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BAGRY LAKE – VOLUME 2. HISTORY WRITTEN IN CARTOGRAPHIC ARCHIVES

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Abstract

One of the biggest and the most valuable water bodies in the aspect of nature, landscape, economy and recreation, localized within the city of Krakow is the Bagry Lake (Bagry Reservoir). Despite the fact that mining stopped in 1970s, the water body has not been inventoried so far (including hydrographical survey) and has not been investigated in an interdisciplinary way. Although it is a relatively new object, in the preserved publications and local press articles it is difficult to find information about the history of the origin and the stages of the development of the water body. The analysis of archival cartographic materials and hydrographical measurements made by the author makes a perfect supplementary material to learn about history of the formation of such an urban water body, specific in ecological and landscape-related aspect.

ZALEW BAGRY – CZĘŚĆ 2. HISTORIA ZBIORNIKA ZAPISANA W ARCHIWALIACH KARTOGRAFICZNYCH

Słowa kluczowe: Zalew Bagry, pomiary hydrograficzne, archiwalne mapy

Abstrakt

Jednym z największych i najbardziej wartościowych pod względem przyrodniczo-krajobrazowym, gospodarczym oraz rekreacyjnym akwenów wodnych zlokalizowanych w granicach miasta Krakowa jest Zalew Bagry. Pomimo niegórniczego użytkowania już od lat 70. XX wieku, zbiornik nie doczekał się gruntownej inwentaryzacji (w tym opracowania hydrograficznego) i nie został poddany szczegółowym interdyscyplinarnym badaniom naukowym. Mimo iż jest on względnie młodym obiektem, z zachowanych publikacji i artykułów prasowych lokalnych wydawnictw trudno doszukać się historii powstania i opisu etapów jego rozwoju. Analiza archiwalnych materiałów kartograficznych oraz dokonane przez autora pomiary hydrograficzne, stanowią doskonały materiał uzupełniający dla poznania historii tworzenia tak szczególnego pod względem krajobrazowo-przyrodniczym akwenu miejskiego.

1. INTRODUCTION

Surface water bodies, usually spontaneously formed due to favourable geological conditions make a new element of post-mining landscape. Mining activities connected with the exploitation of natural aggregates carried out in 20th century in the area of Krakow, left many geometrically interesting mining excavations. In the combination with the regeneration forces of nature, many of them are attractive in tourist, landscape and nature terms fragments of geographic space. The features of this space are formed by mutual overlapping of

abiotic and biotic elements of natural environment and long-lasting effects of economic activities (economic environment), attributing to them definite values and functions (Fagiewicz K., 2009). One of such areas is the area of the Bagry Lake (Bagry Reservoir) in Krakow–Płaszow. Intensive industrial activities connected with the exploitation of clay, sand and gravel, ended in 1972, left degraded geographic space. The present character and the appearance of the water body is mainly due to „spontaneous" water reclamation and – in less degree – human activities in 1980s (by the owner and the manager of the area), which resulted from financial administrative units on reclamation activities. Despite poor financial investment on this object and minimalism in the area of human intervention since the exploitation, the water body is an example of multi-directional reclamation. It makes the area of overlapping of various types of habitats of specific structure, characterized by high natural, cultural and practical values, which makes the analysed area an area, which is qualitatively new in terms of tourist reception.

The water table is relatively constant, which is due to geological structure. In the area of Krakow underground waters occur within the following water-bearing horizons: Palaeozoic and Jurassic (cracked and karst-affected limestones), Cretaceous and Quaternary (sand and gravel). The following horizons are dominant in terms of water bearing: upper-Jurassic, sand Tertiary (Bogucice sands) and Pleistocene [*Studium uwarunkowań*… 2010]. Thus favourable geological conditions of Krakow make the base for creating a space of high natural values (post-mining areas of pogórniczych), which has great significance for water management and the development of tourism and water-related recreation. Many water bodies formed in post-exploitation troughs, despite relatively young age and localization is surrounded by mystery, and their origin and morphometric characteristic are not fully documented.

The article presents the history of the development of mining excavations in the area of the present Bagry Wielkie, supplementing the information contained in the first part (Gawałkiewicz R., 2017). In the shape of the bottom there is its history printed. The results of the first detail inventory of the water body and the analysis of preserved cartographic and photogrammetric documents allowed more precise characteristic of the water body and the chronology of mining activities.

2. LOCALIZATION OF THE BAGRY LAKE

Bagry is situated in an industrial quarter of Płaszów alongside the railway no. 91: Kraków – Medyka (initially Carl Ludwig Galicia Railway (Kolej Galicyjska Karola Ludwika) – section Krakow – Lvov/Lviv) in the neighbourhood of a big railway siding, making communication link for the nearby warehouses and the rail of the hump in Prokocim (freight station Krakow – Prokocim). The upgrading of the sideway rail adjacent to water bodies in 1970s (among others buildings – the protective rib – figure x), caused change in the shape of the shoreline. Nowadays the water body from the north is restricted by the streets: Kozia, Kacza, Marian Batko and Łanowa of characteristically low building, also present in the places of already non-existent mining excavations. From the east, Bagry is limited by Bagrowa, making the border of the densely built-up industrial and office part of Płaszow, while from the west – by the Żołnierska street, alongside which there are small allotments, fundaments of industrial halls, including the already nonexistent Płaszowska Fabryka Cegieł i Dachówki S.A (Płaszów Factory of Bricks and Tiles), which was stocked with material taken from the borrow pits (figures 3,4,5).

