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BOULDER CLUSTER INFLUENCE ON HYDRAULIC MICROHABITATS DISTRIBUTION UNDER VARIED INSTREAM FLOW REGIME

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Abstract. The study is related to determine the influence on local hydraulic conditions of a group of boulders carried out in 2016 in the context of a restoration project in the Wisłoka river channel. After the boulders deposition in 2013, the study aims to determine whether there is a local impact of the cluster on the microhabitats distribution. The studied hydraulic features were: velocity, velocity pulsation, discharge, water depth and topographical measurements from three field sessions at three different discharges (31.2, 19.3 and 10.4 $m^3 \cdot s^{-1}$). A study of the velocity profiles as well as pictures and videos allowed to determine the microhabitats distribution. Calculation method presented by Byczkowski were used to get mean velocity values. The boulders create different kinds of velocity profiles: „logarithmic", „uniform", „reverse logarithmic" and even with „negative velocities". The cluster influences on the creation of different microhabitats. Distribution of them depends on discharge value. „Fast run", „turbulence zone", and „recirculate zone" have been observed around boulders at higher discharge. This influence is not so strong for the lower discharges, but the creation of several microhabitats can still be observed: „shallow water", „turbulent", „ripples".

Key words: boulder, microhabitat, the Wisłoka River, velocity distribution

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INTRODUCTION

Economic use of rivers led to transformation of river valleys and river channels. Negative outcomes of human activity causing degradation of river channels [Książek and Michalik 2005, Korpak et al. 2008, Radecki-Pawlik 2014] destroying of the riverbed armouring layer, a change of bedload granulometric composition or its total washout. The consequence was disturbance of hydrodynamic balance of the river bed, lowering of groundwater level and disappearance of places favouring the existence and reproduction of ichtiofauna. For example on the Wisłoka River during last centuary the population of the fish reduce from 35 fish species to 22 species [Bieniarz and Epler 1977, 1991, Jelonek et al. 2002, Bartnik et al. 2011].

One of the issue of the Water Framework is to improve or prevent the ecological status of the river. Restoration activities denote recognizing the principle of influence of hydraulic objectives in river channel on water flow conditions. The restoration measures in the watercourse channel comprise restoration of hydrodynamic balance, restructuring of the horizontal pattern of the watercourse through diversification of the river course, correction of the longitudinal profile and change of cross-sections, i.e. diversification of the shape and dimensions. Local obstacles like fallen trees or stone up thrusts of the bed are elements which change water flow conditions and enrich the diversity of habitat conditions [Żelazo 2006].

Diversification of water discharge conditions in sections between Mokrzec and Pustków was achieved through placing boulders, deposition of bedload in the river channel, forcing a change of horizontal river pattern through controlled lateral erosion of its banks [Bartnik et al. 2015]. As the example, the sector of the Wisłoka River at Dębica was chosen in order to measure the impacts of the adjustments at the sections' scale after two floods which took place in May and July 2014 with the discharges respectively 621 $m^3 \cdot s^{-1}$ and 623 $m^3 \cdot s^{-1}$ at the Łabuzie gaging station which corresponds to discharges between $Q_{20\%}$ and $Q_{10\%}$ [Maciejewski 2011]. These floods had an impact on the riverbed's morphology.

Presence of boulders in the channel causes changes in the flow hydraulics. Around grains the bed material is washed out, which leads to diversification of depth and velocity distribution. Behind boulders there is a zone of higher flow turbulence. Its size depends on the size, shape and degree of single boulder exposure above the cover [Strutyński et al. 2013]. Fig. 1 shows erosion zone and zone of intensified turbulence in

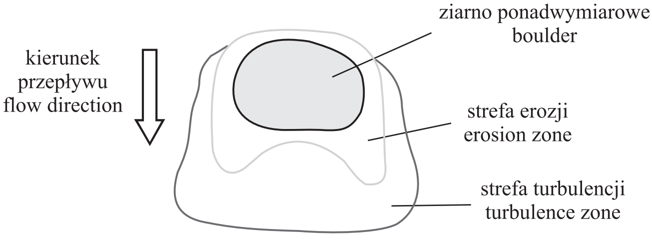

Fig. 1. Zones of erosion and turbulence in the area of boulder impact [Bartnik at al. 2015]
Ryc. 1. Strefy erozji i turbulencji na obszrze oddziaływania ziarna ponadwymiarowego [Bartnik i in. 2015]

the boulder impact zone. Occurrence of boulder in the channel diversifies the bedload composition [Bartnik et al, 2015], air entrainment, energy dissipation as well as lead to deposition of fine bedload behind a boulder. The boulders deposit has some disadvantages too. It can need heavy equipments to put the structures in place as well as generate an expensive transport. Moreover, it can change the natural sequence riffle-pool if it is placed at the wrong position [Chaussis and Suaudeau 2009]. The impact of single boulders on flow conditions in wide channels increases owing to their placement in groups, which may have several variants. The structure of their placement and the distances between them depends on the local hydraulic conditions of water flow on individual measurement sections.

