Agnieszka Bieda[*]

Ryszard Hycner[*]

Changes of shape of river-bed in the period of time on the basis of Vistula River before Cracow[**]

1. Introduction

Rivers belong to the most important factors changing surface of the Earth. Their activity can be gradual and not visible or, on the contrary, extremely spectacular. Yet, apart from the manner how water interferes in its environment, it is necessary to determine emerging changes [1], [3]. Such necessity is a result of need of preparing accurate and updated maps, both cadastral and those, ordered for projects.

Although erosion processes, taking part in the surrounding of waters concern equally the whole cross-section of river, yet these which take place on the plane are more important [2]. It comes from the fact, that within surveying works (especially of surveying-legal types) it is important to know how river „travels" on the bottom of its valley (creating changes) and how these changes can influence on shapes of cadastral boundaries and also on contours of land use and contours of soil classes.

A sight of the surface of terrain are of course various kinds of mapping works. They carry full and detail knowledge about landscape, which part are rivers, in four dimensions one (x, y, z, t)[1] [4]. They describe changes caused by rivers. Regularly updated let on analysis of river-bed changes which took part in space, within the period of time.

2. An influence of changes of the shape of river-bed on cadastre

Surveying and Mapping Law [8] obliges surveyors to permanent updating of base map, being results of all surveying works. Changes of river-beds have particular influence on such an important contents of base map as cadastral layer is.

Such updating has connection with changes of boundaries of river banks and influences on changes of shapes of:

[*] AGH University of Science and Technology, Faculty Mining Surveying and Environmental Engineering, Department of Geomatics

[**] This work has been made within scientific research program of Geomatics Department no. 11.11.150.006.

[1] x, y, z – mean "spatial coordinates", while t – denotes "time" (authors' remark)

1) Cadastral boundaries in connection with displacing the range of real estate ownership [3], according to regulations of Water Law [9], which says that: „if inner, flowing water will permanently occupy a land being not property of owner of this water, a consequence of this event is that this land becomes a property of owner of water".
2) Contours of land use and contours of soil classes resulting from definitions of lands under flowing waters, according to Order in case of Lands and Buildings register [7].

3. Factors influence on changes of shape of river-bed

In the opinion of geomorphologist, rivers belong to the most important outside factors, transforming the surface of the Earth [6]. Changes, which can take place at rivers surrounding can be caused both by activity of water and also by antropogenic factors.

The river itself can form its surrounding in two ways. Creating its elements through moving rock materials or destroy them by erosion process. In any case, influence on the shape of river-bed is equally strong. Objects of destroying are bottom of river and its banks. This activity, although in different levels, can become at all pieces of river flow. Processes, taking place as a result of erosion of river are shown in table 1.

Table 1: River erosion

River section	Type of erosion	Result of river activity
upper (source)	subterranean	river cuts into river-bed through damaging its by transporting rock material
	backward	moving back source of river toward watershed can cause joining two rivers or moving back of waterfalls
	side (waterside)	undermining action of water of river banks; leads to damaging of banks
	bottom	channelling of bottom of river; leads to creating flood-land terraces
middle	side	undermining action of water of river banks; leads to damaging of banks, creating meanders and old river-beds
	bottom	channelling of bottom of river; leads to creating flood-land terraces
lower (mouth)	erosion is usually not visible	

Source: Own work based upon [5] and [6]

Creative activity of any river is however based upon on the fact, that river transports rock material, which can be timely deposited, or permanently collected it in river-bed or outside it, as a result of diminishing transport force [5].

Accumulative activity of rivers can take place along with the whole distance of river-bed and leads to becoming various types of sediments. Yet, most often one can observe this activity when water level is raised or when water ability of to transport diminishes.

As a result of diminishing an accumulation potential of river is becoming alluvial cones, deltas and alluvial plains. In time of freshets, when water, when water does not come out of river-bed, rock material is moved and deposited in shape of sandy backwater (sandbanks) that is sandy or gravelly islands. They can be located centrally in the river or on the side of river-bed. Whereas a river overflows, a deposition takes place in the area of river-bed and contributes to form river mud.

Additionally, permanent aspiration of human being to subordinate its natural environmental, causes antropogenic changes of river-bed. In order to take control of rivers one can try to regulate them and built up in its neighbourhood building structures, which have to facilitate human being domination over nature. Most of them causes change of river-bed in the manner to be convenient for human being or creates rivers sediments in front of them.

