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KIWiG

Prediction of fluvial processes change within mountain streams on the example of the Porębianka stream

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Presentation schedule

1. Basin description
2. Porębianka stream
3. Flow data
4. Methodology
5. Results
6. Results interpretation
7. Additional solutions
8. Conclusions

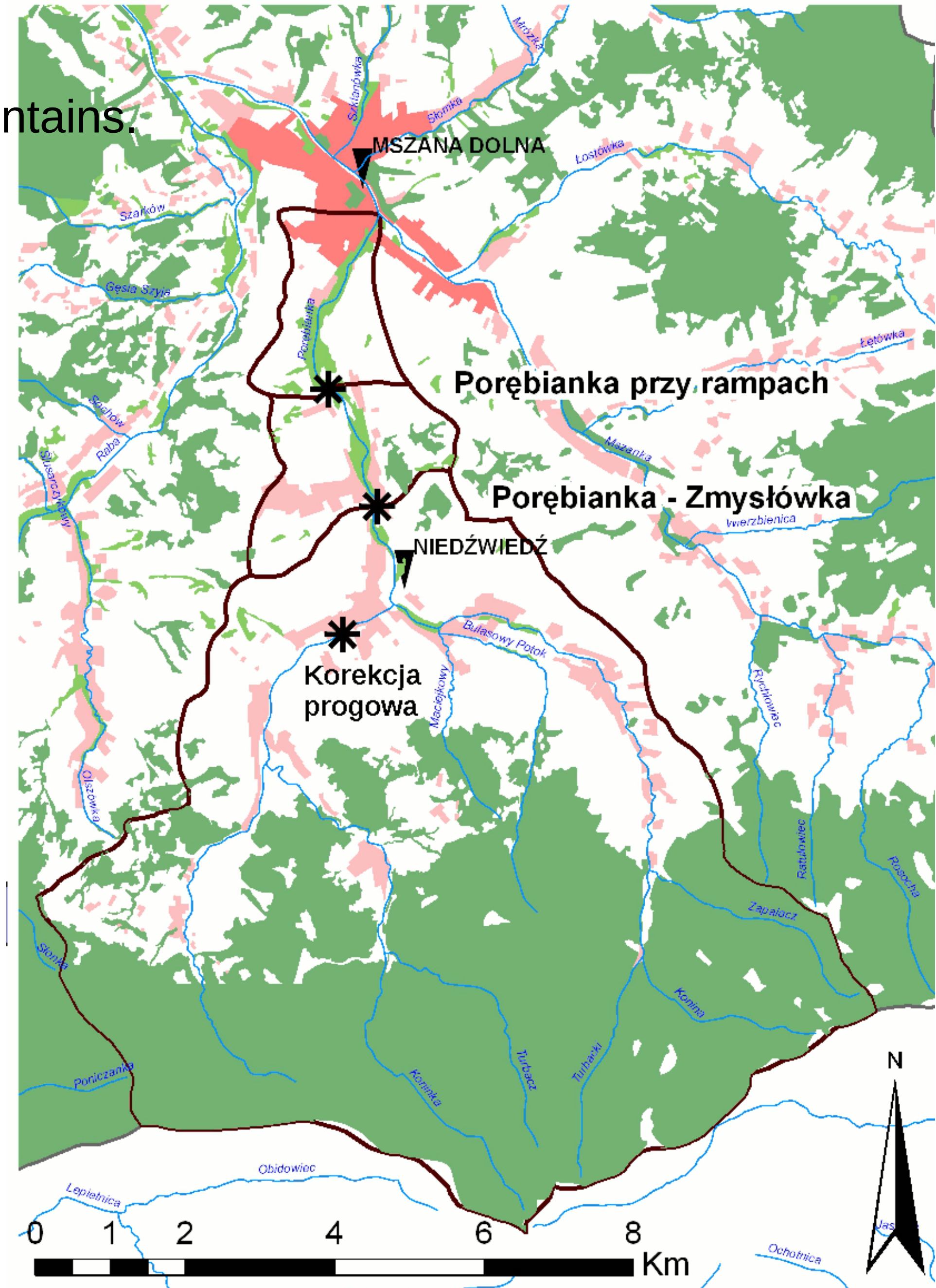
1. Basin

Porębianka is a stream flowing in the Gorce Mountains.
It is a left tributary of the Mszanka River.

Sources of the stream are located in Pośrednie col between Obidowiec and Bardo Mountains (1030 m a.s.l.).

Area of basin is 71 km^2 and the length – 15 km.

It can be stated that afforestation had increased here from 49.2 % in year 1984 to 59% in 2003.



1. Basin

reaches

reach 1 - korekcja progowa
sub-basin1 $A1 = 33.6\ km^2$
slope (middle part) $S = 0.9\%$
slope (lower part) $S = 0.1\%$

reach 2 - Zmysłówka
sub-basin2 $A2 = 63.5\ km^2$
slope high water $S = 1.8\%$
slope low water
$S_r = 7.9\%$ $S_p = 0.8\%$

reach 3 – przy rampach
sub-basin3 $A3 = 67.7\ km^2$
slope high water $S = 1.9\%$
slope low water
$S_r = 6.0\%$ $S_p = 0.14\%$

