IDENTIFICATION AND ANALYSIS OF AREAS OF HISTORICAL PONDS (CHRUDIMKA RIVER BASIN)

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Abstract

This study deals with the possibilities of creation of a map database of historical ponds and its usability in combination with other sources of spatial information, using an example of a compact territory: the Chrudimka River Basin (Eastern Bohemia). A number of available data sources were used for the creation of the database: the maps of the historical exploitation of the landscape (the Military Survey, the Stabile Cadastre), the digital database of water management data, the database of geographical data of the Czech Republic, etc. The methods of both automatic (in ArcGIS 9.3) and manual localisation of basins were tested for the territory in question. In addition, the paper describes in detail the method of creation of the digital layer in the GIS environment, pointing out the problems encountered in the creation of this layer of ponds from the Second Military Survey (historical ponds). The paper also includes analyses of the areas of ponds from the Second Military Survey (the altitude, the size) and analyses of the land use of the areas of these ponds in the Chrudimka River Basin.

Key words: historical ponds, land use, old maps, Chrudimka River.

INTRODUCTION

Small water reservoirs are one of the principal elements of agricultural landscape in the Central European context (Juszczak and Kędziora 2003). They represent one of the most valuable natural components of the cultural landscape, otherwise entirely transformed by intense human activities (Waldon 2012). In the landscape, small water reservoirs fulfil a number of important roles. From the environmental point of view, they are significant local biocentres increasing the biodiversity of the landscape (Pechar 2011). From the point of view of the water management, they retain water within the river basin and affect its further distribution (Krol et al. 2010); they influence the groundwater level and the soil moisture (Kosturkiewicz and Fiedler 1996). If the retention area is handled correctly, they are able to transform the flood waves (Beran 2005; Rozkošný et al. 2010). In addition, small water reservoirs influence the microclimate. From the social point of view, they may become source of material property (fish farming); they may supply water to industrial plants and drinking and service water to the areas suffering from water shortage (Hamer et al. 2008). Their other functions include the landscape aesthetical function, the historical function (identifying a certain place for many generations, serving sometimes as a defence against enemies). Rees (1997) mentions also the ritual and archaeological functions (small water reservoirs often represent archives of sediments). Small water reservoir, including ponds, may also contribute to the improvement of water quality, if the principles of their correct management are observed (Luzar et al. 2010; Rozkošný et al. 2011). Despite their irreplaceability in the landscape, small water reservoirs are among the European endangered ecosystems and they are under incessant anthropogenic pressure. The water reservoirs near large settlements and those located in intensive farming landscapes are the most sensitive ones, facing the risk of pollution by sewage, the eutrophication caused by artificial fertilisers, the drainage of littoral marshlands, etc. (Waldon 2012).

In the Czech Republic, small water reservoirs have a long historical tradition, related in particular with fish farming and construction of ponds. In the past, the designation rybník (pond) became practically the only word used for small water reservoirs (Vrána 2004), whatever their function was. The ponds had become a landscape phenomenon of the Czech lands. The history of pond construction in the Czech lands has always attracted the attention of historians (e.g. Teplý 1935; Míka 1955; Hurt 1960; Andreska 1997). The first ponds were established in this territory as early as in the 10th century (Liebscher and Rendek 2010). However, the boom of their construction dates back to the 15th and 16th centuries, connected with the flourishing and economically profitable fish farming run by leading aristocratic families. The scope of this construction activities is reflected in the estimates of the total number of ponds in the Czech lands at the end of the 16th century, mentioning from 75,000 (Vrána and Beran 2002) to 78,000 ponds (Matoušek 2010) with an area over 180,000 ha. However, it is not possible to identify the final scope of this phenomenon, since most ponds were suppressed at the end of the 18th century and in course of the 19th century as a consequence of the introduction of crop rotation farming, the abolition of serfdom, unprofitability of fish farming and the sugar beet growing. The ponds became new arable land, meadows and woods. Nowadays, there are around 22,000 ponds in the territory of the Czech Republic (Generel rybníků a nádrží České republiky 1995). Thus, more than two thirds of small water reservoirs were cancelled during the two centuries. The research of these defunct pond systems and their precise localisation is important for:

- proving or disproving the general hypotheses concerning the extinction of ponds in individual regions or confirmation of the grounds for their suppression;
- getting to know the local historical hydrological conditions;
- identification of the current use of former pond areas and their comparison with the surrounding non-pond areas (e.g. from the point of view of soil value);
- identification of the localities for a possible renewal of ponds, e.g. within National Programmes, such as the Programme of Revitalisation of River Systems or the current Landscape Care Programme.