The basic unit, in accordance to multi-scale framework for ecological classification of aquatic habitats was defined as microhabitat. The classification is as follow: ecoregion (level 1) → bioclimatic unit → aquatic ecosystem → stream segment → reach → channel unit → microhabitat (level 7) [Miers 1994, Gordon et al. 2004]. Channel units are defined as quasi-discrete areas of relatively homogeneous depth and flow that are bounded by sharp physical gradients e.g., riffles and pools, runs, glides. These units are called mesohabitats. While the microhabitats are small, areas, such as a clump of grass or a space between rocks. Microhabitats are patches within pool/riffle systems that have relatively homogeneous substrate, type, water depth, and velocity and have low temporal stability. Flow obstructions and microtopography such as pebble clusters, rocks and roots wads can have a significant influence on surrounding hydraulics and create important microhabitats for biota [Harvey and Clifford 2009]. Microhabitat classes will vary according to study objective [Hawkins at al. 1993].

The goal of this study is to define an influence of a microstructure (boulder cluster) on local channel hydraulic by analysis of some hydraulic parameters: water depth, velocity values, velocity pulsation, discharge, topography. Such local diversification of hydraulic features creates valuable mosaic of microhabitats for riverine communities.

MATERIAL AND METHODS

The study site is located in Dębica city. Research area is situated on the Wisłoka river, 110 meters downstream of the confluence between the Wisłoka and the Grabinianka. It is about 110 km away from the river's source. The catchment area which corresponds to this site is 2942.71 km^2 [Czarnecka et al, 2005, Ksiażek et al. 2012]. It is a curved segment of river and there with gravel bank on the river right bank. Many groups of boulders were put in the riverbed on this sector (Fig. 2).

The are cluster of 8 boulders arranged in group which work as an openwork deflector (Fig 3a, b). They were located on the gravel bar so they are submerged for decade discharge in March and April $Q = 30.66\ \mathrm{m^3 \cdot s^{-1}}$ [Ksiażek et al. 2012]. Individual grains are spherical with diameter up to 1 m. The distances between them is about 1.5–2.0 m. Longitudinal profile shows the selected group of boulder located on the riffle. The boulders create microhabitats within the riffle with spatial distribution of flow parameters under turbulent flow (order of magnitude of Reynolds number $\mathrm{Re} = v^* \cdot h \cdot v^{-1}$ is $10^5 \div 10^6$).

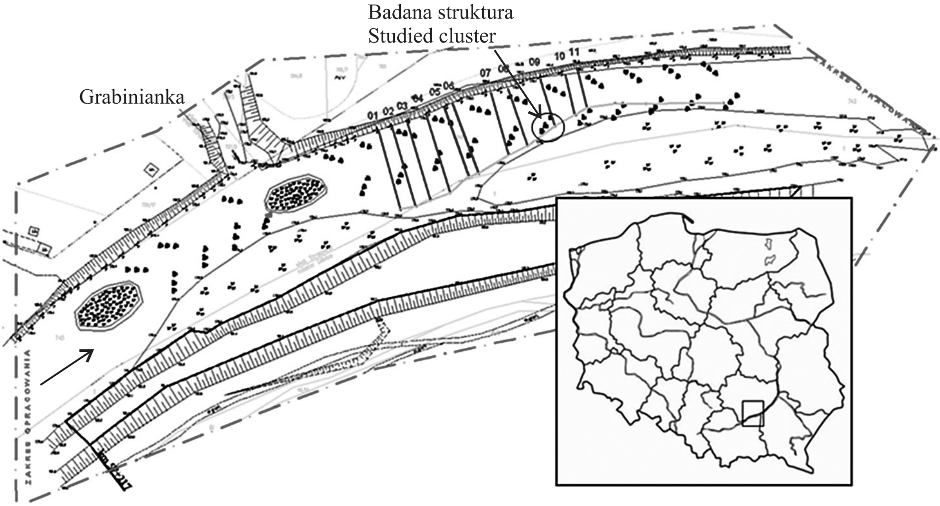

Fig. 2. Study site of the Wisłoka River and location of bulder clusters
Ryc. 2. Badany odcinek Wisłoki i rozmieszczenie struktur ułożenia głazów

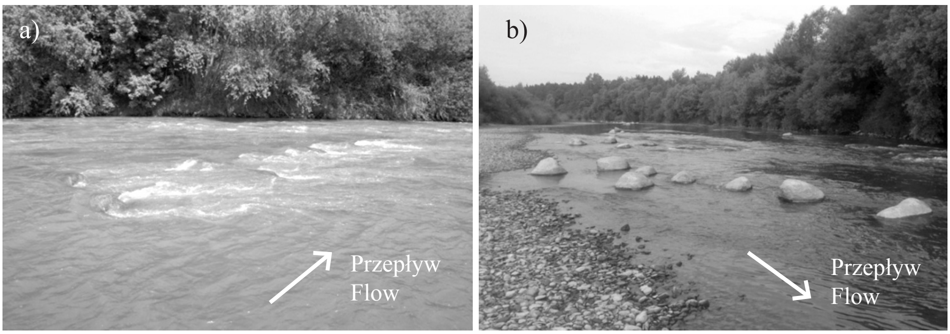

Fig. 3. View of the boulder cluster at discharge: a) 31.2 $m^3 \cdot s^{-1}$, b) 10.4 $m^3 \cdot s^{-1}$
Ryc. 3. Widok struktury ułożenia głazów przy przepływie: a) 31.2 $m^3 \cdot s^{-1}$, b) 10.4 $m^3 \cdot s^{-1}$