basin
total area $A = 71\ km^2$

Niedźwiedź water gauge
sub-basin $A = 61.7\ km^2$

1. Basin

reach I - river is regulated by series of small steps

1. Basin

reach II - river banks are stabilized

1. Basin

reach III - river is regulated by ramps

2. Porębianka Stream

reach I, cross-section 1 - river is regulated by series of small steps

2. Porębianka Stream

reach I, cross-section 2 - river is regulated by series of small steps

2. Porębianka Stream

reach I, cross-section 2 - river is regulated by series of small steps

2. Porębianka Stream

reach I, cross-section 3 - river is regulated by series of small steps

2. Porębianka Stream

below reach I, bridge in Niedźwiedź – rocky bed

2. Porębianka Stream

below the outlet of the Konina Stream

2. Porębianka Stream

reach II (Zmysłówka) - river banks are stabilized

2. Porębianka Stream

reach II (Zmysłówka) - river banks are stabilized

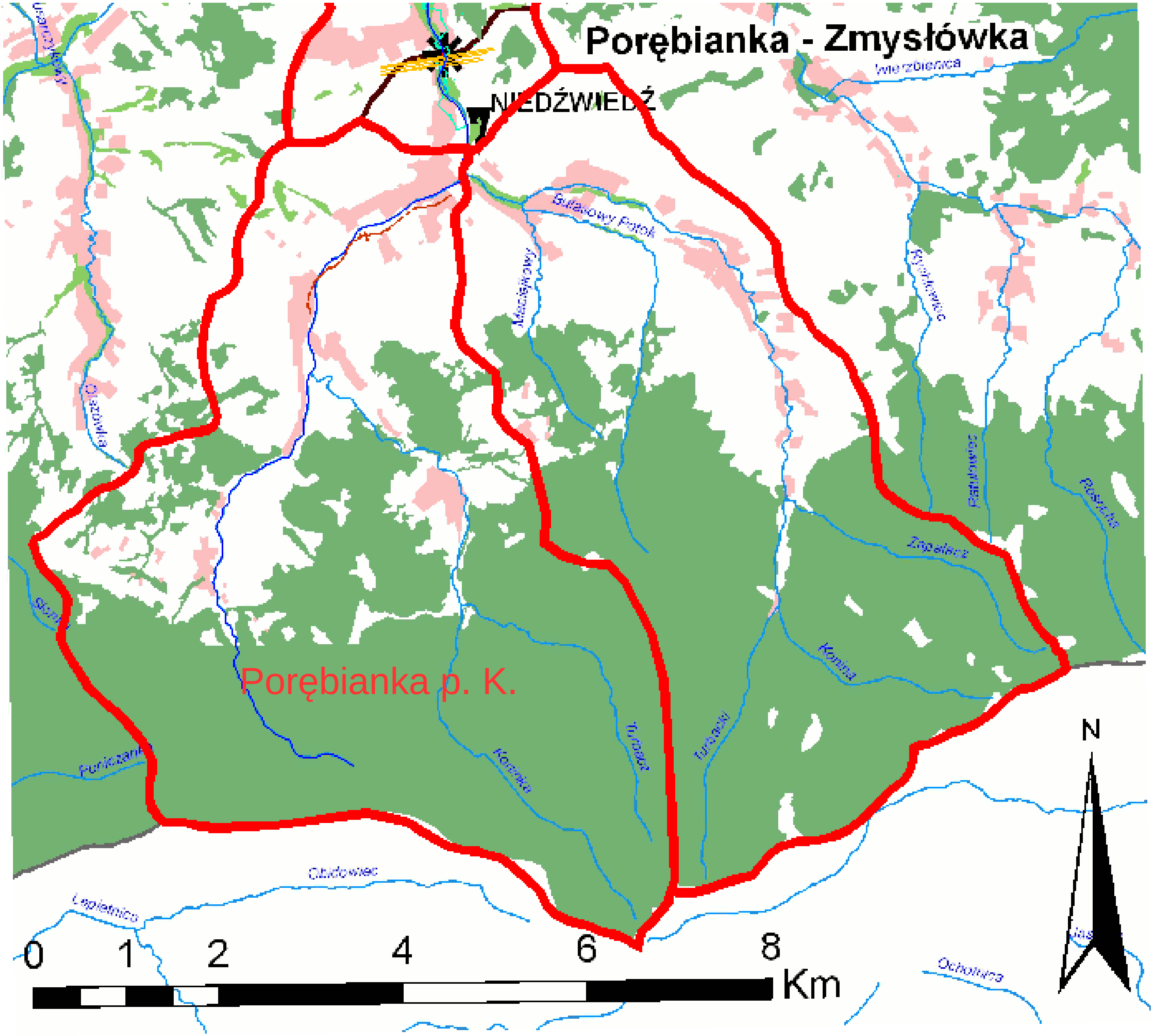
2. Porębianka Stream

reach III - river is regulated by ramps

2. Porębianka Stream

reach III - river is regulated by ramps

2. Porębianka Stream



reach II

3. Flow data

p%	Niedzwiedź water gauge	reach I	reach II	reach III
	Q [m3/s]			
0.1	273	149	277	288
0.2	245	134	249	259
0.3	229	125	233	242
0.5	209	114	212	221
1	181	99	184	191
2	153	83	155	162
3	136	74	138	144
4	124	68	126	132
5	115	63	117	122
10	85.7	47	87.1	91.2
20	56.7	31	57.7	60.6
25	47.5	26	48.4	50.9
30	40.4	22	41.2	43.3
40	30.1	16	30.8	32.5
50	25	14	25.6	27

source: IMGW, calculated with Punzet equation

probability of the maximum annual peak discharges

4. Methodology

1. In situ measurements – 2009 – 2014
    - geodesy measurement (long. profiles, cross-sections)
    - granulometry
    - photos

Assumption – steady state

2. HEC-RAS

3. Konsum, Chezy – Manning eq.

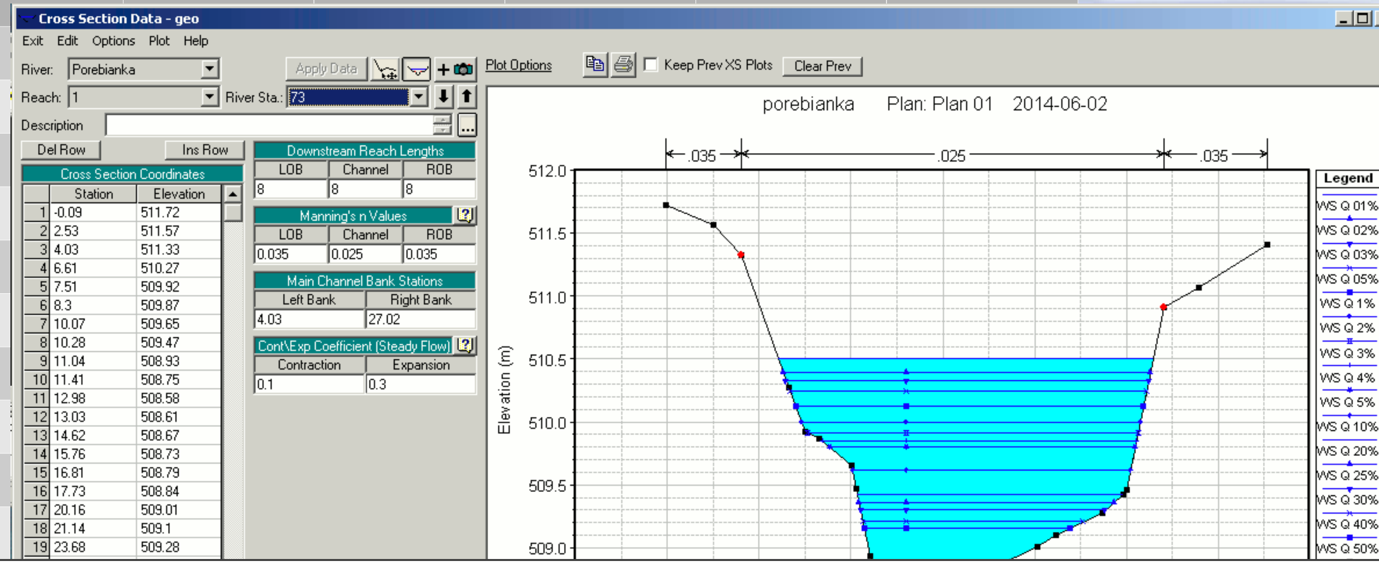
4. Armour, Wang, Bartnik, Gessler, Komura eq-s