For the solution of these problems, however, it is necessary to create a spatial database mapping the areas of the historical ponds, their current use and to prepare in this way the basis for further analyses. This study deals with the possibilities of creation of such map database, examining its possible use in combination with other sources of territorial information and using an example of a compact territory: the Chrudimka River Basin (Eastern Bohemia).

CHARACTERISTICS OF THE TERRITORY IN QUESTION

The Chrudimka River spring is located 700 m above sea level in the Bohemian-Moravian Highlands. The river drains also a large part of the Železné hory. The total area of its basin is 859 km^2. It flows into the Labe River in Pardubice. In Nemošice profile, the long-term flow rate of the Chrudimka River is 5.99 m^3 s^{-1}. There are the Hamry, the Seč and the Křižanovice dams and the Padrty and the Práčov balance dams on the Chrudimka River. The Hamry Dam serves particularly for waterworks purposes (supply of water for the Hamry water treatment plant of 105 litres per second), partially as flood protection and for the improvement of minimum flow rates. The total volume of the reservoir (the total space) is 3.6 mil. km^3. The flooded area is 0.806 km^2. The average long-term annual flow rate is 0.735 m^3 s^{-1} and the flow rate Q_{100} 49 m^3 s^{-1} (Povodí Labe, s.p. 2009). The Seč Dam serves particularly for the accumulation of water for waterworks purposes, partially also serving as a flood protection, for energetic purposes, for the improvement of minimum flow rates, for recreation and sport fishing. The total volume of the reservoir (the total space) is 22.1 mil. m^3. The flooded area is 2.2 km^2. The average long-term annual flow rate is 2.28 m^3 s^{-1}, and the flow rate Q_{100} is 157 m^3 s^{-1}. When processing the plan of the Labe River Basin, with the Chrudimka River Basin as its part, the Skuteč Pond System was defined within this basin. Parts of pond areas of Žďár nad Sázavou and Lázně Bohdaneč also marginally lie in this basin. For detailed data on geomorphological, geological and climatic conditions of the Chrudimka River Basin, see e.g. Adámek (2012).

For the potential renewal or the construction of new small water reservoir and ponds, it is necessary to assess the territory from the point of view of the risk of surface water pollution. The EU Water Framework Directive (2000) mentions the so-called vulnerable and sensitive areas. The vulnerable areas include the river basins or their parts where agricultural activities negatively influence the concentration of nitrates in surface and ground water. They also include areas influencing the surface, coastal and sea water, where the nitrogen from agriculture causes the eutrophication with subsequent adverse effects on the entire aquatic ecosystem. In the area of the Upper and the Middle Labe River Basins, the vulnerable areas cover 6,918 km^2, i.e. around 48.2% of the total area of the basin. The sensitive areas comprise the areas (rivers or their sections, lakes and other reservoirs, coastal and sea waters) where waste waters from agglomerations over 10,000 equivalent inhabitants cause either the eutrophication, or the exceeding of concentration limit for nitrates, or where the fulfilment of objectives of other directives is threatened. Larger sections of the Chrudimka River Basin have been classified as vulnerable, namely the lower course of the Chrudimka River, from the Křižanovice Dam up to the estuary, and particularly the basin of the right-bank tributary, the Novohradka River, with the Ležák River, the Žejbro River, and the Krounka River affluents. The water bodies located in the section of the Chrudimka River from the Seč Dam up to the confluence with the Novohradka River and, along the Novohradka up to the estuary of the Krounka River, as well as the water body of the Chrudimka River in the surroundings of Hlinsko, have been classified as risk parts of the Chrudimka River Basin as for the presence of nitrogen originating from point sources of pollution. These areas have been classified as risk areas also as for the phosphorus. From the point of view of non-point sources of pollution, this concerns the Chrudimka River Basin from the Seč Dam up to the estuary and the whole of the Krounka Basin, without the partial Ležák Basin. As for the phosphorus from non-point sources of pollution, the Chrudimka River Basin falls into the category of potentially risk water bodies, except for the lower sections of the courses belonging among the non-risk bodies. The Plan of the Labe River Basin Area (Povodí Labe, s.p. 2009) sets the category of the balance excess in the Chrudimka River Basin in the category of 15-30 kg ha^{-1} per year. As for the phosphorus entering the water network by erosion, most of the river basin falls into the category of 0.75-1.5 kg ha^{-1} per year.