In accordance to Książek et al. [2012] the average slope equals I_{ave} = 0.001 ($I_{\max}$ = 0.004), Width/Depth ratio = 16.3 (Fig. 4a) and Floodplain/Bankfull discharge Width = 1.3 [Rosgen 1996]. With the Church classification [1996] this Wisłoka sector is stable one, with small amount of bedmaterial supplied: winding channel, reasonable slope, gravel bed [Radecki-Pawlik 2014]. Mean diameter of bed material at middle part of the bar vary from d_m = 0,021 m to d_m = 0,024 ($d_{\max}$ = 0.122 m). Standard deviation of the sieve curve equals δ = 3,54 (–) indicate non uniform grain size composition of bed material.

The characteristic discharges equal as follow: $Q_{50\%}$ = 381 $m^3 \cdot s^{-1}$ (Fig. 4b), mean annual flow equals $SSQ_{2006–2010}$ = 37.83 $m^3 \cdot s^{-1}$ and mean low flow is $SNQ_{2006–2010}$ = 5.01 $m^3 \cdot s^{-1}$ [Ksiażek et al. 2012].

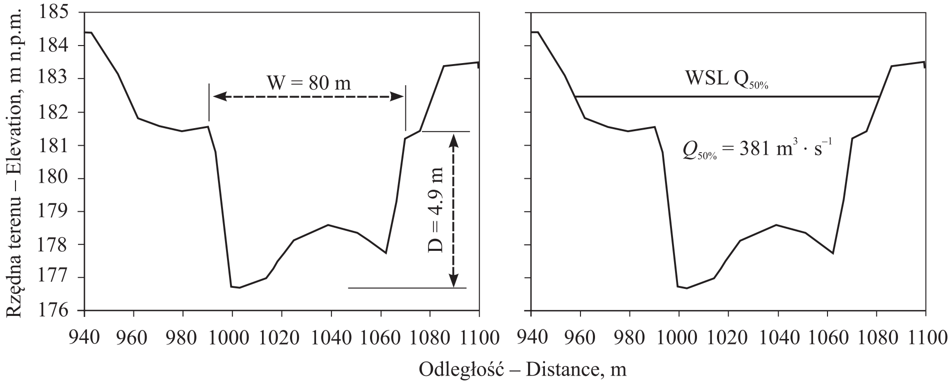

Fig. 4. Cross-section km 56+915, a) main channel, b) water surface level at $Q_{50\%} = 381\ m^3 \cdot s^{-1}$
Ryc. 4. Przekrój poprzeczny w km 56+915, a) koryto główne, b) poziom zwierciadła wody przy $Q_{50\%} = 381\ m^3 \cdot s^{-1}$

WATER FLOW MEASUREMENTS

The three field measurement sessions have been performed at discharges respectively $Q_{21.05.2016} = 31{,}2\ m^3 \cdot s^{-1}$, $Q_{01.06.2016} = 19{,}3\ m^3 \cdot s^{-1}$ and $Q_{11.06.2016} = 10{,}4\ m^3 \cdot s^{-1}$ (Tab. 2). The first two discharges were calculated on the base of gauging station using an interpolation method [Byczkowski 1979], the third was measured using Acoustic Doppler Current Profiler ADCP. The field measurements included: longitudinal profile cross-sections, boulders shape and location, instantaneous velocity, flow depth and water temperature. Velocity pulsations was calculated as standard deviation of instantaneous velocity values. It is one of the most common characteristic of turbulent flow. The pulsation is maximum value of standard deviations because it is interesting to see what a fish can meet as biggest turbulences in each point. There 27 velocity profiles in each session were obtained. Velocity were measured at few locations (depending on flow depth) (Tab. 1) using electromagnetic velocimeter with sampling time t = 30 s, 2 Hz [Operation Manual 1999].

Table 1. Location of measurements depending on the water depth [Byczkowski 1996]
Tabela 1. Rozmieszczenie punktów pomiarowych w zależności od napełnienia [Byczkowski 1996]

Water depth *h*, m Napełnienie *h*, m	Arrangement of measurement points Rozmieszczenie punktów pomiarowych	Number of points Ilość punktów
< 0.2	0.4 *h*	1
0.2–0.6	0.2 *h*, 0.4 *h*, 0.8 *h*	3
> 0.6	at the bottom – przy dnie, 0.2 *h*, 0.4 *h*, 0.8 *h*, at the surface – pod powierzchnią	5

There is a significant velocity gradient around the bouder so the location of measurement were located respectively: upstream, where the flow is not disturbed, in turbulence zone, between the boulders and finally outside of the impact zone in order to characterize the water flow phenomena. Average velocity were, calculated using the following method [Byczkowski 1996]:

a) if the velocity profile is logarithmic, the average velocity is calculated with formulas :
   - profile with 3 points $v_{ave} = (v_{0,2h} + 2v_{0,4h} + v_{0,8h})$ /4
   - profile with 5 points $v_{ave} = (v_{\mathrm{bottom}} + 2v_{0,2h} + 3v_{0,4h} + 3v_{0,8h} + v_{\mathrm{surface}})$ /10,

b) if the velocity profile is non-logarithmic (uniform, with negative velocities or reverse logarithmic), the average velociy is calculated by integration. However, for the points with only three measurements, there is a lack of information on the velocities from the first and last 20% of flow depth. Therefore two hypothesis have been tested: the velocity between 80% of the water depth and the surface velocity is constant and equal to $v_{0,8h}$; the velocity between 10% and 20% of the water depth is constant and equal to $v_{0,2h}$ and the velocity between the riverbed and 10% of the water depth is linear from 0 m/s in the riverbed to $v_{0,2h}$ at 10% of the water height.