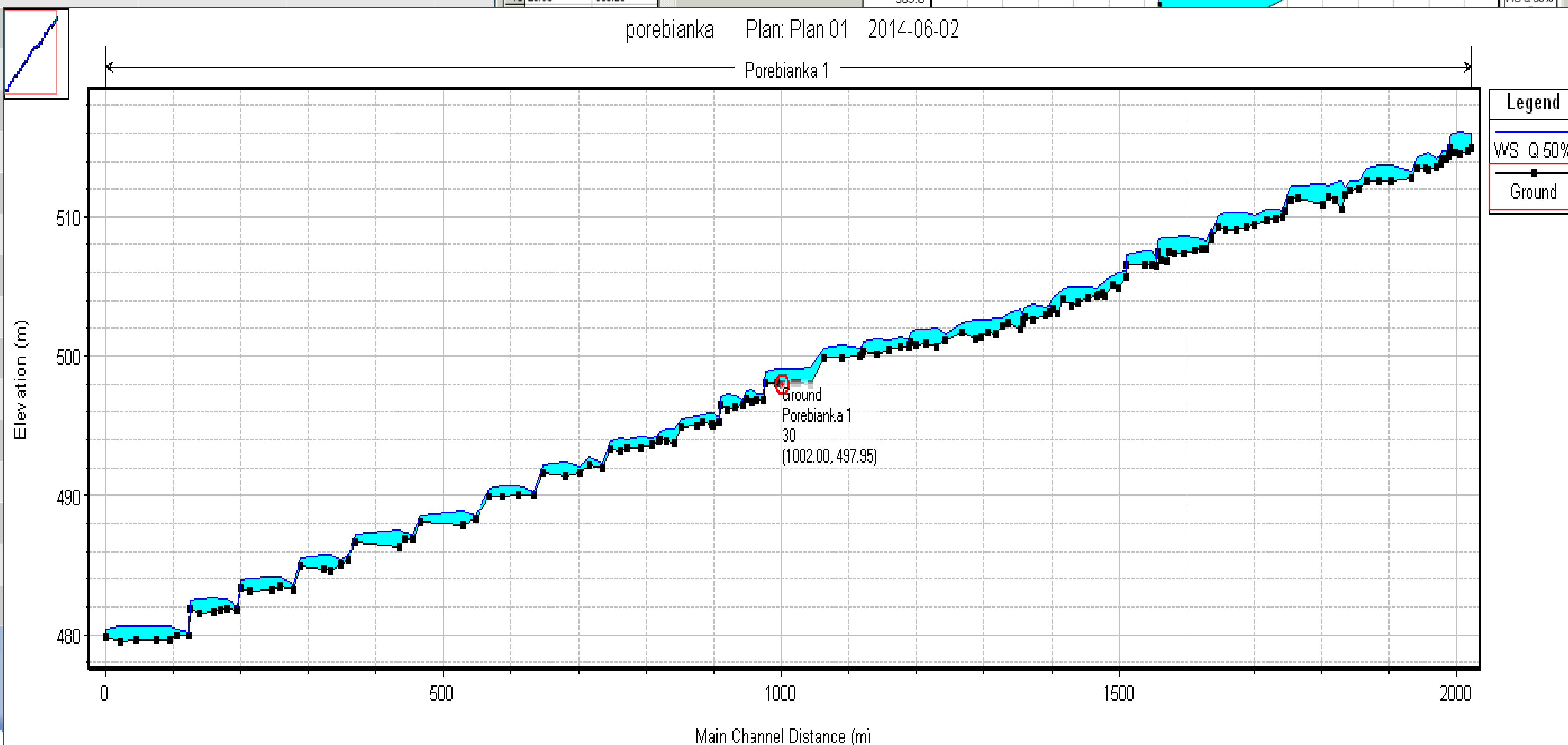
5. Incipient motion – bed stability prognosis

4. Methodology

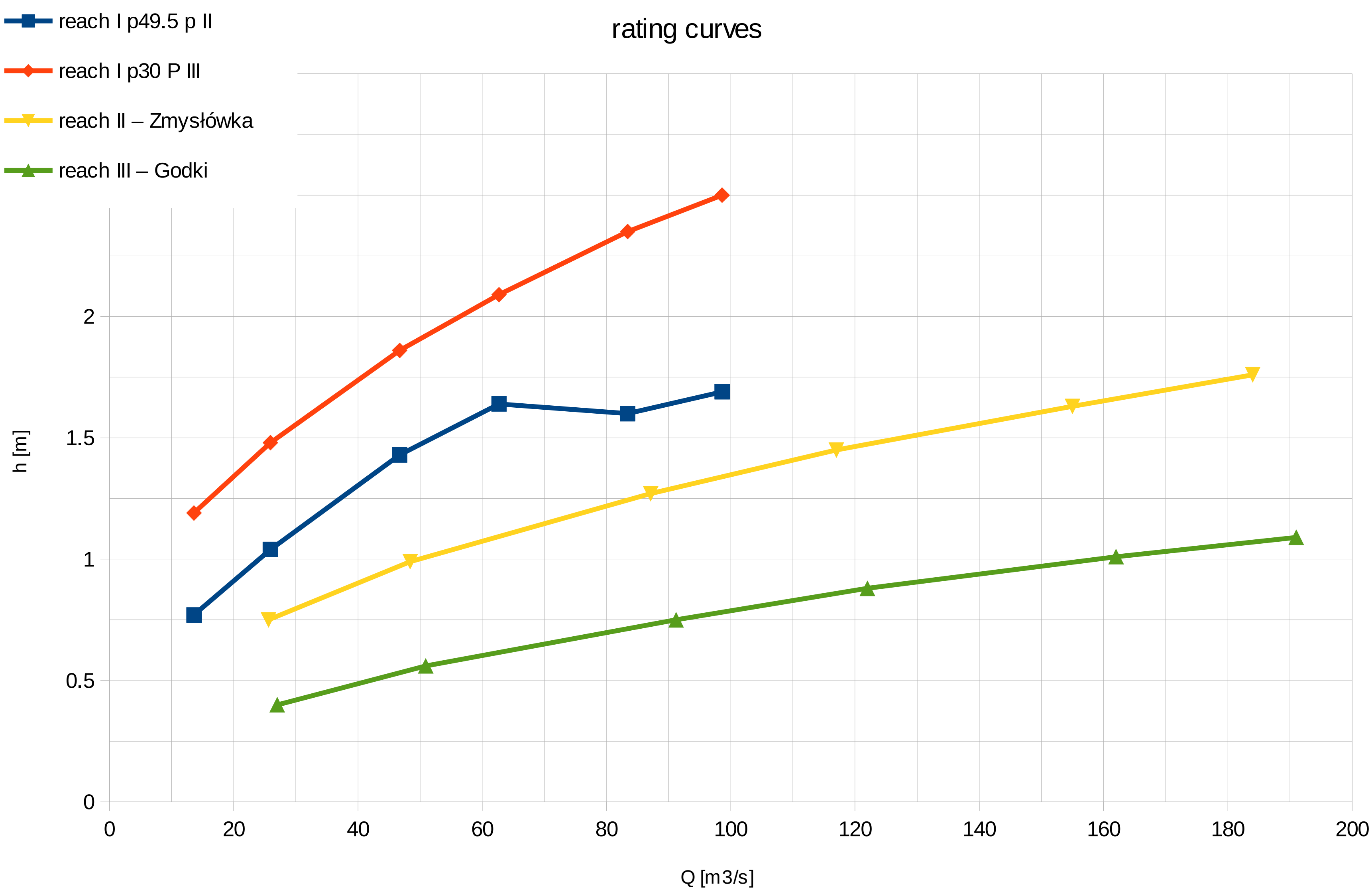
HEC-RAS Konsum

Lp	h[m]	H[m]	Q[m3/s]	v[m/s]	A[m2]	B[m]	Ozw[m]	Rh[m]
0		874.1						
1	0.029	874.129						
2	0.059	874.159						
3	0.088	874.188						
4	0.118	874.218						
5	0.147	874.247						
6	0.177	874.277						
7	0.206	874.306						
8	0.236	874.336						
9	0.265	874.365						