Apart from such restrictive regulation of rivers, there are other methods to restrain them. They lead for such forming of river-bed, which diminish a risk of becoming not planned phenomena along its course. It is the best case, when regulated out river-bed fits with water natural activity and determines in the field such situation which could take place after passing higher water.

4. Analysis of changes of shape of Vistula river-bed

The object for researches has been 13.5 km long section of Vistula river-bed, located west of Cracow. Along with this section of river runs administrative border between Czernichów and Liszki communes and Skawina commune. These three communes are located within krakowski district.

Process of control of river-bed course has been done on the basis of cadastral maps coming from the time of establishing grounds register (early seventies of XX century) on the basis of Decree from 1955 and aerial photos and ortophotomaps made upon flying time in April 2009.

At first, cadastral maps in digital format prepared in raster model in scale 1:2000 have been taken from district surveying documentation centre. Each of these maps has been made for cadastral unit. There have been also taken coordinates of network points, given in state coordinates system „1965". They were used during establishing grounds register. Network points of known coordinates have been taken as control points for transformation of scanned maps. Contemporary bank lines of the river one can find on cadastral maps. They are contour of land use called „flowing waters", and comprises area of all parcels being under the water.

In order to verify data contained on cadastral maps, photogrammetric data coming from Country Documentation Surveying Centre have been used. They are aerial photos made during modernization and updating databases of Land Parcels Identification System (LPIS). River bank boundary has been determined by photogrammetric methods. Measurement has been done on photos through stereoscopic method. According to Water Law [9], upper part of slope, as exists along the whole of analysis river-bed, has been taken as river bank boundary.

Comparison of two river bank boundaries at the whole inspected section, gave unexpected results. It turned out that river "works" all the time and changes its river-bed, despite that these activities are not visible every day. This comparison (green colour: old river bank boundary, red colour: current river bank boundary) - is showed on figures 1, 2 and 3. Considering a lot of researched materials, these figures show only these sections of river-bed where changes are the biggest.

Because Vistula River, west of Cracow is also administrative border between mentioned earlier communes, discussed sections of river-bed are described by names of cadastral units adjoining themselves in the place showed on figures 1, 2 and 3. All presented fragments of maps are oriented north. For their better interpretation, corresponding them pieces of ortophotomaps, have also be put.

Fig. 1. Change of shape of river-bed in years 1977 ÷ 2009,
section between cadastral units Czernichów and Pozowice
Source: [10]

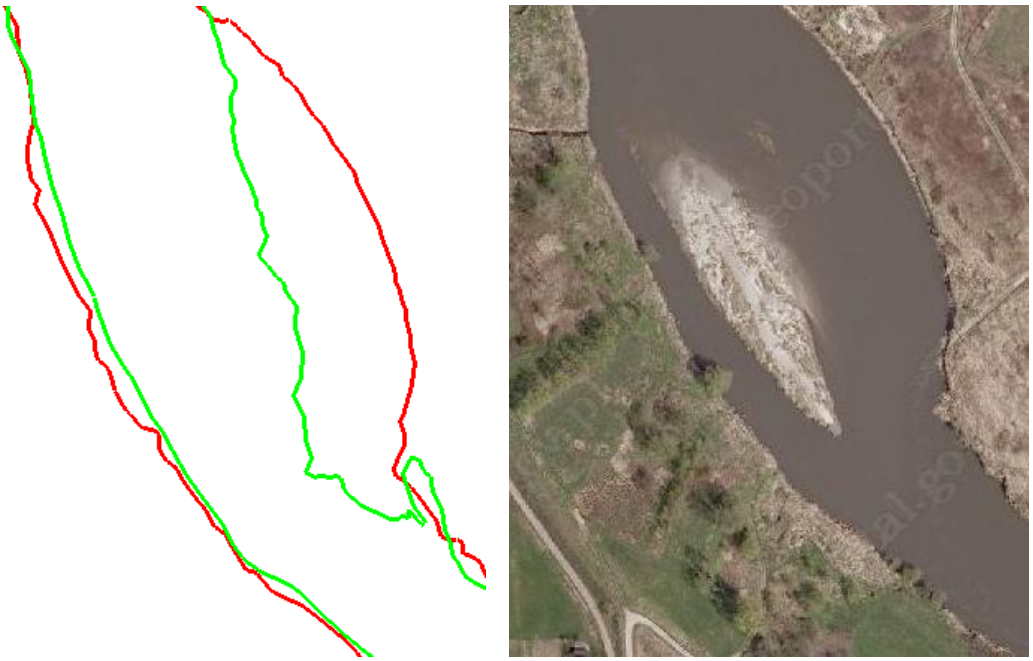

Fig. 2. Change of shape of river-bed in years 1977 ÷ 2009,
section between cadastral units Wołowice and Pozowice
Source: [10]