RESULTS

The bed topography is the effect of two flood peaks in 2014. The discharges were about 623 $m^3 \cdot s^{-1}$ and were equivalent of bankfull discharge. The boulders were stable but the incipient motion of bed material was exceeded. The flood events do not change the channel morphology essentially but reorganized spawning microhabitats, changing bed material composition and flow conditions around the boulder clusters. Velocity profiles, velocity pulsation, water depth and spatial distribution of microhabitats around the boulder cluster were investigated. Measurements have been taken at discharges corresponding three critical minimun flows required for fish and wildlife.

Table 2. Discharges in Łabuzie, Dębica and Pustków for the three sessions of measurements and critical minimum flow required for fish, wildlife and recreation [Tennant 1976, Gordon 2004]
Tabela 2. Natężenie przepływu w Łabuziach, Dębicy i Pustkowie dla trzech sesji pomiarowych oraz minimalny przepływ dla ryb, przyrody i rekreacji [Tennant 1976, Gordon 2004]

Date Data	Discharge, $m^3 \cdot s^{-1}$ Natężenie przepływu, $m^3 \cdot s^{-1}$			% of the mean annual flow *SSQ* % średniego rocznego przepływu *SSQ*	Stream flow conditions Warunki przepływu
	Łabuzie[1)]	Dębica07	Pustków[1)]	Dębica07	Dębica07
21/05/2016	30.2	31.2*	32.8	82.5	Optimum range
01/06/2016	18.2	19.3*	20.8	51.0	Excellent
11/06/2016	8.4	10.4**	12.1	27.5	Fair or degrading

[1)] – gauging station, * – calculated, ** – measured
[1)] – przekrój wodowskazowy, * – wartość obliczona, ** – wartość pomierzona

The mean annual flow at the Wisłoka cross-section 57+095 was calculated on 37.83 $m^3 \cdot s^{-1}$. During the first field session the discharge was higher then 60% and lower than 100% of the mean annual flow (*SSQ*) which was described as „optimum range" of flow for fish, wildlife and recreation (Tab. 2). Second session was performed at discharge 19.3 $m^3 \cdot s^{-1}$ which is 51% of mean annual flow and it was excellent flow regime. During the third session the discharge was about 27.5% of critical flow required for fish, wildlife and recreation for wet season and was described as „fair or degrading" flow regime [Tennant 1976, Gordon 2004].

Due to the varied water flow conditions have been distinguished: i) the logarithmic velocity profile which is characteristic for non disturbed flow in open channel and ii) non logarithmic: uniform flow occurring in fast flowing stream; with negative velocities appearing in vertexes and reverse logarithmic (Fig. 5).

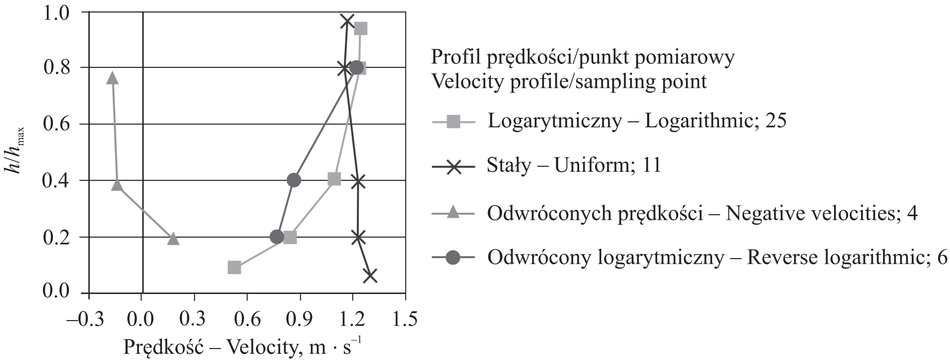

Fig. 5. Velocity profiles around boulder cluster at discharge $Q = 31.2\ m^3 \cdot s^{-1}$, the Wisłoka River
Ryc. 5. Różne profile prędkości w strefie oddziaływania głazów $Q = 31.2\ m^3 \cdot s^{-1}$, Wisłoka

The set of results for vertical point number 11 (X = 671460.6568, Y = 246781.7199) is presented in Tab. 3. The water depth for point 11 decrease from 0.65 m to 0.21 m, mean velocity have changed from 1.21 $m \cdot s^{-1}$ to 0.46÷0.56 $m \cdot s^{-1}$. Turbulence expressed by standard deviation of measuring instantaneous velocity not exceed 0.08 $m \cdot s^{-1}$ and does not depend on value of water velocity or water depth. In addition the velocity profile have changed from uniform one to reverse logarithmic. Those non intuitive description of flow conditions is the result of boulder presence and the subcritical and supercritical flow around it.

