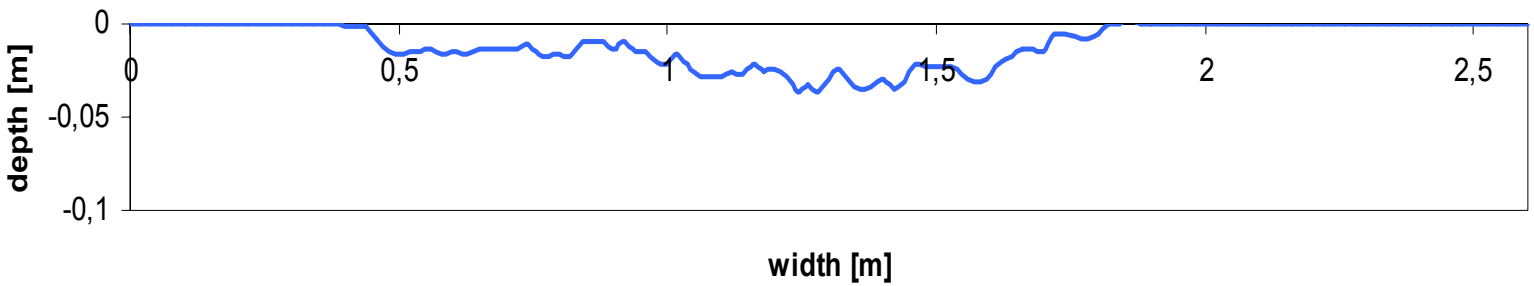
Input data

How to determine the cross-section?



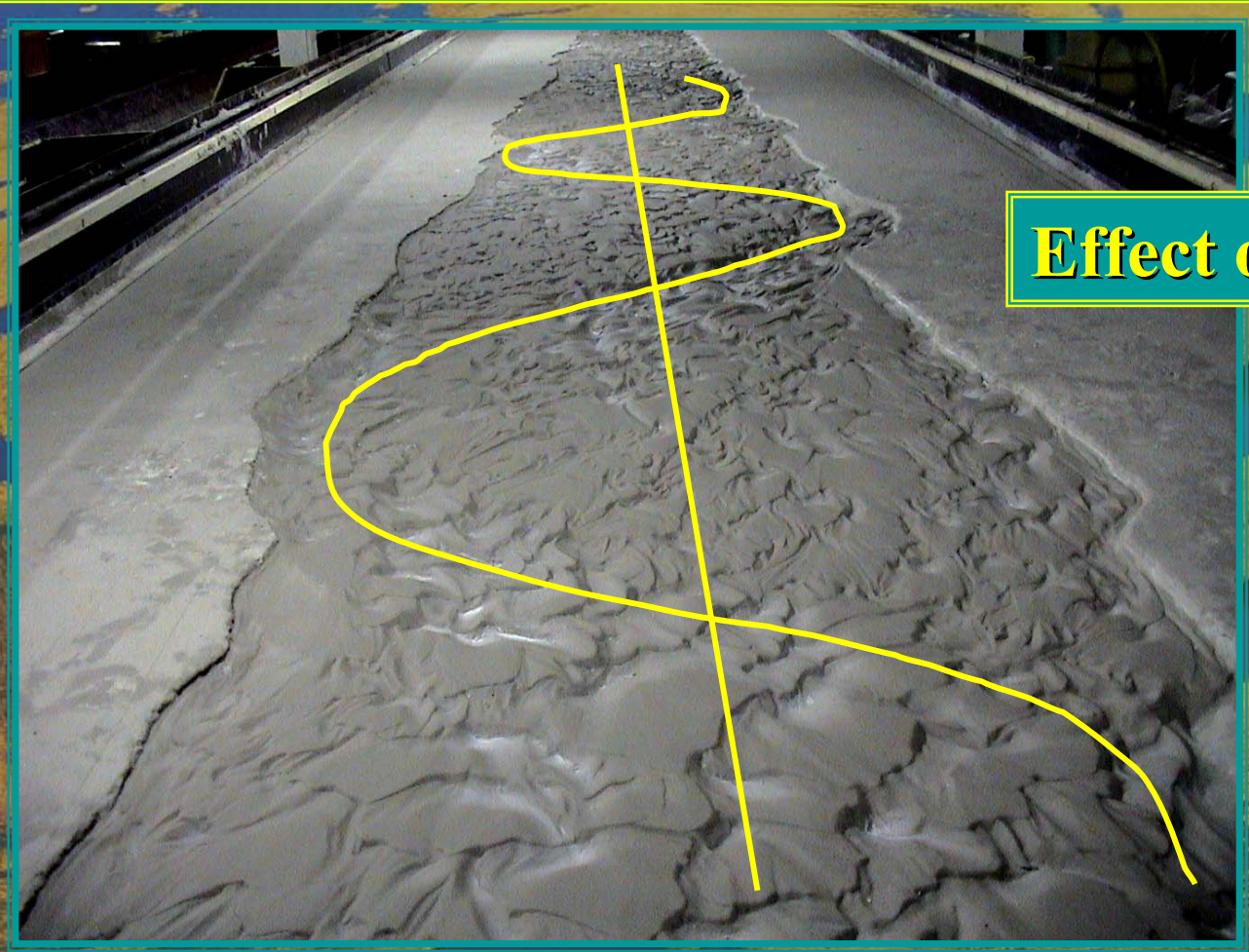
Solution: define cross-section with A, P and R equal to the average value of all cross-sections