Fig.3.: Change of shape of river-bed in years 1977 ÷ 2009,
section between cadastral units Czernichów and Pozowice
Source: [10]

Section of river between Czernichów and Pozowice, being showed as the first (fig.1), is located hard attacking left bank. It is visible big extension of river-bed in this place. Observed differences reach even 30 meters. Right side of river bank is almost without any changes.. Changes, visible, on the west river bank, are probably result of surveyor's interpretation.

Following example is a section of river-bed, located within Wołowice and Pozowice cadastral units. Showed situation (fig.2), is a part of next meander. Water undermines here left bank of river much more, causing more bigger (reaching 50 meters) changes of bank line. Opposite line bank has almost not been modified. Yet, it does not mean that no changes have been remarked. Of course they were, although not so big as it took place by left bank of river. One should say, that stream did not have so big force as water flowing near by east slope. That is a reason why an island become here. Water, flowing round it with more stronger force, hits to east side of river-bed.

The last example (fig.3), is a part of river between two, earlier discussed meanders. River flows here from west to east. Water hits stronger at right river bank. It is clearly visible as line of bank river "invaded" inside a land, causing considerably landslipe of slope, has just been creating right bank.

As a result of mentioned above changes, it is necessary to also change course of contours of land use and soil classes.

Because changes of river bad can prove so big, that as a result of them the range of ownership right can also be changed, it is necessary to change courses of cadastral boundaries. For this purpose, ortophotomaps have been used, in the relation with former

cadastral maps. Figure 4 shows such application and comparison between river boundaries by means of Geoportal data [10].