4. Methodology



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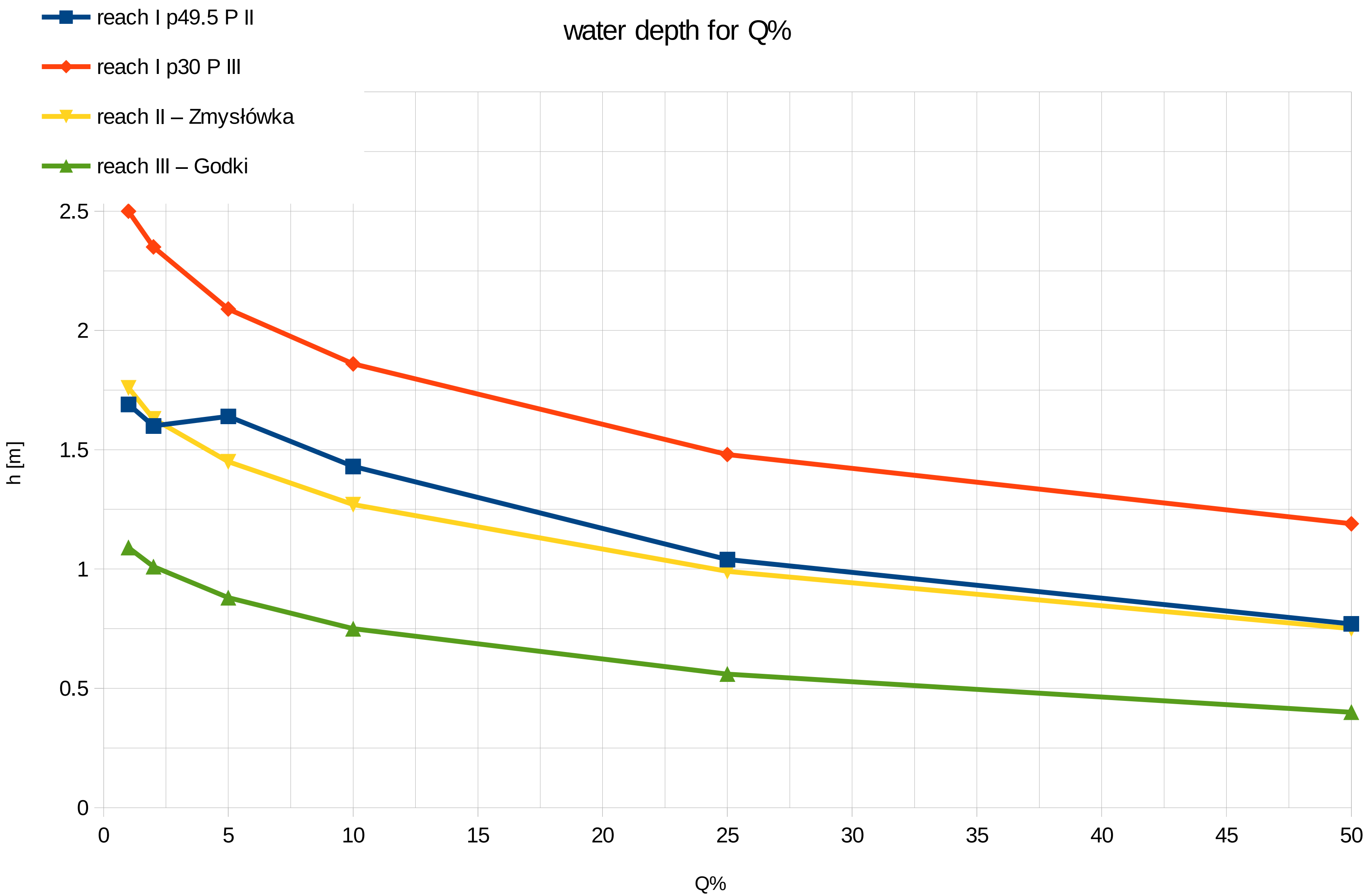
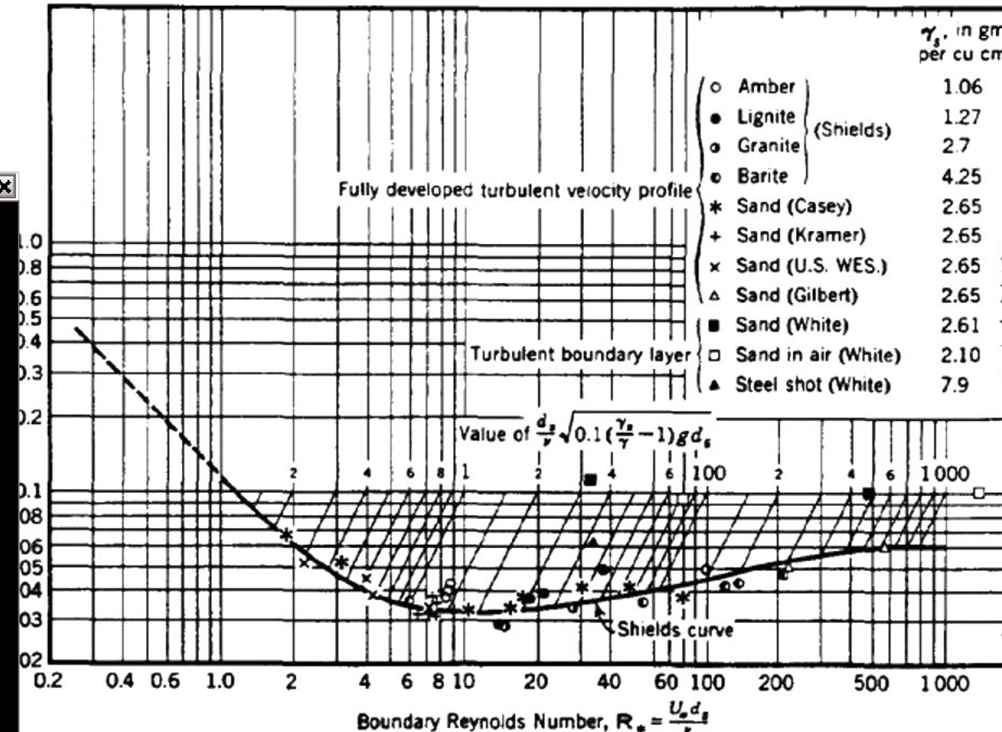
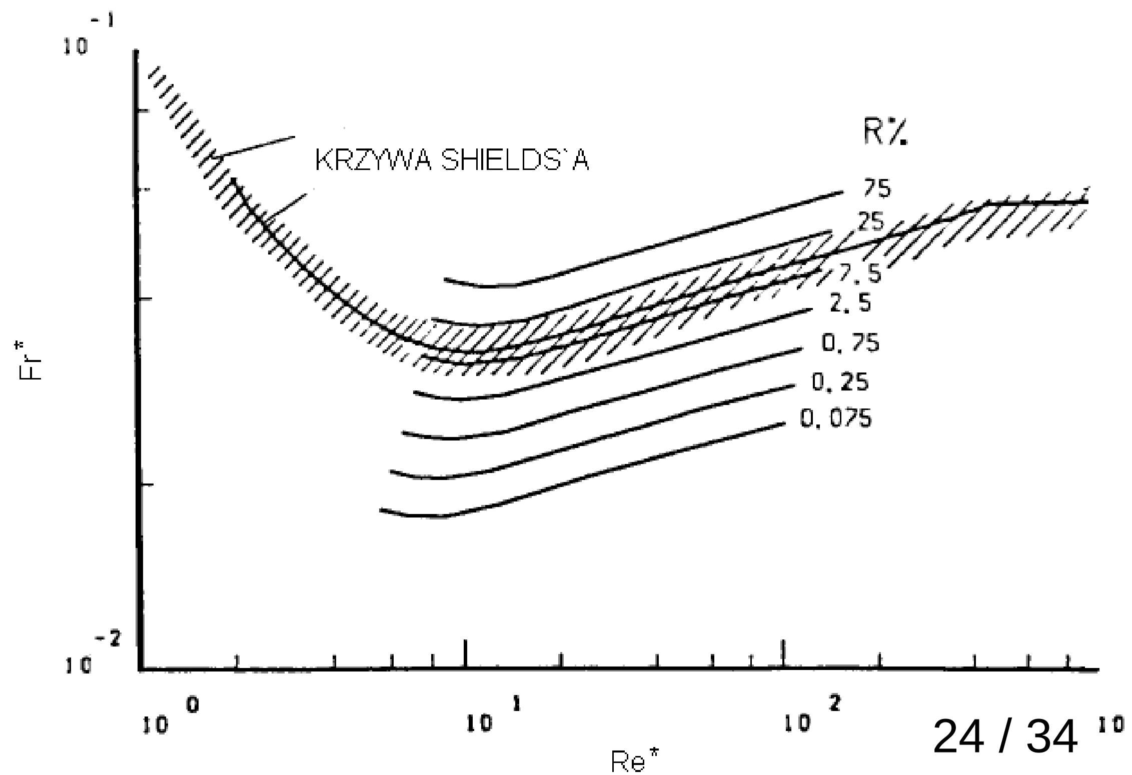