3. THE AMOUNT OF DEPOSITS AS THE FACTOR SHAPING THE BORROW PIT

The documentation of Krakowski Zakład Eksploatacji Kruszyw (Krakow Enterprise for Aggregate Exploitation) shows that the deposit of gravel and sand within the border of the present borrow pit was, in large extent, exploited, with documented thickness of the seam about 10m, which was presented on geological profile – fig. 1. The confirmation of quantitative exploitation of raw materials from the Bagry is the longitudinal section of the Bagry deposit my by the author based on archival data (documentation point charts) of the geological–engineering boreholes of the following numbers: 0581, 5811, 5010, 5012 (boreholes: 0581, 5010 and 5012 – source: http://bazagis.pgi.gov.pl/website/cbdg) and bathymetric measurements. From the profile and geological–engineering boreholes documented in the neighbourhood it results that in the area of the present water body gravel, sand

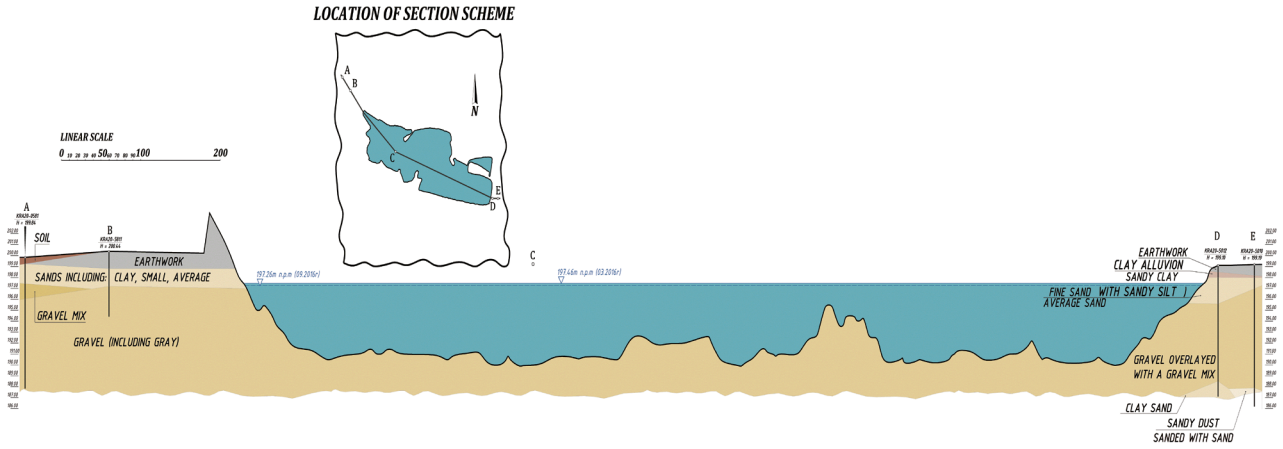


Fig. 1. Geological longitudinal section through the Bagry Lake
Rys. 1. Podłużny przekrój geologiczny przez Zalew Bagry

and dust clay (clay layer of thickness between 0.6 and 0.9m).

The knowledge of mean thickness of individual layers, estimated based on the data of geological–engineering boreholes (boreholes: D and partially B – figure 1) and the morphological model of the bottom of the water body, made by the author in 2016, allowed the definition of the amount of the exploited aggregates from Bagry in the part which is now used for sports and recreation. The analysis of the model shows that the cubature of individual mineral formations is as follows:

- gravel (Ż) – 620 342m^3;
- clay sand (Pg) – 639 220m^3;
- sand clay (Gp) – 225 225m^3.

1. THE WATER BODY OF BAGRY IN THE ARCHIVE CARTOGRAPHIC DOCUMENTATION

Despite relatively „young age", the history of the development of the water body Bagry Wielkie has not been documented in detail in the Polish literature. Much of the quoted by the author information on the history of the borrow pit refers to the period of the World War II (1939–1945). Thus in the studies on the landscape in the Bagry region, excellent sources of information on mining in the region of Big Płaszow (*Płaszow Duży*) (progress and development of mining) are the preserved cartographic materials in the form of city maps (scale 1:20 000), topographic maps (scale 1:25 000) and the basic map (scale 1:500). The analysis allows the definition of the characteristics of mining activities and their influence on the geometry of pits as well as the range of the part filled with water. The map of Krakow of 1914 confirms that during the First World War, despite the activities of brickyards in the neighbourhood, i.e. the Płaszow Factory of Bricks and Tiles S.A (documented activities of the factory go back to 1896), the area of the present Bagry consisted of meadows, partially with bushes. This shows that until 1914, no aggregate exploitation was carried out, or it was carried out, but on a local scale, not organized in a form of a mining enterprise. In the map of 1925 the only trace of getting the raw material was a small pit south of the brickyard (fig. 2), which at the beginning of 1930s was filled with ground and precipitation waters. In the central part of the Bagry area, a riverbed of the Drwina Długa stream was situated, which existed to at least 1965 – figure 4.

The first preserved document proving mining activities on an industrial scale, showing localization and the range of excavations localized in the neighbourhood of working in those time brickyard, i.e. Płaszow Factory of Bricks and Tiles, is a Russian topographic map in scale 1:100 000 according to the state of 1931–1934, made by the General Staff of the Red Army based on the compilation of several maps of various scales and origin – figures 3a and 3b. Due to the scale of the map, the level of generalization of the content is high. More detail is another map – Polish mid-scale cartographic