Spatial distribution of hydraulic parameters is presented on the maps (Fig. 6, 7 and 9). The color discribe the velocity profile, size of the circle –mean velocity value, distinctive circle sector – maximum velocity pulsation, the number – water depth.

At discharge 31.2 $m^3 \cdot s^{-1}$ the water depth increase from 0.30 m near the gravel bank to 0.80 m (Fig. 6). The maximum mean velocity equals 1.38 $m \cdot s^{-1}$. The highest velocity pulsation is 0.19 $m \cdot s^{-1}$ at location in the middle of the cluster. Two different hydraulic areas have been observed. The first one stretches from before the boulders through its right side to more than 4 meters behind the cluster. It presents logarithmic velocity profiles. The second one, is situated in the area comprised between 2.5 m and 4 m behind the boulders and presents uniform velocity profiles. Globally, four kinds of velocity profiles have been observed: logarithmic, uniform, reverse logarithmic and with negative velocities.

Table 3. Evolution of the hydraulic parameters for the measurement point n°11, The Wisłoka River
Tabela 3. Zmiana parametrów hydraulicznych w punkcie pomiarowym n°11, Wisłoka

Sampling point Punkt pomiarowy	Discharge Natężenie przepływu $m^3 \cdot s^{-1}$	Water depth Napełnienie m	Mean velocity Prędkość średnia $m \cdot s^{-1}$	$Re \times 10^6$	Pulsacja prędkości, Velocity pulsation, $m \cdot s^{-1}$ Prędkość, Velocity, $m \cdot s^{-1}$					Kind of profile Rodzaj profilu prędkości
					bottom dno	20%	40%	80%	surface powierzchnia	
n° 11	31.2	0.65	1.21	6.87	1.300	1.228	1.230	1.152	1.169	Uniform Stały
					0.066	0.081	0.028	0.060	0.052	
	19.3	0.42	0.46	1.69	–	0.541	0.350	0.599	–	Uniform Stały
						0.015	0.063	0.014		
	10.4	0.21	0.56	1.19	–	0.467	0.529	0.704	–	Reverse logarithmic Odwrócony logarytmiczny
						0.075	0.026	0.011		

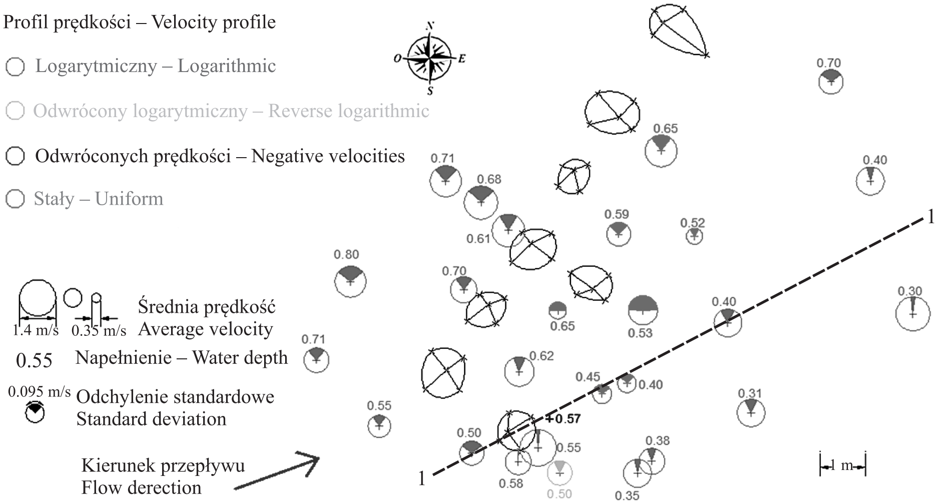

Fig. 6. Spatial velocity distribution around boulder cluster at discharge $Q = 31.2 m^3 \cdot s^{-1}$, The Wisłoka River

Ryc. 6. Przestrzenny rozkład prędkości w strefie oddziaływania głazów przy przepływie $Q = 31.2\ m^3 \cdot s^{-1}$, Wisłoka

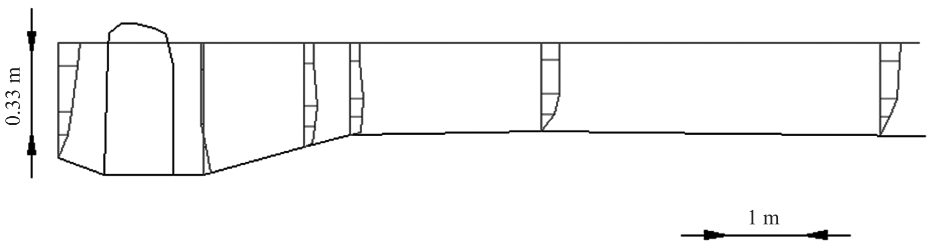

Fig. 7. Longitudinal profile n°1 at discharge $Q = 31.2\ m^3 \cdot s^{-1}$, the Wisłoka River

Ryc. 7. Profil podłużny n°1 przy przepływie $Q = 31.2\ m^3 \cdot s^{-1}$, Wisłoka

Evolution of velocity profiles downstream the boulder is presented on Fig. 7. The profile before the stone has logarithmic form. Next there is a profile with negative velocities directly behind the grain located in turbulence zone where three-dimention vertexes cause change of flow directions. Two uniform profiles are between 1 and 2 meters after the bloc. Finally, the velocity profiles go back to a logarithmic from after about 4 meters.