4. Methodology



$$p_a(d) = \frac{\sum_{d\,\min}^{d} q(d)\,\Delta\, p_0(d)}{\sum_{d\,\min}^{d\,\max} q(d)\,\Delta\, p_0(d)}$$

$$q_g = \phi_p \frac{\tau_{gr}}{\tau_0}$$



4. Methodology

$$\tau_c = f_i g \Delta \rho_s d_i$$

$$\varepsilon = f_i / f_m = \left(d_i / d_m \right)^{-r}$$

$$f_i = \frac{f_{m1}}{1.786 \left(\frac{d_i}{d_m} \right)^{0.947}}$$

$$f_i = \frac{f_{m2}}{\left(\frac{d_i}{d_m} \right)^{0.314}}$$

Wang [1977]

[Bartnik, 1992]

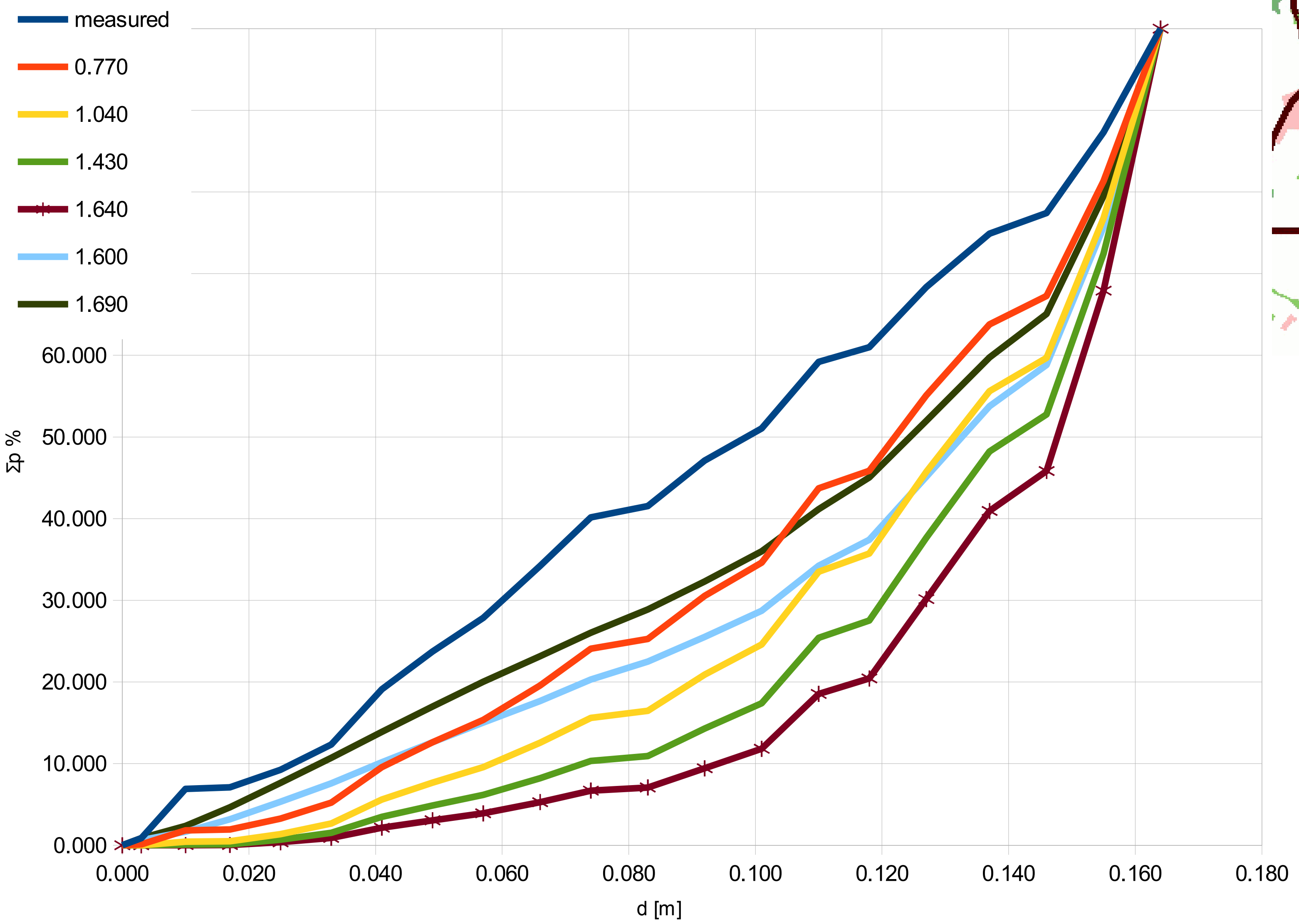
$$f_{m1} = 0.039\ \delta^{0.26} \quad \text{for } d_i/d_m < 0.6$$

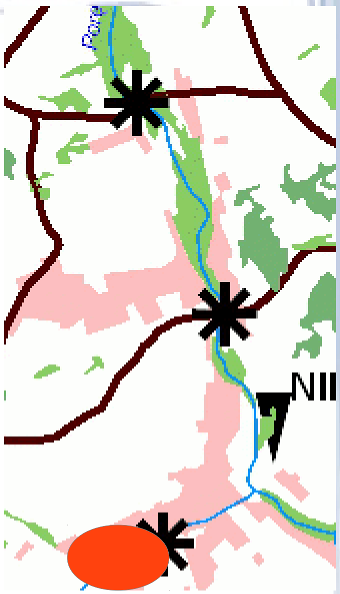
$$f_{m2} = 0.028\ \delta^{0.26} \quad \text{for } d_i/d_m > 0.6$$

$$f_m = 0.0123\ e^{1.6\ SF}$$

Bartnik [1997]