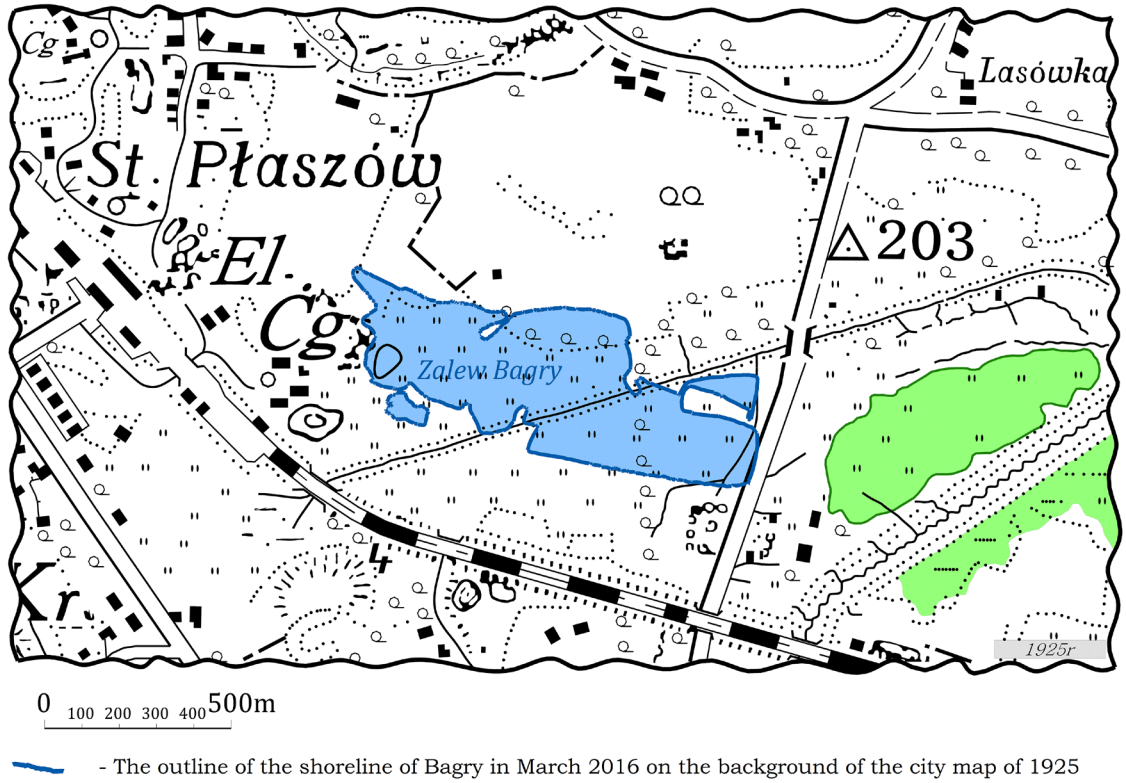


Fig. 2. Localization of the Bagry Lake in its present shape on the background of a historic topographic map, scale 1:100 000, of 1925 (PAS A48-SŁUP B-30 KRAKÓW) made by the Military Geographic Institute (Wojskowy Instytut Geograficzny) based on the Austrian map of 1914, scale 1:75 000 (vectorization: R. Gawałkiewicz)

Rys. 2. Lokalizacja Zalewu Bagry w jego obecnym kształcie na tle fragmentu historycznej mapy topograficznej w skali 1:100 000 z 1925 roku (PAS A48-SŁUP B-30 KRAKÓW) sporządzonej przez Wojskowy Instytut Geograficzny na podstawie wydania austriackiego z 1914 roku w skali 1:75 000 (wektoryzacja: R. Gawałkiewicz)

projection of 1932–1933 (figure 3b), where the outline of the scarps main excavations in the neighbourhood of the flooded parts of the mining field.

Already then the relief of workings allowed the retention of precipitation waters and ground waters in several small water bodies. Some of them are located beyond the present outline of Bagry. Till present not even one borrow pit outside of the present shoreline of the water body was preserved, which means that they were filled with soil after the Second World War. Already then large scale industrial mining was only documented by the presence of the track belonging to the narrow-gauge railway connecting the brickyard with the mining excavations.

Another preserved document proving the mining activities on an industrial scale, showing the localization and range of borrow pits localized in the neighbourhood of a brickyard, i.e. the Płaszow Factory of Brick and Tiles S.A., is a topographic map in scale 1:25 000 of 1936, made by the Military Geographic Institute (*Wojskowy Instytut Geograficzny*) in Warsaw – figure 4. Already that time the relief of pits allowed the retention of precipitation waters and ground waters in several small water bodies. A part of them was located beyond the present outline of the present Bagry water body. Until now no post-exploitation pit was preserved beyond the outline of the present water body, which means that they were ground-filled after WW2. Already then the mining was documented by the presence of the localization of the rails of gauge railway joining the neighbouring brickyard with the borrow pits.

The characteristics and the range of quarrying can be seen in the subsequent city map of 1944, where troughs filled with water were additionally marked with bathy-

metric cartographic contents – isobaths (figure 4). Small changes in geometry of the pits can be observed in the map of 1943 – figure 4.

The analysis of the preserved cartographic materials and data of the current measurement, allowed the identification of the change in the characteristic of the water body in time. Until the end of the 2nd World War the state of watering of the pits was controlled by German managers. Despite mining works carried out on a large area, the generalization of the topographic maps

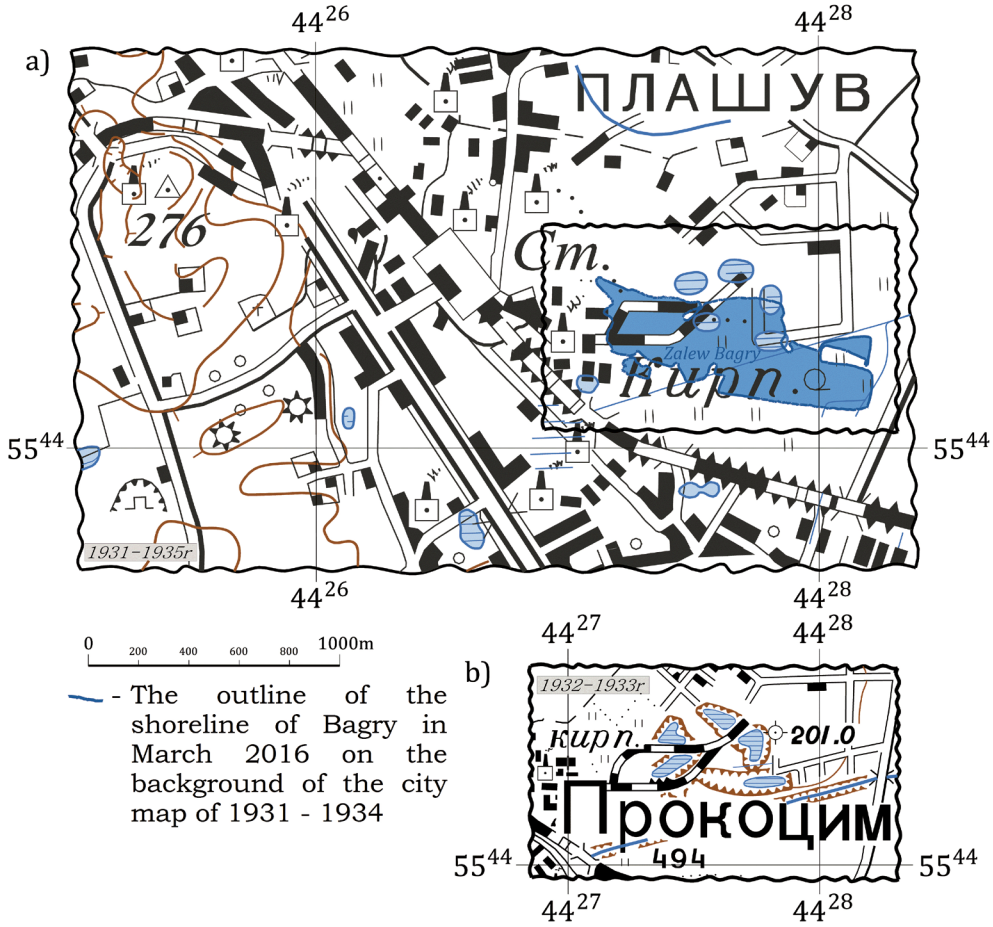


Fig. 3. Fragments of historical topographic maps of the Bagry Region:

a) **in** scale 1:100 000, the map of 1940 (second edition N° 1 (3)) – section: M-34-64 КРАКОВ (Krakow), made by the Генеральный Штаб Красной Армии (General Staff of the Red Army) 1936 based on cartographic information obtained from maps: 1:84 000 (1895–1897), 1:75 000 (1907–1909) – map of the Austro–Hungarian Empire; 1:100 000 – Polish work of 1931–1934 (vectorization: R. Gawałkiewicz);

b) **scale** 1:50 000 of 1944 (first edition N° 1 (1)) – section: M-34-64-Г КРАКОВ (Krakow), made by Генеральный Штаб Красной Армии (General Staff of the Red Army) based on cartographic information obtained from maps: 1:25 000 (1875––1898) – Polish work and updating of 1932–1933 (vectorization: R. Gawałkiewicz).

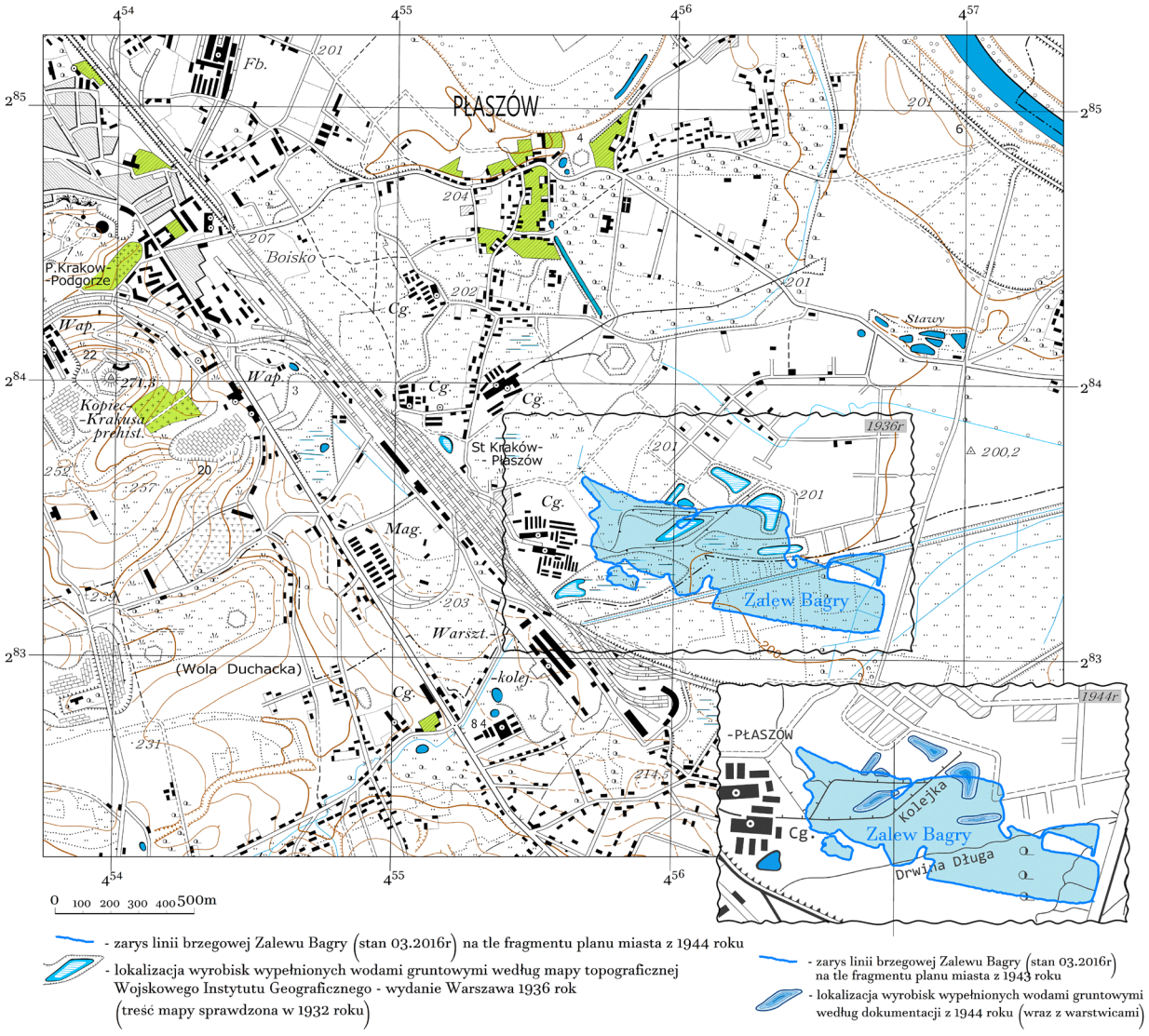
Rys. 3. Fragmenty historycznych map topograficznych rejonu Bagrów:

a) **w skali** 1:100 000 z 1940 roku (wydanie drugie N° 1 (3)) – sekcja: M-34-64 КРАКОВ, sporządzonej przez Генеральный Штаб Красной Армии w 1936 roku na podstawie informacji kartograficznych pozyskanych z map: 1:84 000 (1895–1897), 1:75 000 (1907–1909) – mapa Austro-Węgier; 1:100 000 – opracowanie polskie z lat 1931–1934 (wektoryzacja: R. Gawałkiewicz);

b) **w skali** 1:50 000 z 1944 roku (wydanie pierwsze N° 1 (1)) – sekcja: M-34-64-Г КРАКОВ, sporządzonej przez Генеральный Штаб Красной Армии na podstawie informacji kartograficznych pozyskanych z map: 1:25 000 (1875–1898) – opracowanie polskie oraz aktualizacje z lat 1932–1933 (wektoryzacja: R. Gawałkiewicz).

content means the registration of only the flooded part, represented by small water bodies and selected scarps (tab. 1). Spontaneous liquidation of depression channel lead to filling post-mining subsidence areas with water.