>> Calibration of friction coefficient becomes very important !!!



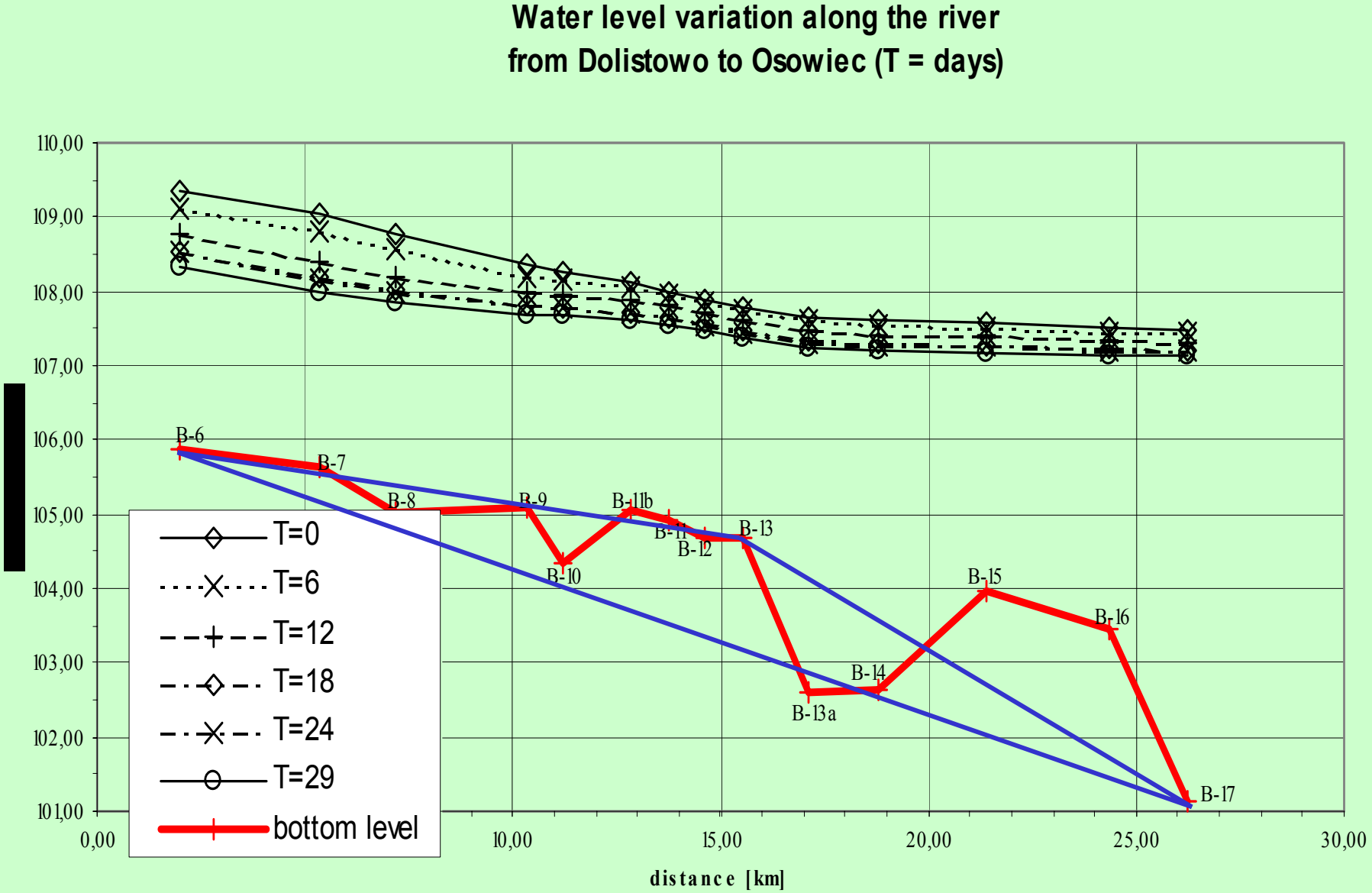
Input data

How to determine the longitudinal profile?



Effect of friction!