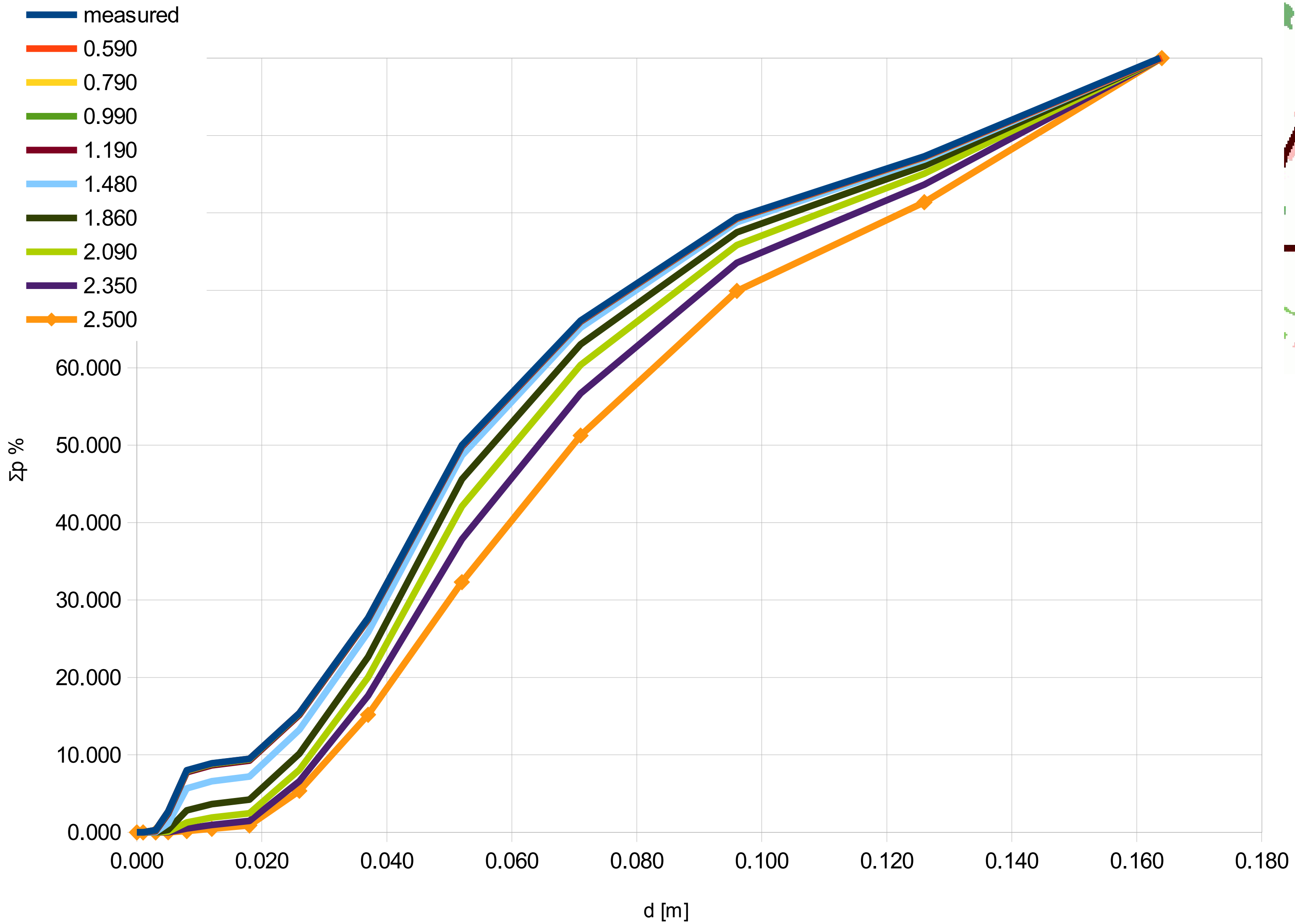
5. Results

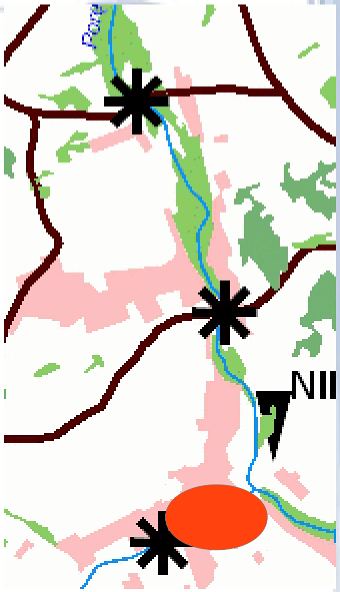




reach I, cross-section 2 – armour coat up to $Q_{5\%}$

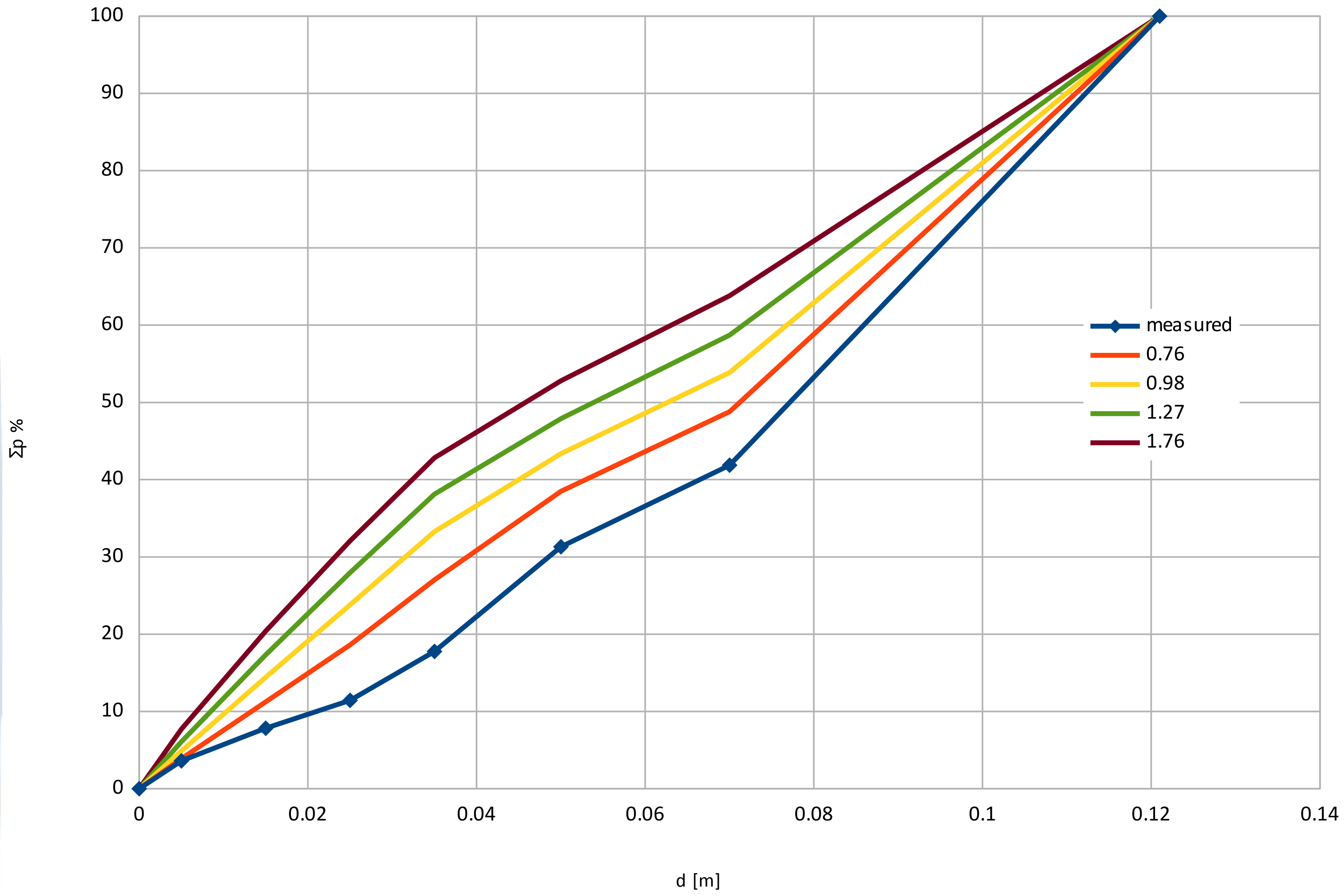
5. Results

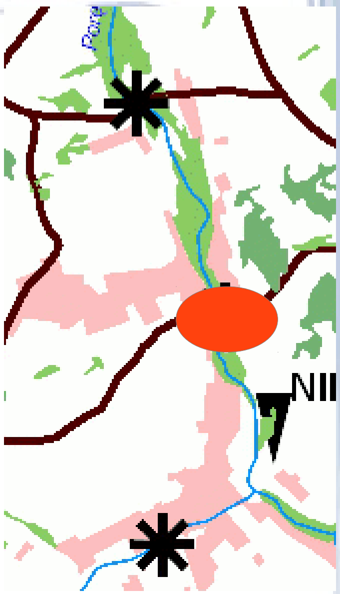




reach I, cross-section 3 – armoring processes coat up to $Q_{1\%}$ and higher

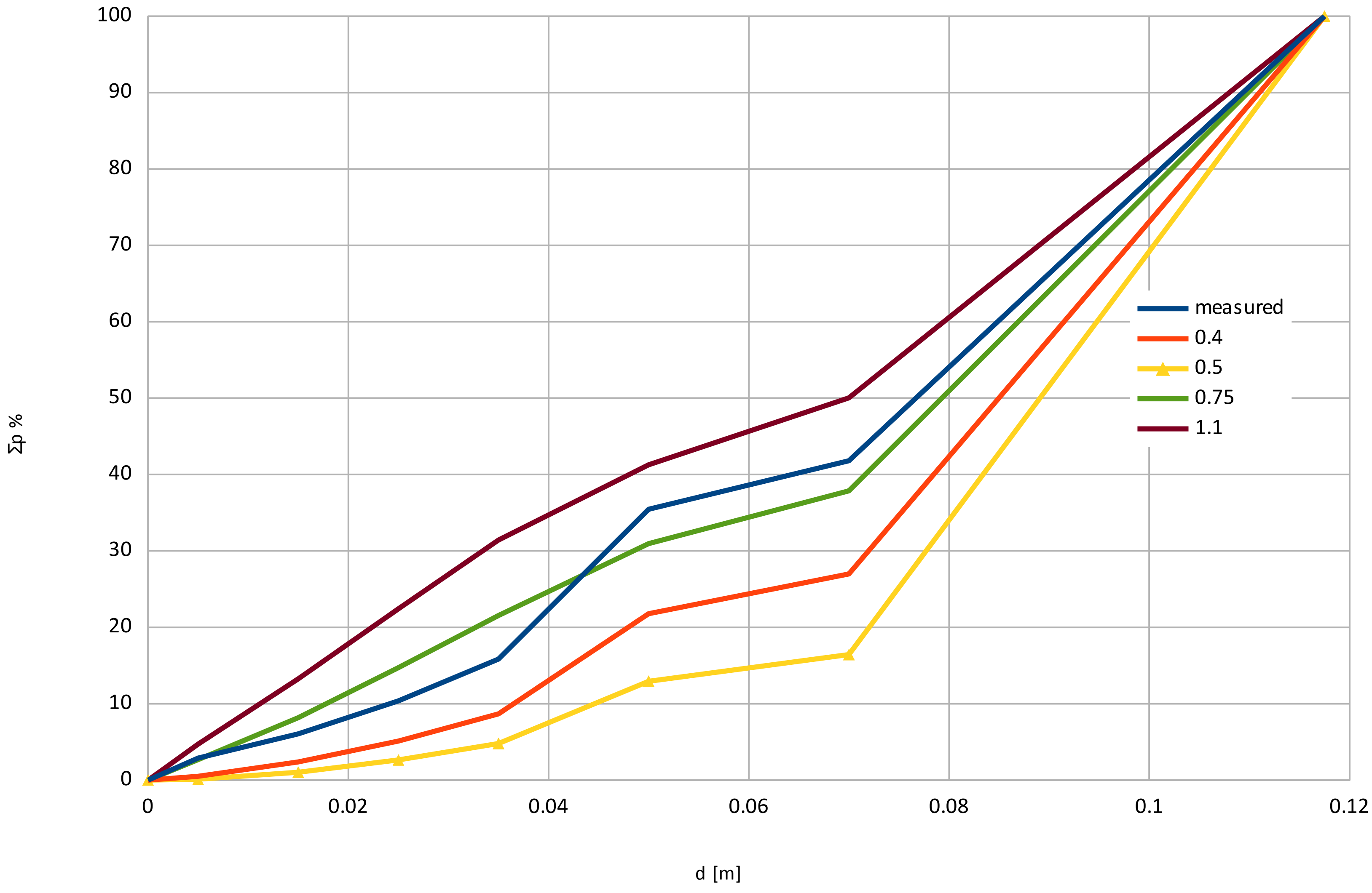
5. Results

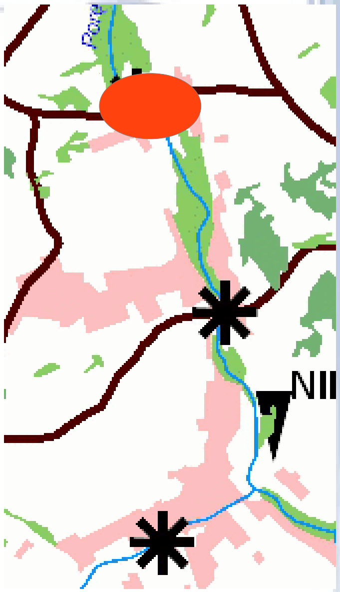




reach II – bed not stable – high transportation reach

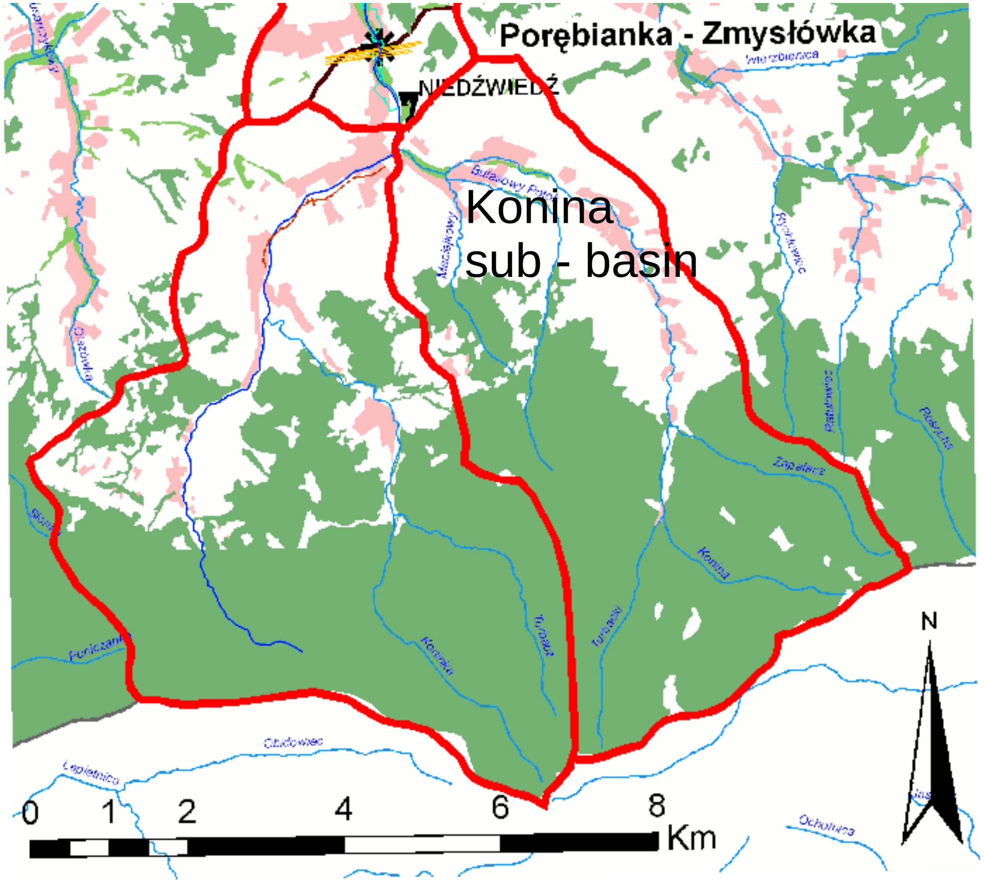
5. Results





reach III – armour coat up to $Q_{35\%}$ (dominant discharge often meets $Q_{75\%}$)

6. Results interpretation