After the end of the war the exploitation of aggregates continued in the western part. Only airborne photographs taken in 1965 allowed defining the range of carried out exploitation and the shape of the excavations.



– **localization** of the pits filled in with ground waters, according to the topographic map of the Military Geographic Institute (Wojskowy Instytut Geograficzny) – published in Warsaw, 1936 (the map content checked in 1932)
– **localization** of the pits filled in with ground waters, according to the documentation of 1944 (with the layers)

Fig. 4. Localization of the Bagry Reservoir in its present shape against the fragment of a historical topographic map in scale 1:25 000 of 1936 (PAS 48-SŁUP 30-G) made by the Military Geographic Institute (*Wojskowy Instytut Geograficzny*) – Warsaw 1936 and the fragment of the Krakow map of 1944, presenting the outline of the flooded pits and isobaths [based on: msip.um.krakow.pl/msip/index.html]

Rys. 4. Lokalizacja Zalewu Bagry w jego obecnym kształcie na tle fragmentu historycznej mapy topograficznej w skali 1:25 000 z 1944 roku (PAS 48-SŁUP 30-G) według stanu na rok 1934, sporządzonej przez Wojskowy Instytut Geograficzny – Warszawa 1936 rok oraz fragment planu Krakowa z 1944 roku przedstawiający zarysy zatopionych wyrobisk wraz z izobatami [sporządzono na podstawie: msip.um.krakow.pl/msip/index.html]

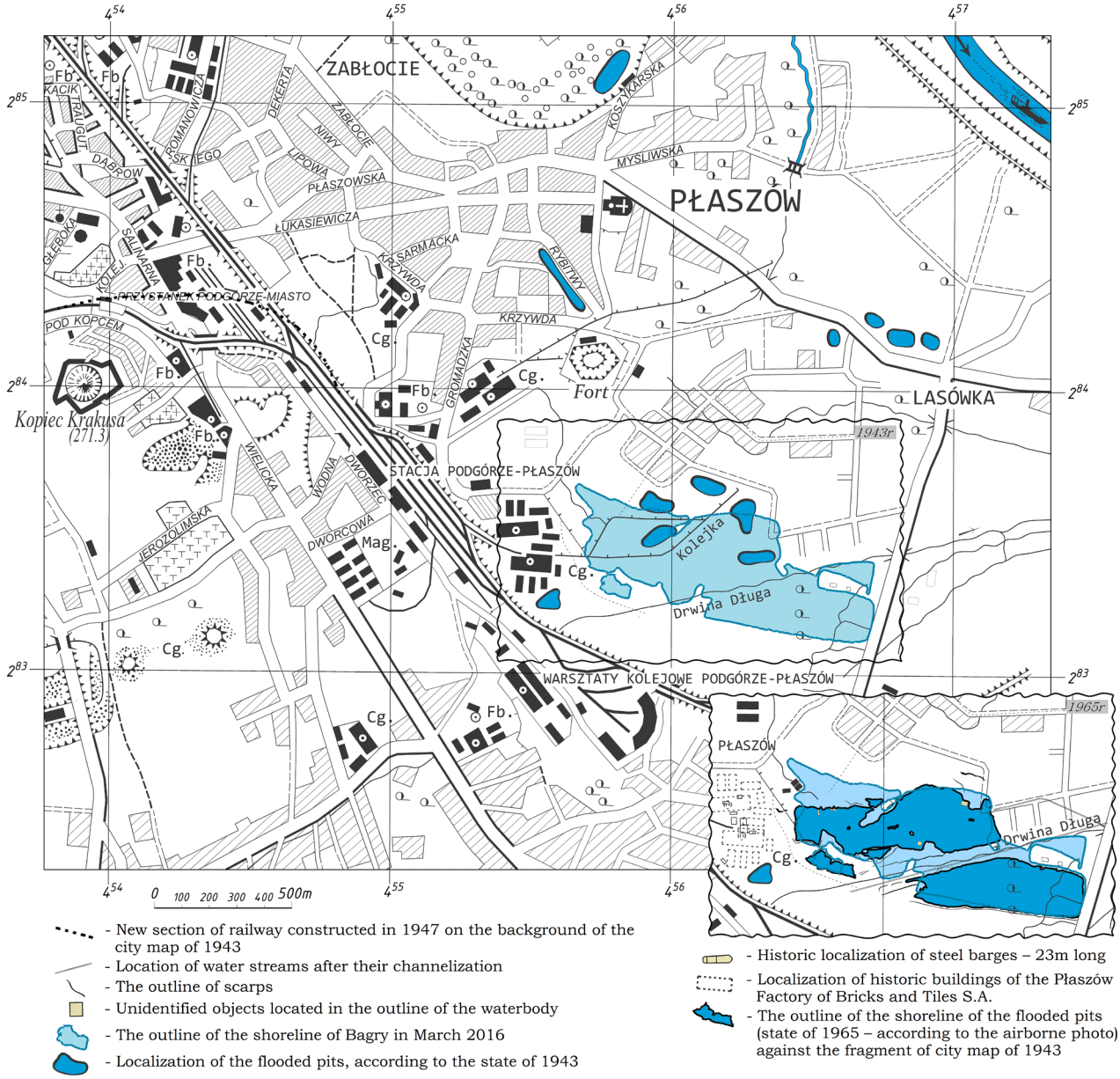
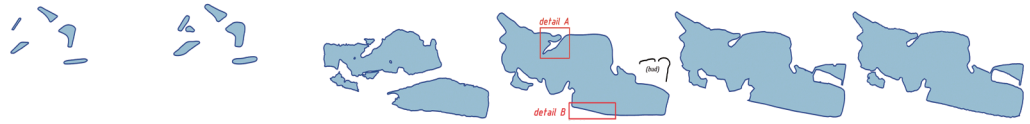


Fig. 5. Localization of post-mining pits, according to the state for 1943 and the shape of the inundated pits mapped based on the calibrated airborne photo of 1965 on the background of the historic map of the city of 1943 (Town Plans of Poland – Kraków; photolithographed by the War Office 1943, drawn by Geographical Section, Polish General Staff N° 4435)