The maximum velocity value is 0.91 $m \cdot s^{-1}$ and the highest pulsation is 0.11 $m \cdot s^{-1}$ at discharge 19.3 $m^3 \cdot s^{-1}$ (Fig. 8). Flow depth vary from 0.03 m to 0.59 m. The same kind of profiles as before have been observed. At discharge 10.4 $m^3 \cdot s^{-1}$ (Fig. 9) the highest velocity is 0.75 $m \cdot s^{-1}$ and the maximal velocity pulsation 0.11 $m \cdot s^{-1}$. The water depth is in the range 0÷0.35 m. Some part of the area is above the water surface. There are only logarithmic velocity profiles in this zone. Once again, all previous kinds of profile have been observed.

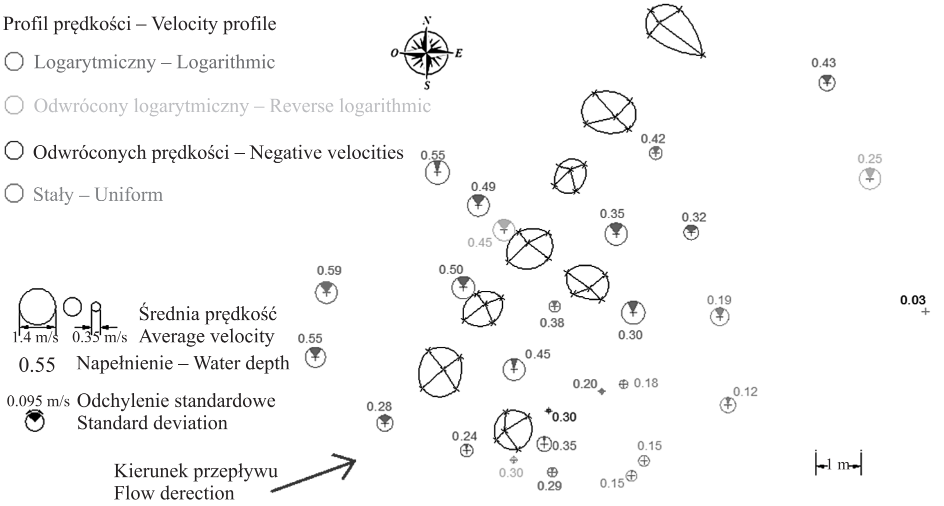

Fig. 8. Spatial velocity distribution around boulder cluster at discharge 19.3 $m^3 \cdot s^{-1}$
Ryc. 8. Przestrzenny rozkład prędkości w strefie oddziaływania głazów przy przepływie 19.3 $m^3 \cdot s^{-1}$

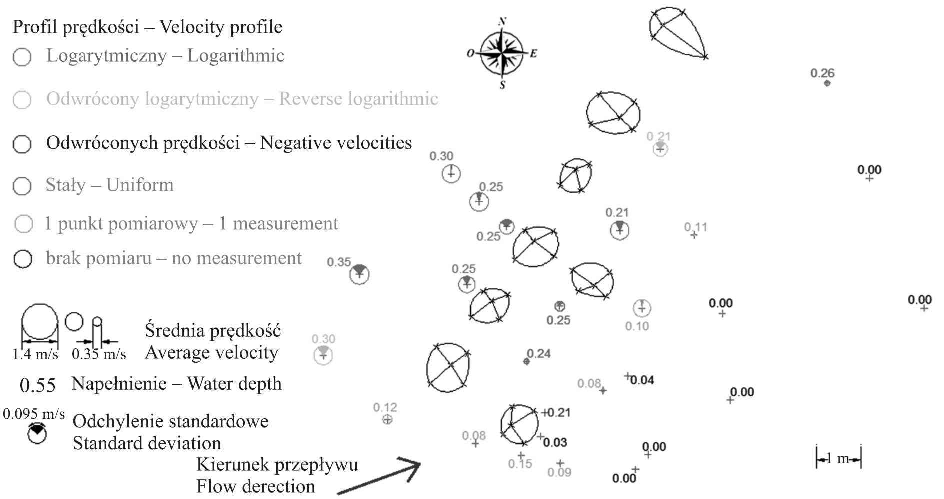

Fig. 9. Spatial velocity distribution around boulder cluster at discharge 10.4 $m^3 \cdot s^{-1}$
Ryc. 9. Przestrzenny rozkład prędkości w strefie oddziaływania głazów przy przepływie 10.4 $m^3 \cdot s^{-1}$

Base on the velocity distribution the impact of boulder cluster on the flow phenomena was determined. Velocity profile characteristic has been taken into account as well as water flow pattern (water surface level, water jumps) from the pictures and movies. Besides flow regime without influence of boulders three zones (microhabitats) have been distinguished: fast flow, turbulent and recirculation. The limit of the boulder cluster impact is at the end of turbulent zone (Fig. 10). The dimensions a (length), b (width), c (height) of the boulder are a = 1 m, b = 1 m and c = 0.5 m. For submerged boulder cluster the end of the impacted zone is about 4 m so this distance is about d = 8 × c/a.