INPUT DATA (SOURCES)

The location and the scope of the former pond system are hard to define for the whole of the Czech Republic. In the documentary sources, the ponds were mentioned only in connection with transfers of property (Teplý 2008) or in the case of their significant economical profitability. The research based on archive sources is very complicated for the whole of the Czech Republic and the precise spatial data are often missing. The realisation of a field research based on the relics of former ponds in the landscape (Frajer and Pavelková Chmelová 2009) is problematic in a larger territory. The old surveys with an acceptable scale remain the only tool. If regional maps (e.g. those of domains) are not considered, two large historical surveys of the Czech lands can be used for this purpose: the First Military Survey from 1764-1783 and the Second Military Survey from 1836-1852, as well as the maps of the Stabile Cadastre from 1824-1843. The First Military

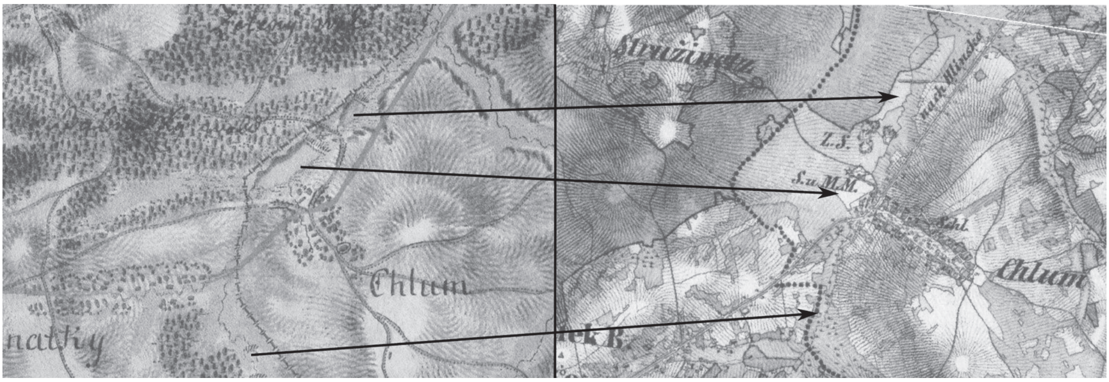

Figure 1 A sample of the drawing of small water reservoirs in the surroundings of Chlum in the First Military Survey and the Second Military Survey (showing only one of them, but with a higher precision, the others being already defunct).
Source: © 1st Military Survey, Section No. c148 and 2nd Military Survey, Section No. 0_9_VIII Austrian State Archive/Military Archive, Vienna; © Geoinformatics Laboratory, University of J. E. Purkyně; © Ministry of Environment of Czech Republic.

Survey (also called Josephine Survey), in a scale of 1 : 28,800, was carried out as a reaction to the necessity of a detailed mapping of the Habsburg Monarchy, particularly after the lost Seven Years' War with Prussia. Due to time pressure, the mapping was not based on precise geodetic data. The landscape was mapped by a specially trained imperial officer using the method *à la vue* or step counting (Mikšovský and Zimová 2006). The result is a unique image of the landscape of the Habsburg Monarchy before the onset of the Industrial Revolution, although it is considerably deformed and cartographically inaccurate. Its further interpretation, e.g. using the geographical information systems (GIS), is highly problematic (see Veverka et al. 2007; Mikšovský and Zimová 2006; Pešťák and Zimová 2005; Frajer and Geletič 2011). The deviations of the precise location of the objects in the maps from their real location are within 160 m to 2,200 m.

In contrast, the Second Military Survey (1 : 28,800) was carried out using the pantographic method, based on detailed cadastral maps of the Stabile Cadastre, made on a precise trigonometric net (Cajthaml 2012). The inaccuracy was considerably eliminated and the deviation of the location of objects in the map from the reality is within 29-50 m (Pešťák and Zimová 2005; Veverka et al. 2007; Frajer and Geletič 2011). However, the Second Military Survey was carried out fifty years after the first survey, i.e. after the first wave of suppression of ponds in the Czech lands. That is why these maps show a much smaller number of ponds than those of the First Military Survey. However, their boundaries are very deformed in the First Military Survey (see Figure 1).