Rys. 5. Lokalizacja wyrobisk górniczych według stanu na rok 1943 oraz kształt zatopionych wyrobisk górniczych skartowanych na podstawie skalibrowanego zdjęcia lotniczego z 1965 roku na tle historycznego planu miasta z 1943 roku (Town Plans of Poland – Kraków; Photolithographed by the War Office 1943, Drawn by Geographical Section, Polish General Staff N° 4435)

Post-war development of the city and its industrialization generated the need for aggregates, leading to the renewal of the exploitation of gravel in the western part of the water body, in 1960s. This contributed to a significant elongation of the water body. The historical part of the Bagry lake (eastern part) was separated from the mining industry with a broad ditch (fig. 5) fulfilling the role of the communication route for the vehicles transporting the output to the near-by brickyards and concrete plants producing components for

Table 1. Comparison of the area and geometry of the Bagry Lake in various stages of its development
Tabela 1. Zestawienie powierzchni i geometrii Zalewu Bagry w różnych etapach jego rozwoju

Year	1936	1944	1965	1977	1999 [*]	2016 [**]
Area [ha]	1.62	2.90	21.72	28.75	30.31	30.60
Outlines of water bodies						

* – based on vectorization of the basic map coming from the resources of the District Centre of Geodetic and Cartographic Documentation in Krakow of 1999.
** – author's own work based on direct measurements (by *R. Gawałkiewicz*)

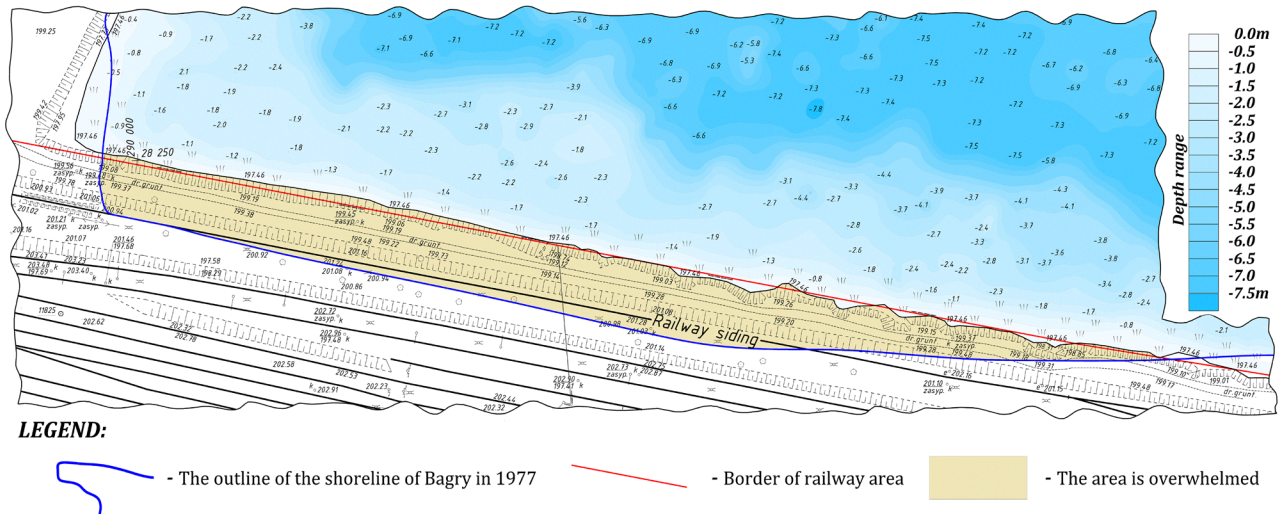


Fig. 6. Changes in the shoreline in 1970s, resulting from the earthworks connected with building the sideway track in the southern part of the water body
Rys. 6. Zmiana linii brzegowej w latach 70. XX wieku, wynikająca z prac ziemnych związanych z budową toru bocznicowego w części południowej akwenu

the construction of apartment buildings (panels) – state of 1965 (table 1).

A publication of 1977 shows the area affected by the mining activities in the north-east part in the place of the existing now small bay. This can indicate that cartographic documentation based on outdated topographic data.

Comparing maps of 1977 and 2016 allows the conclusions that there were two significant changes in the shape of the water body and the water resources in 1970s and in the period of 40–50 of the recent years. The analysis shows that:

– in the southern part (detail B – table 1), a clear change in the shoreline is observed. This results from filling with ground to the border of the closed area of the Polish State Railways (PKP) (red line – figure 6) fragment of the water body (about 0.6ha) to build the last track of the railway siding. To liquidate the fragment of the water body, partially railway wastes were applied, including the used concrete underlay visible from boats very well;
– in the northern part (in the characteristic headland – detail A in figure 7), the similarity in geometry of the outline of the headland of 1970s with the