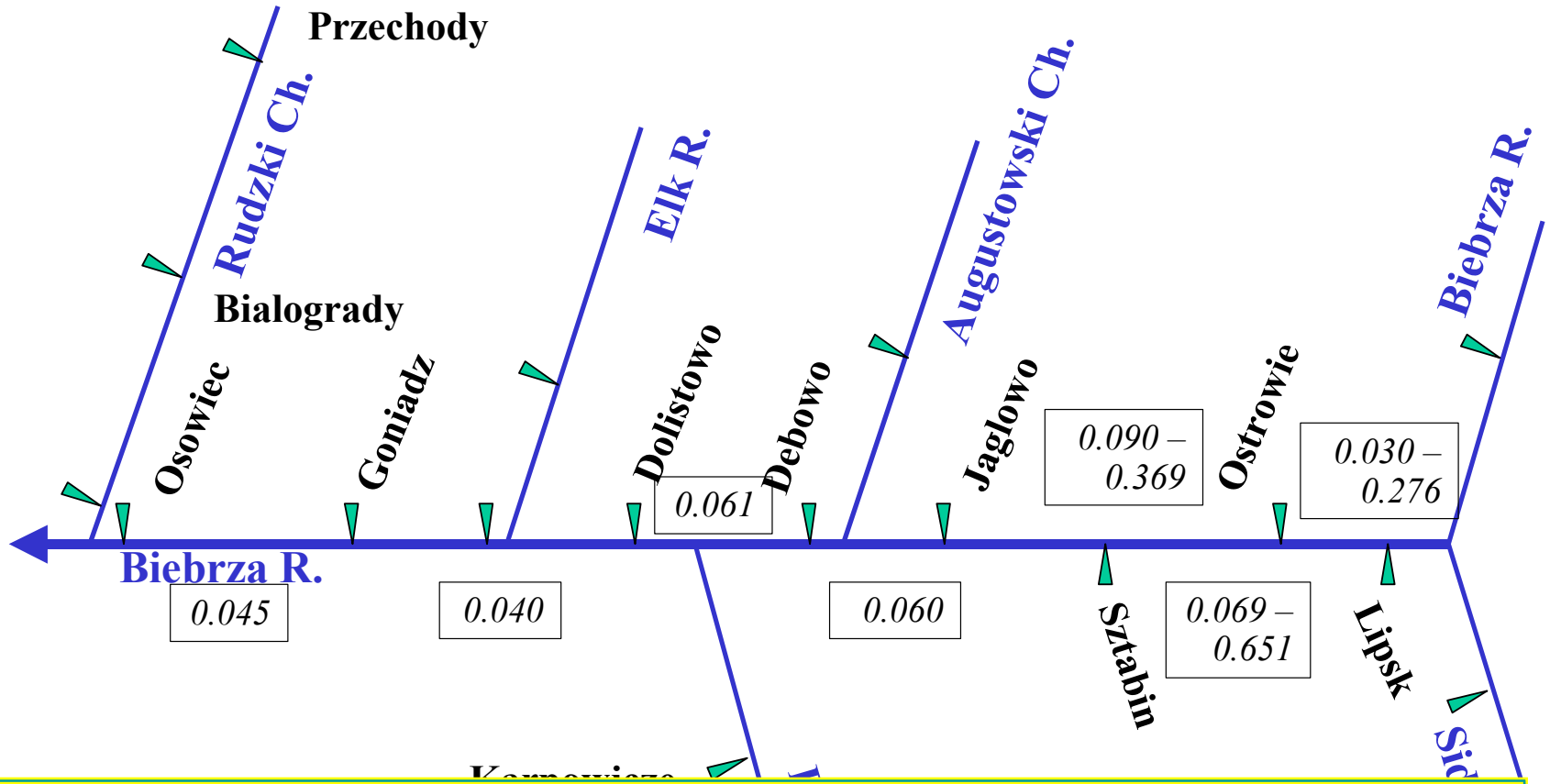
Input data


Water level variation along the river
from Dolistowo to Osowiec (T = days)
110,00
109,00
108,00
107,00
106,00
105,00
104,00
103,00
102,00
101,00
0,00
10,00
15,00
20,00
25,00
30,00
distance [km]
T=0
T=6
T=12
T=18
T=24
T=29
bottom level
B-6
B-7
B-8
B-9
B-10
B-11b
B-11
B-12
B-13