The highest precision of identification and location of historical ponds available is provided by the maps of the Stabile Cadastre. The mapping was carried out between 1824 and 1843. The scans of the so-called Mandatory Imperial Prints of the Stabile Cadastre, held in Vienna, are available on the pages of the Czech Office for Surveying, Mapping and Cadastre. They are of good quality, in colour and well arranged. However, they are not available for the whole territory of the Czech Republic and they are not orthorectified. The orthorectification of the map sheets of the Stabile Cadastre is time demanding and financially impossible, considering the objectives and the scope of work.

From the above-mentioned reasons, the map database of extinct ponds was created using the set of maps of the Second Military Survey, available via WMS services, which were further processed in ArcGIS 9.3.

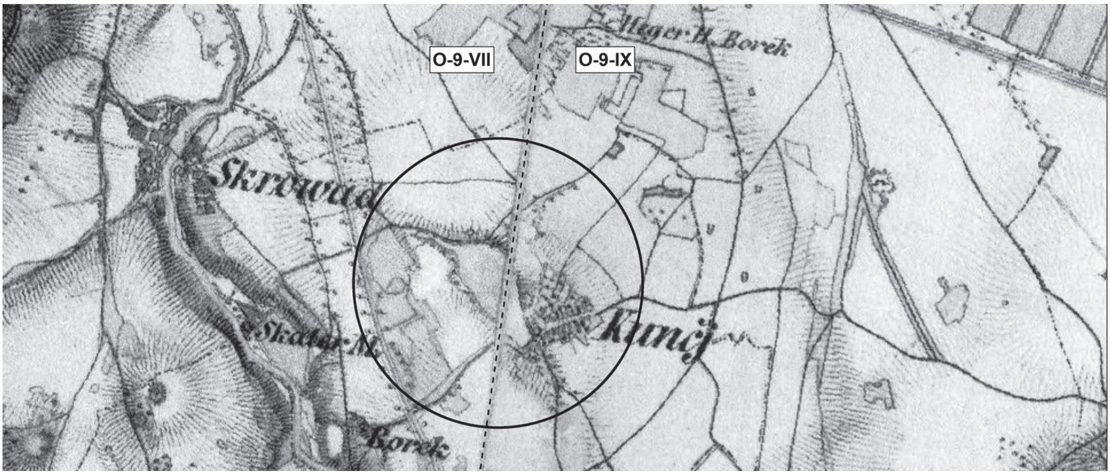

Figure 2 Drawing of Velký rybník near the village of Kunčí. The pond was divided into two map sheets. In the first of them, it has retained the original colour. In the second one, the colour has completely faded.
Source: © 2nd Military Survey, Section No. 0_9_VIII and O_9_IX, Austrian State Archive/Military Archive, Vienna; © Geoinformatics Laboratory, University of J.E.Purkyně; © Ministry of Environment of Czech Republic.

RESULTS

Processing and identification of defunct ponds in GIS

The maps of the Second Military Survey are available free of charge through WMS service from the National Geoportal of the Czech Republic. These sheets are rectified by the method of projective transformation using the coordinates of the edges of the used map sheets (Čada 2005). The ponds drawn in the Second Military Survey were subsequently vectorised in ArcGIS 9.3 in a scale of 1 : 5,000. Within the grid resolution, the use of a higher scale would lead to imprecision of the vectorisation. The identification of ponds in the maps of the Second Military Survey is often not clear and it requires more signs:

- **colour**: the original maps of the Second Military Survey were hand coloured and during the decades, their colours have changed due to the effect of light. The water areas were originally marked with a dark blue border and filled with light blue colour. The colours of the maps have changed and the water areas are now identical with the colour of the base (i.e. light yellow to white, see Figure 2). The dark blue contours of shore lines have become black and they are now easily confusable with the lines marking thoroughfares and borders of lands. In addition, the originally green meadows and graze lands along water courses have got light blue shades and now they can be easily confused with water areas. The same happened with water courses which have either faded to the colour of the base or have become black. As Vichrová (2005) puts it, it may be said that water areas and courses rank among the objects hardest to identify.
- **toponyms**: in the Second Military Survey, some ponds appear directly with their name. The name of the pond is often complemented with the German "Teich" or the abbreviation "T". However, this may lead to confusion, since the names of the ponds were used even if the pond had been emptied for a long time or had been let to be grown over for the renewal of nutrients. In the catalogue of objects of the Second Military Survey (Vichrová 2009), under no. V26-16, such a pond is drawn as a "pond sometimes used as farming land". Considering the difficulty to identify such a pond and to differentiate it from the entirely suppressed ponds, these small water reservoirs were drawn within this research, but they were labelled as suppressed ponds.