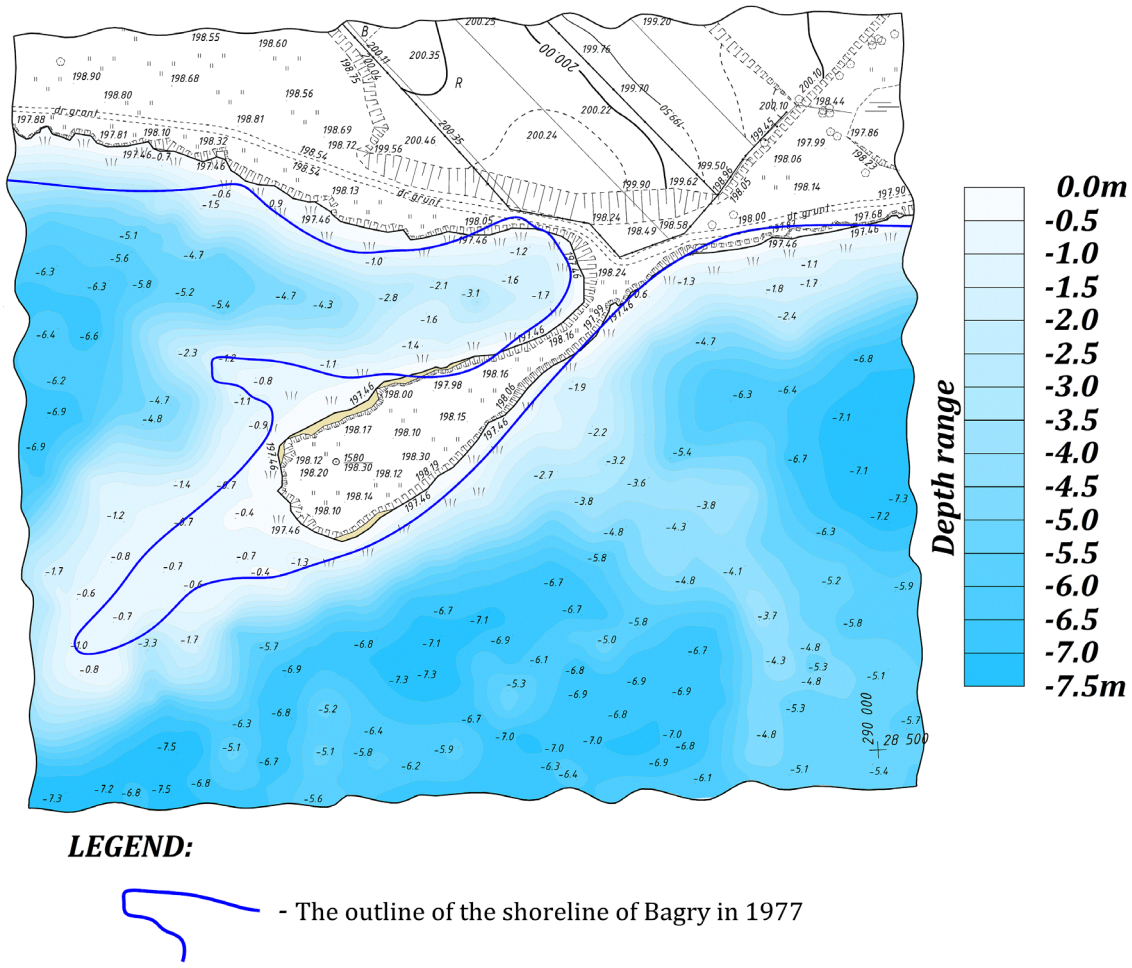


Fig. 7. The outline of the shoreline according to the cartographic documentation of 1977 on the background of a contemporary bathymetric map

Rys. 7. Zarys linii brzegowej według dokumentacji kartograficznej z 1977 roku na tle aktualnej mapy batymetrycznej

present isobaths: –1.0 and –1.5m, which confirms a significant growth of the ordinate of the water table (of about 1.0–1.5m), and – in the same way – water resources of Bagry Wielkie (depth growth). This means the change in the water resources by 20.5–29.9% (values of volume changes in waters were calculated based on the GRID model).

1. MAKING CARTOGRAPHIC DOCUMENTATION OF THE BAGRY RESERVOIR

To illustrate geometric changes of the water body of Bagry for the last several years and know its micrometric characteristics, it was necessary to take photos of the details in the field, including the update for the shoreline and bathymetric measurements.

In the framework of the complex inventory of the Bagry Reservoir, the measurements were made in three stages:

- situation – height of the fragment of the area (detail image) directly adjacent to the water body with the shoreline, using integrated measurements, i.e.: electronic total stations (using Trimble 5503) in the scarps covered with bushes and trees in the northern part and satellite technology GNSS in GPS-RTK (set Trimble: aerial R8s +controller TSC3);
- height – using geometric levelling (code leveller Na 3003 Leica + measuring rod GPCL3) of

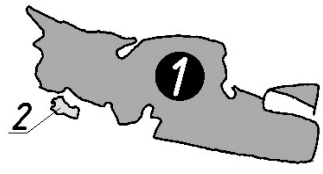
the grid of the detail control line points localized in the neighbourhood of the water body (the calibration points of the satellite spatial data, also treated as control points) and points permanently stabilized in the neighbourhood of the shoreline of "working points" making base to define the changeability of the water table in time;
– hydrographical (bathymetric), with the purpose to investigate and document the relief of the bottom of the water body with the help of a supersonic sonar – echo-sonar Lowrence Elit-4 (measurement of the depth component H) and satellite set by Trimble (aerial R8s + controller TSC3 – measurement of components XY), installed coaxially on the rod attached to the side of a pedalo.

Integration of all the data (altogether 7 937 points), allowed detail geomorphologic parameterization of the water body at the stage of post-processing, updating the shoreline and topographic information of the adjacent area. Basic morphometric parameters of the Great Bagry were put in table 2. A graphic picture of geomorphologii of the bottom, registered by the author in 2016 was illustrated in figure 8.

2. CONCLUSIONS

The Bagry Reservoir is an example of a new geographic space, formed within the last 100 years and subdued to further permanent evolution. Since the moment of ending the exploitation, the water body, apart from recreational function (bathing, beaches), has also been managed for tourists (piers, renting water sports equipment, restaurants and food-selling points). In further perspective, the owner of the area, in the framework of the tourist colonization process, plan creating in the vicinity of the water body further forms of permanent management of the objects in the space of tourist colonization, i.e.: recreational objects (construction of sports playgrounds) and additional elements of functionality, such as walking and cycling didactic routes.

Table 2. Morphometrical Parameters of the Bagry Resorvoir (sport and recreation part marked with symbol ❶ on the scheme)
Tabela 2. Parametry morfometryczne Zalewu Bagry (część rekreacyjno-sportowa oznaczona symbolem ❶ na schemacie)

Parameter	Wartość (stan 03.2016r)		
Area of water [ha]	**30.60**	❶	**30.03**
		❷	**0.57**
Length of the shoreline	**4633 m** (1)	❶	**4066.7**
		❷	**364.6**
Maximal depth [m]	**7.8**		
Mean depth of the water body [m]	**4.66** (Gawałkiewicz R., 2017)		
Volume of the accessible part of waters (according to scheme ❶) in [m^3]	**1 405 762**		
Ordinate of the water table Measurement date	**197.457** (2) **21/03/2016**		
Scheme			