B-13a
B-14
B-15
B-16
B-17

Input data

How to determine the friction coefficient

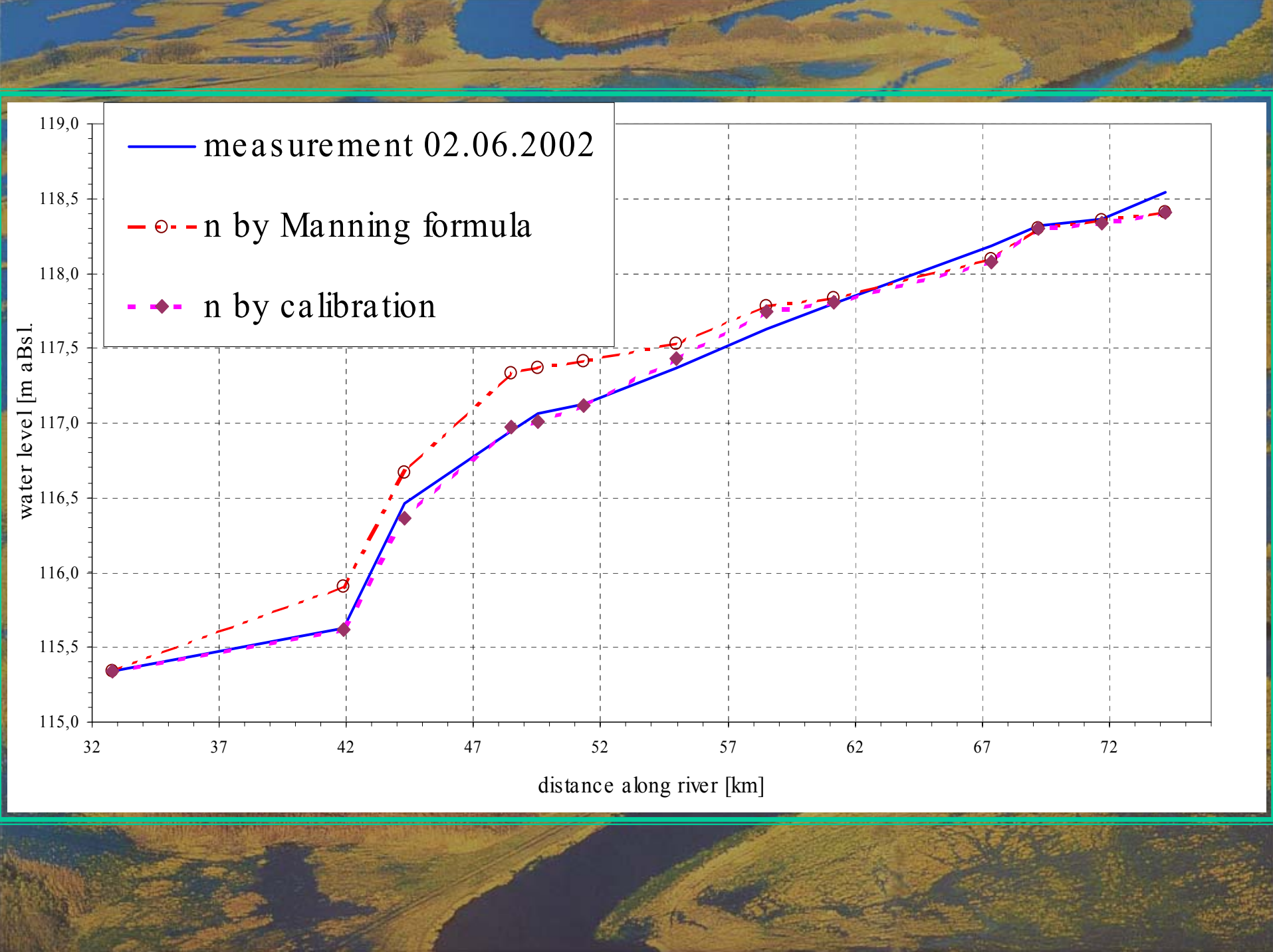
- n = f (bottom roughness, shape cross-section, vegetation, obstacles, meandering, velocity distribution, …)
- n = f (time, location, interaction of previous parameters)
- n must be determined from measurements