Figure 3 Confirmation of the existence of the pond in the map of the Second Military Survey and the Stabile Cadastre. Source: © 2nd Military Survey, Section No. O_9_IX, Austrian State Archive/Military Archive, Vienna; © Geoinformatics Laboratory, University of J.E.Purkyně; © Ministry of Environment of the Czech Republic; © Czech Office for Surveying, Mapping and Cadastre (COSMC).

- **dam**: one of the important signs of small water reservoirs. In the maps of the Second Military Survey, the dams are marked with a double or a highlighted line or a line hachure (in case of larger dams). The dam is often identical with a road leading on it and crossing the water-soaked land difficult for transportation.

The existence of each vectorised reservoir in the Second Military Survey was confirmed by a comparative method, using the detailed maps of the Stabile Cadastre (1 : 2,880) serving as a basis for the survey (Figure 3). In several cases, the pond was drawn in the maps of the Stabile Cadastre but, in the maps of the Second Military Survey, it was depicted as empty, emptied for summer or grown over (Figure 4).

Despite the possibility of using several identifiers and the verification in the Stabile Cadastre, there were several problematic objects. The database does not include the drawn fluvial lakes created by the activity of the meandering water course, provided that they were easily identifiable and they were not anthropogenically modified. In addition, the water courses extended by the influence of weirs were not vectorised. Other natural lakes appear in the maps with the German term “See”. However, in the studied territory, there is no object of this type. The objects created by obvious mining activity have also been excluded.

Identification of the precise location of historical ponds

For spatial analyses and further research of localities, it is necessary to know the precise position of historical ponds. For this reason, and also for the verification of the precision of drawings, it was necessary to make a correction of the drawings reflecting the drawing imprecision and the transformation of maps of the Second Military Survey. In the studied territory, the correction was made manually, using DIBAVOD, a database of the existing water areas, the current and the historical aerial photos, the situation according to the Base Map 1 : 10,000 and the maps of the land register or the land cadastre. Most of these bases were available through WMS or they were sources of T. G. Masaryk Water Research Institute, public research institution (HEIS). With the help of them, it was possible to shift the drawn objects to the coordinates corresponding with their real location and to further analyse them.

A total of 259 objects out of 355 objects drawn in the studied territory were shifted. In 93 objects (24 objects over 0.5 ha), the position was preserved (Figure 5, Figure 6). The average shift was 29 m (or 22 m including the objects which were not shifted). The maximum distance was 80 m. It is clear that the imprecision of the maps of the Second Military Survey may considerably influence further analyses and

Figure 4 The ponds being grown over in the maps of the Second Military Survey.
Source: © 2nd Military Survey, Section No. O_10_VIII, O_10_IX, Austrian State Archive/Military Archive, Vienna; © Geoinformatics Laboratory, University of J.E.Purkyně; © Ministry of Environment of the Czech Republic; © Czech Office for Surveying, Mapping and Cadastre (COSMC).