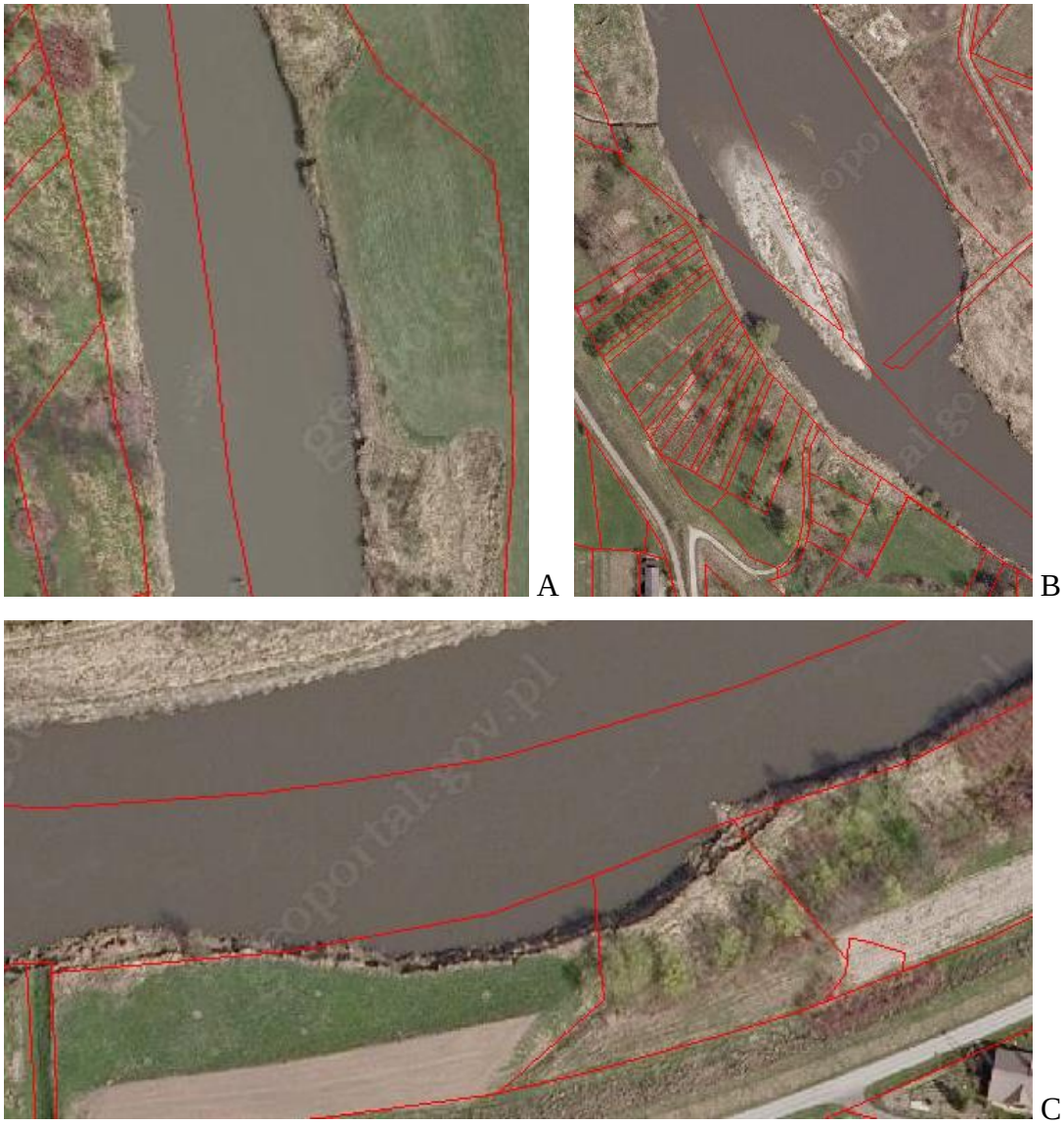

Fig..4. Comparison between current river-bed boundary
with data boundaries coming from grounds and buildings register
A – in relation with fig. 1, B – in relation with fig. 2,
C – in relation with fig. 3
Source: [10]

In two from three discussed cases (fig. 4B and fig. 4C) waters of river have constantly occupied adjoining lands. So, according to Water Law [9] range of ownership right had to be also moved. In case B, water rushed in parcel located in Wołowice, but in case C – water took

part of parcel located in Pozowice. Thus, Vistula River diminished area of parcel in Wołowice about 3.5 % and parcel located in Pozowice about almost 20%.

5. Conclusion

To resume, authors want to express the following remarks.

I. Flowing superficial waters, especially big rivers, can influence on their whole environment. It is very important for surveyors, that changes of river-bed can also cause changes in cadastral data.
II. As a consequence of changes of river-bed there will be probable necessary to modify courses of parcel boundaries and also courses of land use and soil classes.
III. There are possible not only changes of ownership right but also its completely transfer without change course of parcel boundaries – in case when water will permanent occupy the whole cadastral parcel.

6. References

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Summary

Flowing waters, especially big rivers, influence on their entirely environment. Yet, for surveyors the most important are these changes caused by rivers, through changes of their beds, which can alternate cadastral data.

Discussed problems result directly from both damaging and constructive features of rivers and also from Water Law and other regulations which give foundations for establishing grounds and buildings register.

Paper contains partly comparison between former situation presented on archive maps and concerning section of Vistula River, west of Cracow and contemporary situation. The purpose of this comparison is to draw reader's attention on such important problem as updating cadastral maps, made in surrounding of accumulative-erosion activity of river, is.

Keywords: cadastral boundaries, land use, flowing waters, river-bed, river bank line

Zmiany kształtu koryta rzecznego w czasie na przykładzie Wisły przed Krakowem

Słowa kluczowe: granice ewidencyjne, użytki gruntowe, wody płynące, koryto rzeczne, linia brzegowa

Streszczenie

Wody płynące, w szczególności duże rzeki, oddziaływają na całe swoje otoczenie. Dla wykonawców geodezyjnych najważniejsze są jednak te modyfikacje, które rzeki mogą wprowadzić w katastrze nieruchomości, poprzez zmiany swojego koryta.

Poruszana problematyka wynika bezpośrednio z właściwości niszczących i konstruktywnych cech rzek oraz zapisów prawa wodnego i aktów normatywnych na podstawie których tworzona jest ewidencja gruntów i budynków.

Publikacja zawiera częściowe porównanie archiwalnych materiałów kartograficznych dotyczących odcinka Wisły na zachód od Krakowa z obecną sytuacją terenową i ma na celu zasygnalizowanie problemu jakim jest utrzymanie w aktualności map zakładanych i prowadzonych w obrębie akumulacyjno-erozyjnej działalności cieków wodnych