At discharge $Q = 10.4\ m^3 \cdot s^{-1}$ there is only three kinds of habitat: „shallow water" zone with small water depth and very low velocities, one little „turbulent" zone and „ripples" zone (Fig. 11). The cluster seems to have less impact a low than at higher discharges.

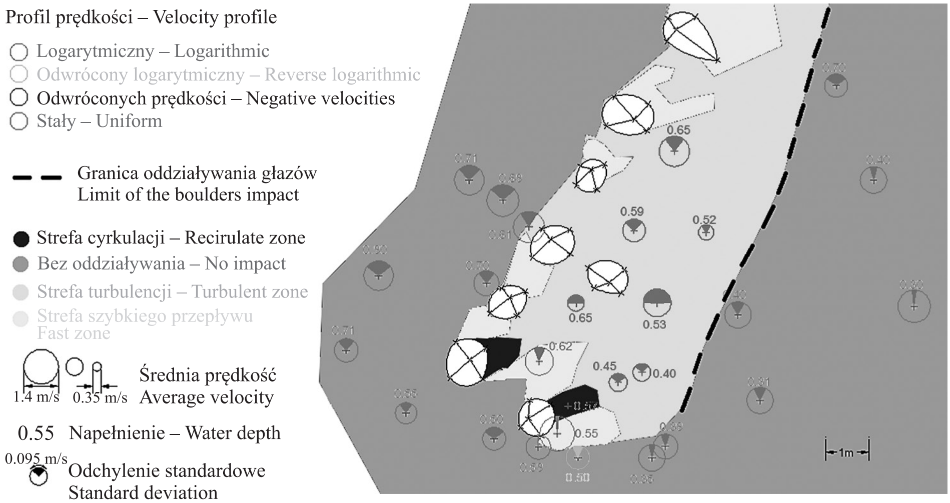

Fig. 10. Microhabitats distribution at discharge 31.2 $m^3 \cdot s^{-1}$

Ryc. 10. Rozmieszczenie mikrosiedlisk przy przepływie 31.2 $m^3 \cdot s^{-1}$

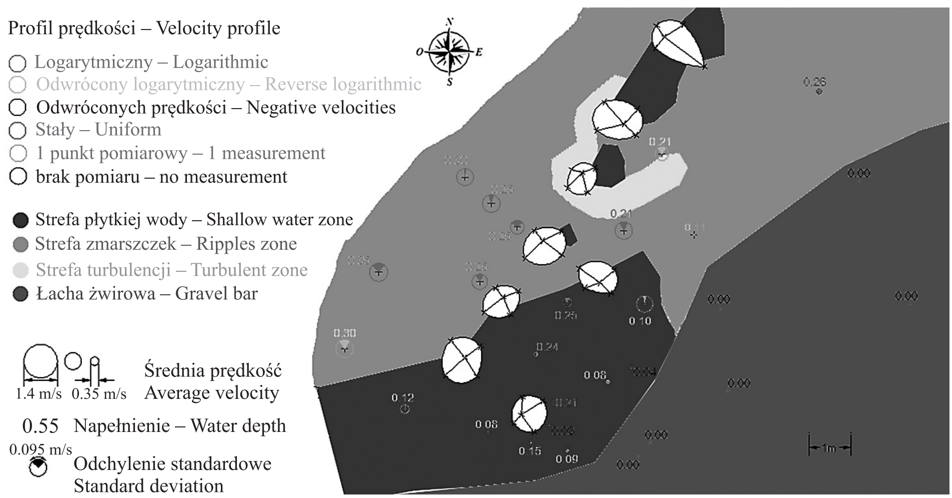

Fig. 11. Microhabitats distribution at discharge 10.4 $m^3 \cdot s^{-1}$

Ryc. 11. Rozmieszczenie mikrosiedlisk przy przepływie 10.4 $m^3 \cdot s^{-1}$

ANALYSIS OF THE RESULTS AND DISCUSION

Concerning the velocity profiles, there are some differences with discharge changes. For discharge equals to 31.2 $m^3 \cdot s^{-1}$, there are two main zones. One is behind the boulders with uniform velocity profile and the other (around this zone) with logarithmic profiles. These two zones (Fig. 7 and 12) correspond to the results obtained during the determination of the microhabitats. All the uniform profiles measured are in the turbulent area. Velocity is also lower in this zone: from 0.61 to 1.20 $m \cdot s^{-1}$ against velocity from 0.86 to 1.30 $m \cdot s^{-1}$ around.In the turbulent area the highest velocity pulsation (between 0.07 to 0.19 $m \cdot s^{-1}$) have been found. Some other small zones also can be observed. Just behind the two bigger boulders which have their top above the water surface, there are recirculate zones with low velocities (about 0.07 $m \cdot s^{-1}$) and, on the both sides of boulders, there is a water flow acceleration with high turbulence (about 1.38 $m \cdot s^{-1}$). There are „fast" zones with small values of pulsation (between 0.01 and 0.07 $m \cdot s^{-1}$). The biggest zone around it is where the flow turbulence is not very influenced by the cluster.