Determination of n using:

- **Uniform flow principle (Manning formula)**
- **Bresse equation**

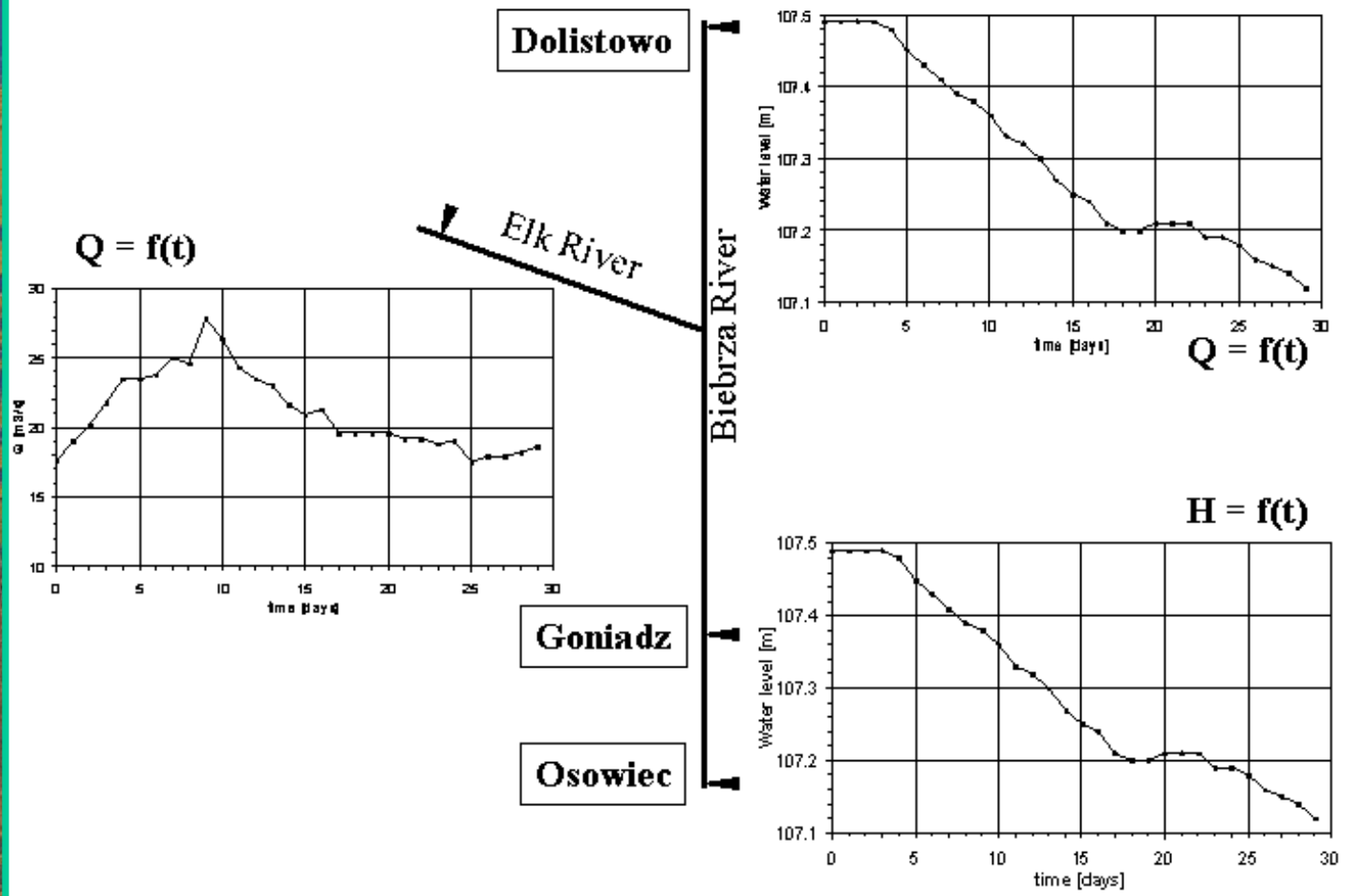
Manning n determination by calibration


measurement 02.06.2002