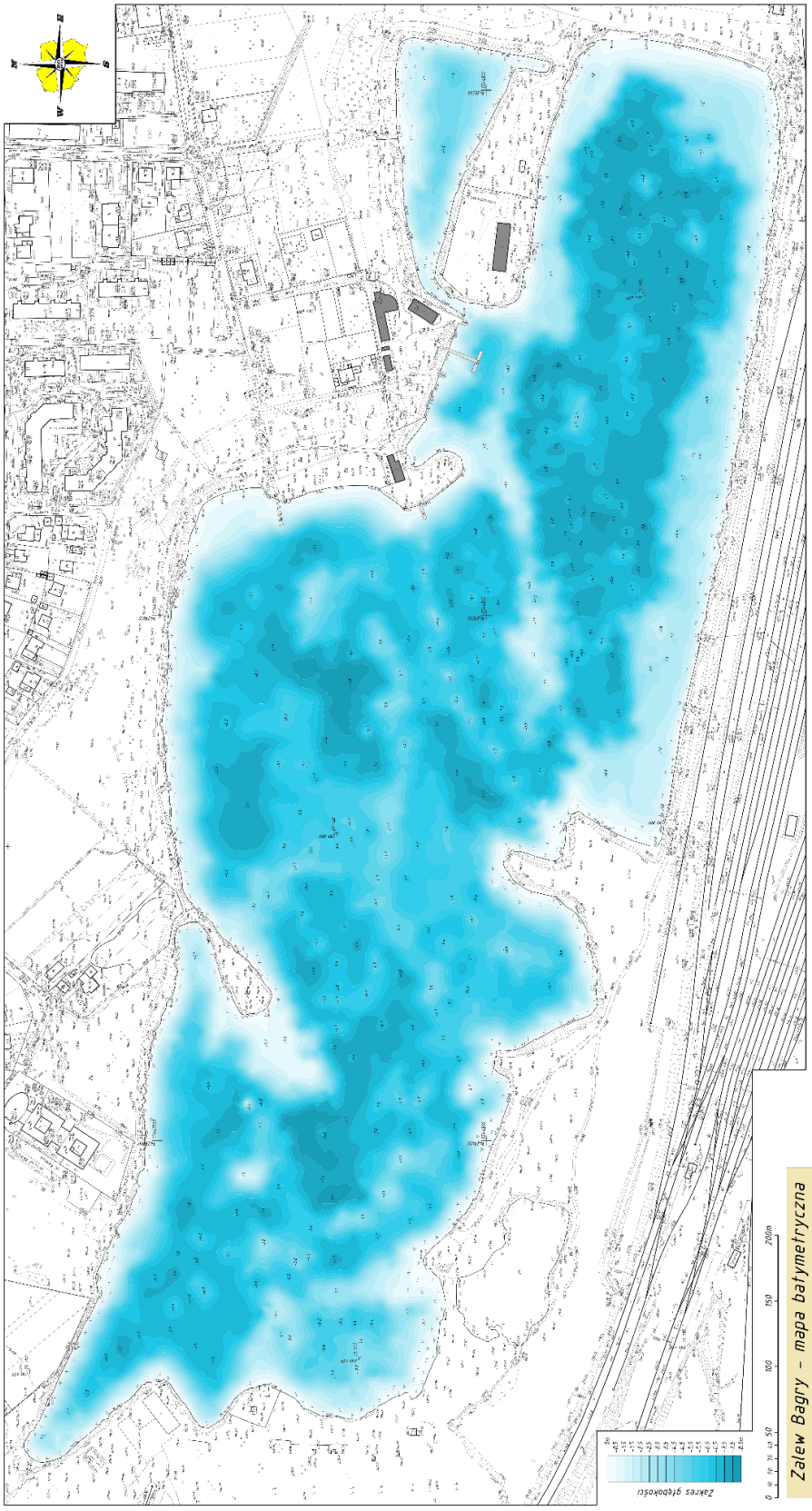


Fig. 8. Cartographic image in the form of a bathymetric map of the Bagry reservoir (by R. Gawałkiewicz – March 2016)
Fig. 8. Opracowanie kartograficzne w formie mapy batymetrycznej Zalewu Bagry (opracowanie R. Gawałkiewicz – marzec 2016r)

If we treat archival maps as pictures, a Chinese proverb saying: "one picture worth ten thousand words" very well describes the history of the water body. In the content of the maps, important data on geographic space are written in a strictly defined time. The compilation of several images illustrating various states of the space provides detail information on the character and range of spatial changes.

The analysis of cartographic materials of the Bagry region, allowed looking through the development the water body Bagry Wielkie, starting from 1930s until nowadays. These data can be treated as discrete, referring to a concrete, strictly defined period. They show gradual development of the excavation in its ninety years old history. One can assume that the shape of the water body recorded in 2016 will be

Preserved for the following decades and the area will not increase. This conclusion is based on the Management Plan (MPZPM), which assumes gradual building up the areas adjacent to Bagry and the borders of plots belonging to the Commune of Kraków. Moreover, nowadays aggregates are obtained on industrial scale on the outskirts of the city (Brzegi) or its neighbourhood.

Presented in the article hydrographical description can in the future help in the project and the implementation of multi-stage actions streaming to comprehensive revitalization of the water body with its surroundings and examining the environment. This can also make base for a detail map of phytocoenoses of Bagry and defining the character of their changes in time (Kowalska A., 2012).

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REFERENCES

Fagiewicz K., (2009): Obszary pogórnicze jako typ krajobrazu recepcyjnego turystyki. [Post-mining areas as a type of reception landscape in tourism]Problemy Ekologii Krajobrazu. [Problems of Landscape Ecology] Vol. XXV, pages 95–103

Gawałkiewicz R., (2017): The application of integration measurement technologies in the inventory of the water body of Bagry. Geomatics and Environmental Engineering, AGH Krakow (in print)

Kowalska A., (2012): Mapy roślinności w badaniach przekształceń środowiska geograficznego [Vegetation maps in the research of environmental transformations]. Prace Komisji Krajobrazu Kulturowego nr 16 – Komisja Krajobrazu Kulturowego PTG, Sosnowiec, pages 157–169

Studium Uwarunkowań i Kierunków Zagospodarowania Przestrzennego Miasta Krakowa – dokument ujednolicony (uchwała nr xii/87/03 z dnia 16 kwietnia 2003 r. zmieniona uchwałą nr XCIII/1256/10 z dnia 3 marca 2010 r. zmieniona uchwałą nr CXII/1700/14 z dnia 9 lipca 2014 r.)

[Study of the Conditions and Directions of Spatial Development of the City of Krakow – unified document (resolution no. xii/87/03 of 16th April 2003, amended by the resolution no. XCIII/1256/10 of 3rd March 2010, amended by the resolution no. CXII/1700/14 of 9th July 2014 r.]