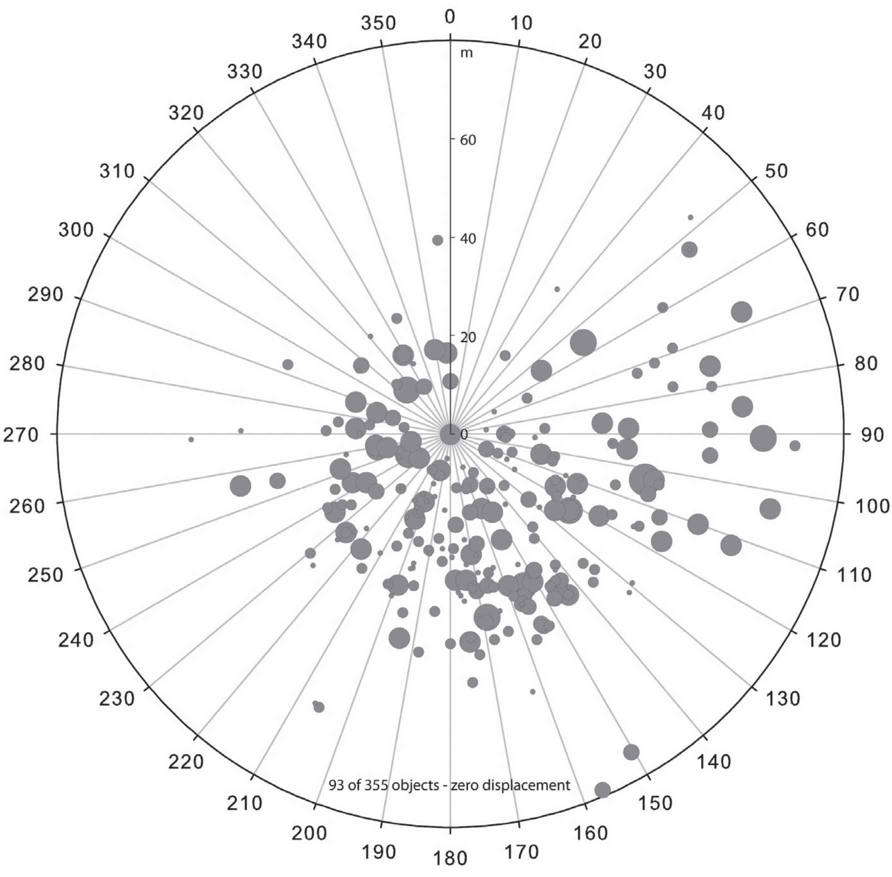

Figure 5 Chart of the direction and the distance of the shift and the size of the shifted objects in the studied territory.

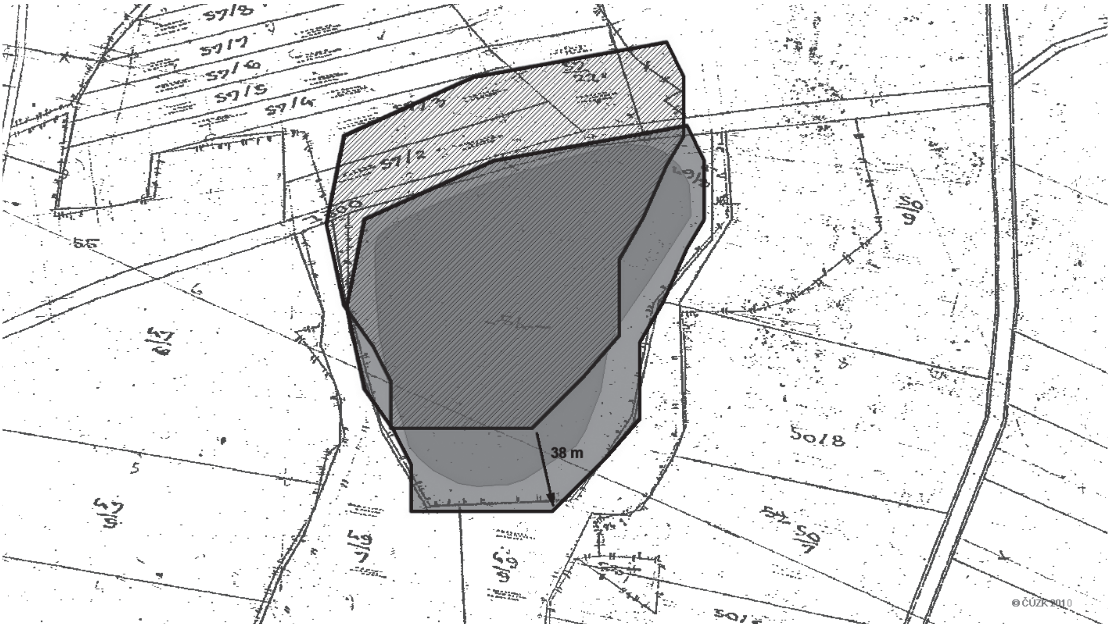

Figure 6 Example of shifted drawing based on a map of land cadastre and the current water area. Source: © Czech Office for Surveying, Mapping and Cadastre (COSMC).

that additional correction is required, in particular in smaller objects. Despite the fact that several neighbouring objects usually showed an identical vector of shift, it is clear that it is not possible to apply any of the available transformations for the correction, since the distance and the direction of the shift is not dependent on the size of the drawn objects or their location in the map sheet or territory.