n by Manning formula
n by calibration
water level [m aBsl.
119,0
118,5
118,0
117,5
117,0
116,5
116,0
115,5
115,0
32
37
42
47
52
57
62
67
72
distance along river [km]

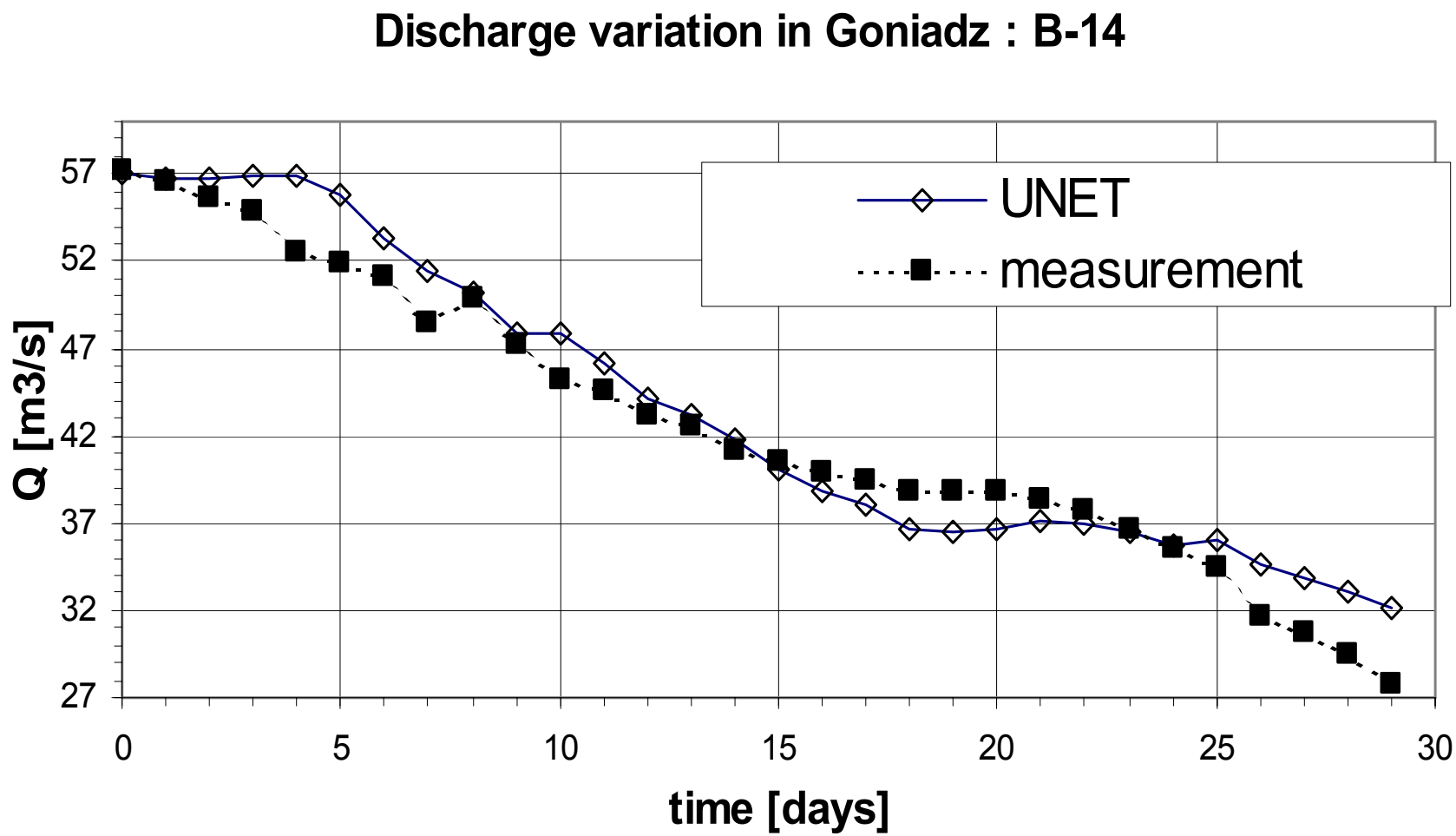
BUT!!!