When discharge decrease to 19.3 $m^3 \cdot s^{-1}$, there is a decrease in velocity values, turbulences and water depths and a diversification of the velocity profiles occures (Fig. 9). The maximal velocity value is 0.91 $m \cdot s^{-1}$. The same recirculation zones are observed behind the boulders with small velocities (about 0.13 $m \cdot s^{-1}$) and there still are higher velocities on the sides of boulders (until 0.82 $m \cdot s^{-1}$). Further reduction of discharge to 10.4 $m^3 \cdot s^{-1}$, causes two main kinds of microhabitats occurrance (Fig. 13). The first one is a shallow water zone with velocity from 0.01 to 0.35 $m \cdot s^{-1}$ and low water depths (less than 20 cm). This zone was located near the gravel bar. The second one is a zone with higher velocity (from 0.18 to 0.75 $m \cdot s^{-1}$) where some ripples on the surface were observed. This zone corresponds to a deeper zone (with the highest velocity) and the area behind the boulder where the cluster causes the increase of velocity Moreover, it corresponds to the presence of logarithmic profiles for the deeper points (Fig. 10). There are some shallow water zones behind the boulders and only one boulder creates a small turbulent zone on its sides. The cluster have less impact on flow hydraulic when the discharge is low.

The group of boulder at a local scale influenced on water flow conditions and if creates a diversity of microhabitats. Average length of adult fish in the Wisłoka River reach is about 0.3–0.5 m and 0.9–1.1 m for diadromous (trout, salmon). The zone created behind the stones is sufficient to provide shelter for fish. This zone has been characterized as a turbulence zone based on the behavior of the water surface. At discharge of 19.3 $m^3 \cdot s^{-1}$ according to Gordon [2004] classification it is an excellent flow regime for fish, wildlife and recreation. Velocity above the bottom (20% h) in this zone vary from 0.17 $m \cdot s^{-}$tes are created.

The gravel bar at water discharge Q = 31.2 $m^3 \cdot s^{-1}$ becomes an island. That discharge was described as an optimum flow range for fish, wildlife and recreation [Gordon 2004]. At that discharge the secondary stream is about 2 m width and 0.3 m depth. At lower discharge the secondary stream disappears so the gravelbar becomes accessible to man and predators. During the measurements no evidence of birds have been noticed. Instead of this, the gravelbar became the place for spending time for people. At lower discharges the boulder cluster attracts the people due to interesting architecture, mosaic of morphology structures. Boulder cluster increase a quality of space so it have a social impact also.

CONCLUSION

The discharges were characterized as optimum range, excellent and fair or degrading flow regime for fish, wildlife and recreation. The boulder cluster placed on the Wisłoka riverbed influence on the microhabitats distribution in the local scale. The study shows there is a creation of several kinds of microhabitats which are not always presents at the same time but depend on the discharge value. The boulders create small areas with different hydraulic paterns with differentiated velocity profiles and pulsation values. Four kinds of velocity profiles around the boulder gravel cluster have been observed: logarithmic, uniform, reverse logarithmic and with negative velocities. The microstructures create a dynamic flow on this local scale. For submerged boulder cluster the end of the creating zone can be described with the relation to size of boulder.

That kind of activity can contribute creation of the ecological corridor of the Wisłok River, reduction of catchment fragmentation and integration of NATURA 2000 areas. It will allow re-creation of historical routes of diadromous fish migration.

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WPŁYW GRUPY GŁAZÓW NA ROZMIESZCZENIE MIKROSIEDLISK PRZY ZMIENNYM REŻIMIE PRZEPŁYWU W KORYCIE GŁÓWNYM

Streszczenie. Praca związana jest z określeniem wpływu ziaren ponadwymiarowych umieszczonych w korycie Wisłoki w 2013 roku w związku z projektem częściowej renaturyzacji koryta. Celem pracy jest określenie wpływu wykonanych prac w korycie na strukturę mikrosiedlisk. W korycie Wisłoki w okolicach Dębicy przeprowadzono trzy sesje pomiarowe obejmujące pomiary głębokości, prędkości przepływu oraz topografii dna cieku przy przepływach odpowiednio 31.2, 19.3 and 10.4 $m^3 \cdot s^{-1}$. Analiza rozkładu prędkości przepływu z wykonanymi dokumentacją fotograficzną pozwoliła określić rozmiesczenie mikrosiedlisk. Prędkość średnią obliczano posługując się metodą Byczkowskiego. W okolicy ziaren ponadwymiarowych tworzą się strefy o różnych rozkładach prędkości: logarytmicznym, ze stałą prędkością, odwróconym logarytmicznym oraz z występującymi prędkościami wstecznymi. Struktury głazów powoduja tworzenie się różnych mikrosiedlisk, których rozkład uzależniony jest od wielkości przepływu. Zaobserwowano występowanie „strefy turbulencji", zybkiego przepływui „strefy z odwóconym przepływem". Wpływ ziaren ponadwymiarowych przy niskich przepływach jest mniej zauważalny, jednak ciągle umożliwa wystąpienie różnych mikrosiedlisk: „płytkiej wody", „strefy turbulencji" i „strefy ze zmarszczkami".

Słowa kluczowe: mikrosiedliska, Wisłoka, profil prędkości, ziarna ponadwymiarowe

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