bedload alimentation weak due to regulation structures and increased afforestation

6. Results interpretation

fluvial processes are currently poorly balanced

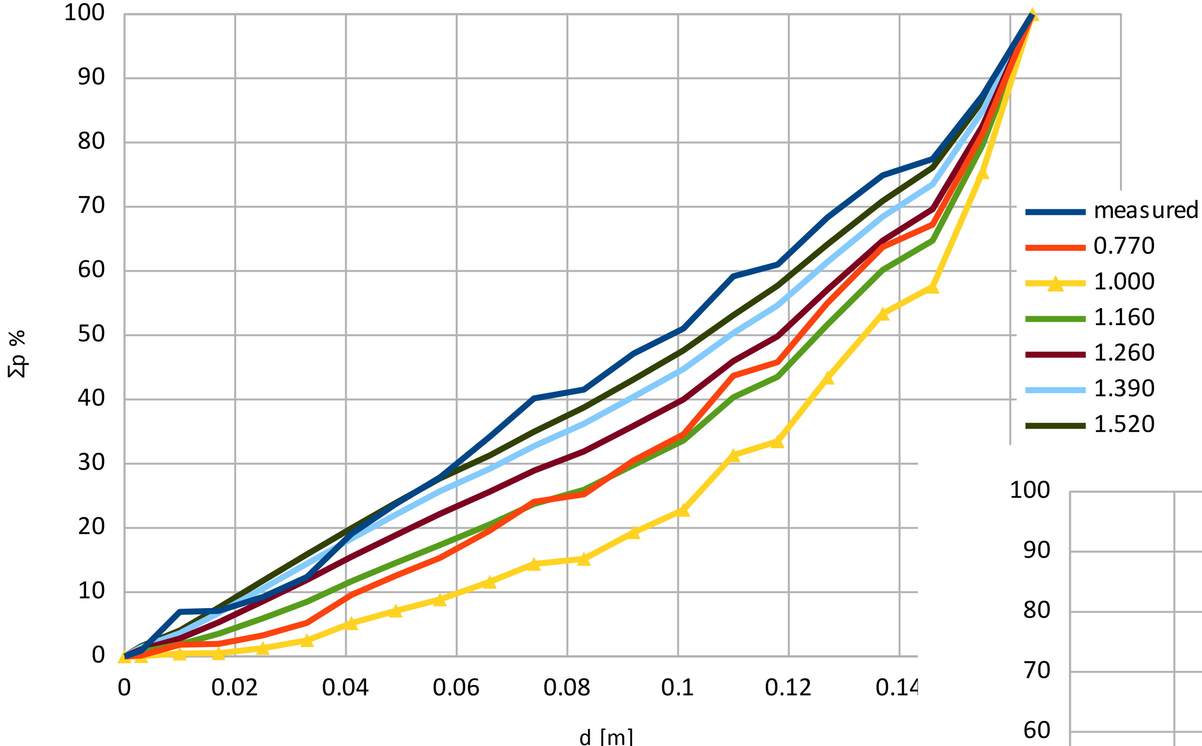
reach I, cross-section II – low transport potentials
reach I, cross-section III – no transport potentials
Konina stream – low bedload supply

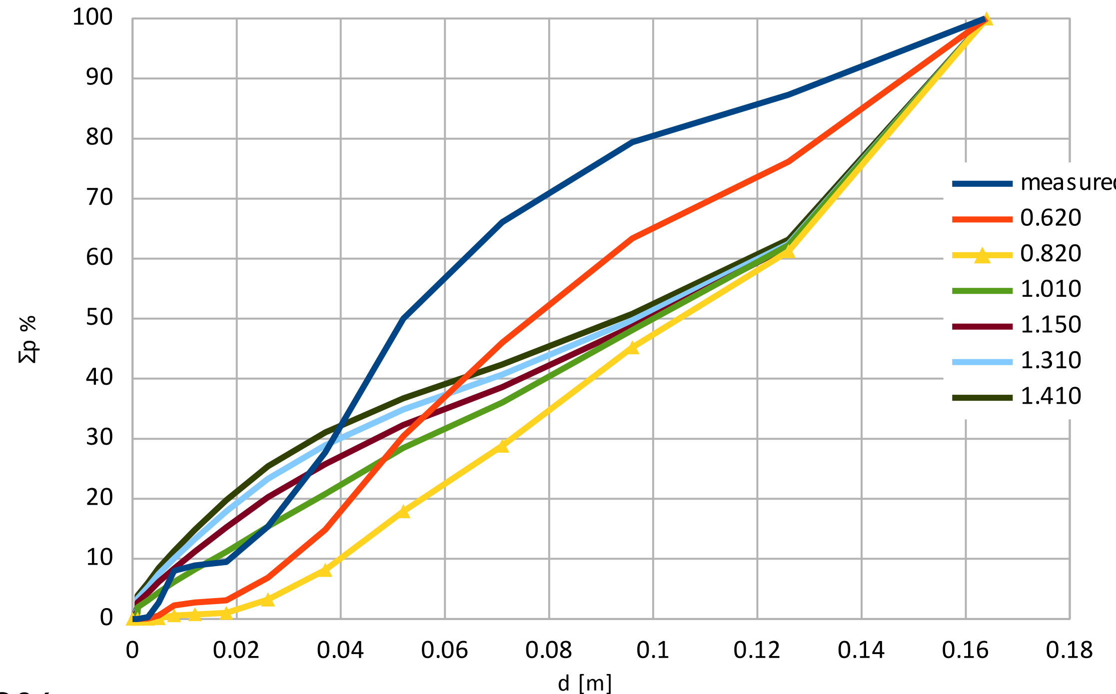
reach II – high transport potentials -> high bed erosion

reach III – average transport potentials

7. Additional solutions

after removing regulation structures
in the highest reach (I)





Q25%

bedload
alimentation potentials
dramatically increased

less than Q50%
!!!

8. Conclusions

1. Regulations, especially done in the highest reach, destroy river continuity

2. At present high erosion processes appear in transportation reach II
   from the end of reach I to reach III,
   especially below outlet of the Konina stream

3. Within reach III effects of decreased bedload alimentation are reduced
   by ramps

3. After removing of the small steps from reach I much more intensive
   fluvial processes would appear
   - this could improve the bed condition in reach II
   but also
   - could also start high movement of bedload and bed erosion within
     the lower part of reach I

Thank You