Hydraulic Modelling of open Channel Flow

Mathematical simulation : Boundary conditions



Hydraulic Modelling of open Channel Flow



Conclusions and Questions

- Flood-routing theory is quite simple
- Numerical solution methods are well developed
- Practical application is confronted with many inaccuracies
- Good simulation results thanks to well considered calibration

- ? Definition of cross-section?
- ? Determination of longitudinal profile?
- ? Best way to determine the friction coefficient?
- ? Suggestions to improve measurements quality?

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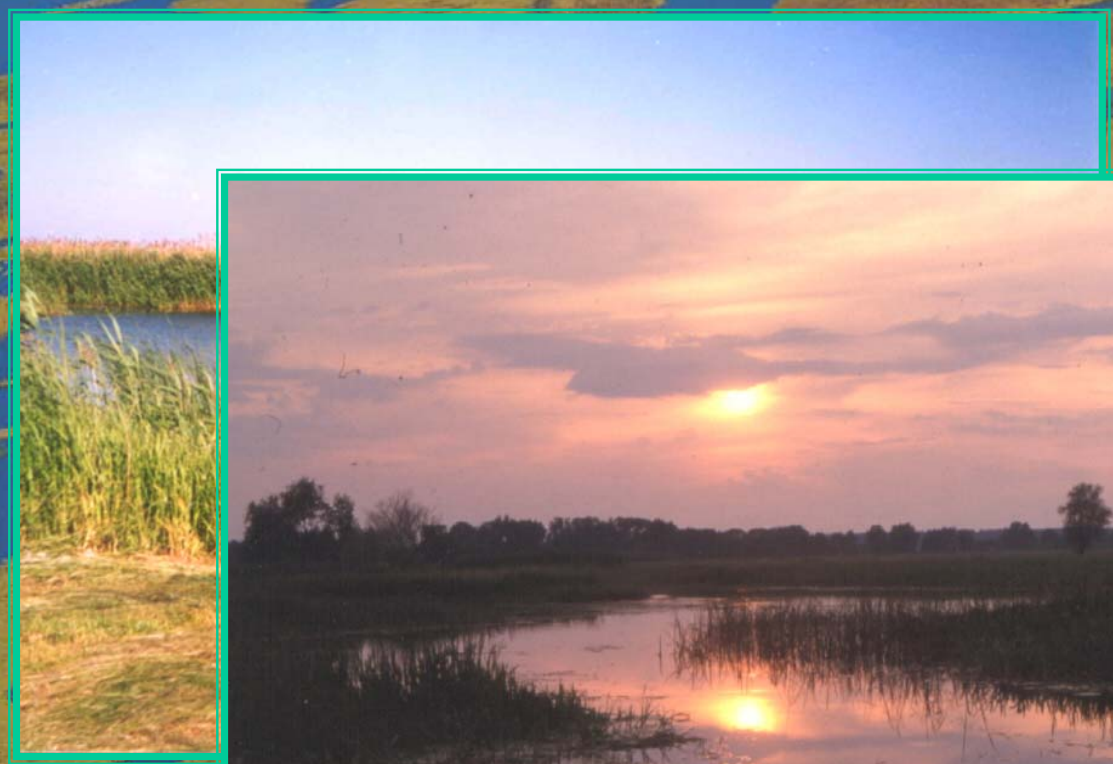
1998

2002