The use of spatial layer from the DIBAVOD database and buffer zones for the identification of preserved ponds

For the purposes of the identification of the current use of the historical ponds, the application of the spatial layer "A05_Vodni_Nadrze" was tested. It forms a part of the DIBAVOD geo-database (Digital Base of Water Management Data), being at the same time the officially used layer of water areas in the Czech Republic. The DIBAVOD geo-database is a specialised superstructure of ZABAGED® operated by the Czech Office for Surveying, Mapping and Cadastre. It represents a digital geographical model of the territory of the Czech Republic, with the precision of the Base Map of the Czech Republic 1 : 10,000. The successful identification of the current use of the areas of historical ponds with the use of the layer of water areas and reservoirs is largely dependent on the characteristics of the given territory.

The spatial analyses in the GIS environment (ArcGIS 10.0) were carried out on two sets of data on defunct ponds of the Chrudimka River Basin. The set "Chrudimka" represents the polygons of ponds drawn over the maps of the Second Military Survey without additional correction. The set "Chrudimka manually corrected" contains the locations manually corrected on the basis of the cadastral map and other base maps (e.g. orthophotos).

The spatial overlap of the layer of the historical ponds and the current water areas showed that 39% (Chrudimka), or 47% (Chrudimka manually corrected) of areas of the historical ponds, have currently the same or similar use (see Table 1). It means that the pond has been preserved, in some form, up to the present. At the same time, it may be stated that the process of the subsequent correction of

Table 1 Overlap of areas of ponds in the Chrudimka River Basin according to the buffer zone.

Buffer (m)	Overlap of the "historical ponds" – "water reservoirs"	
	Number	Percentage (%)
—	**167***	**47***
—	139	39
10	159	45
20	174	49
30	180	51
50	193	55
100	221	63
200	263	75

* Data for the Chrudimka, manually corrected (reference data).

the location of the historical ponds using other base data is necessary. The set of polygons "Chrudimka manually corrected" matches the layer of water areas and reservoirs in 167 polygons.

In the following stage of the analysis, the possibility of application of the so-called buffer zones around the areas of the historical ponds was tested. This step was carried out particularly to test the possible use of automatic accuracy improvement for a territory larger than the Chrudimka River Basin and also for the balancing or partial correction of the position of polygons of the historical ponds showing inaccuracies of the position in their projection in current maps.

Six buffer zones of various sizes were successively used in calculations (Table 1) and the increase of the overlap of the layers of the defunct ponds and the current water areas was observed. It was stated that the use of buffer zones and their successive extension increase the percentage of the overlaps. In the event the method of buffer zones is used for other territories, the application of the buffer of 20 or 30 m appears as the optimum solution. The application of a larger buffer zone has no sense, because this increases the number of incorrectly matched polygons of the historical and the current ponds which would require a manual correction.

Analysis of the areas of historical ponds in the Chrudimka Basin according to area and altitude

During the digitalization of ponds from the maps of the Second Military Survey, 356 historical ponds, occupying 617.5 ha, were identified in the Chrudimka River Basin. It is interesting to classify the historical ponds according to the area: 35% out of all the ponds have an area smaller than 0.1 ha, their number being 124. Within the basin, these ponds lie in various altitudes and they were mostly located in village greens. There are 235 (66.3%) ponds up to 0.5 ha and 338 ponds up to 10 ha (95.5%). Seven ponds were larger than 20 ha.

An analysis of the altitude of the historical ponds was carried out to identify the altitudes at which the ponds were constructed the most often. The results are shown in Figure 7, showing the altitude of the historical pond and its area. The group of ponds up to 0.5 ha (small ponds) is clearly distinguished from the category of ponds larger than 0.5 ha. In the case of ponds above 0.5 ha, the more frequent altitudes are clearly visible for the Chrudimka River Basin: the localities from 250 to 330 m above sea level, from 370 to 420 m above sea level and from 550 to 630 m above sea level.

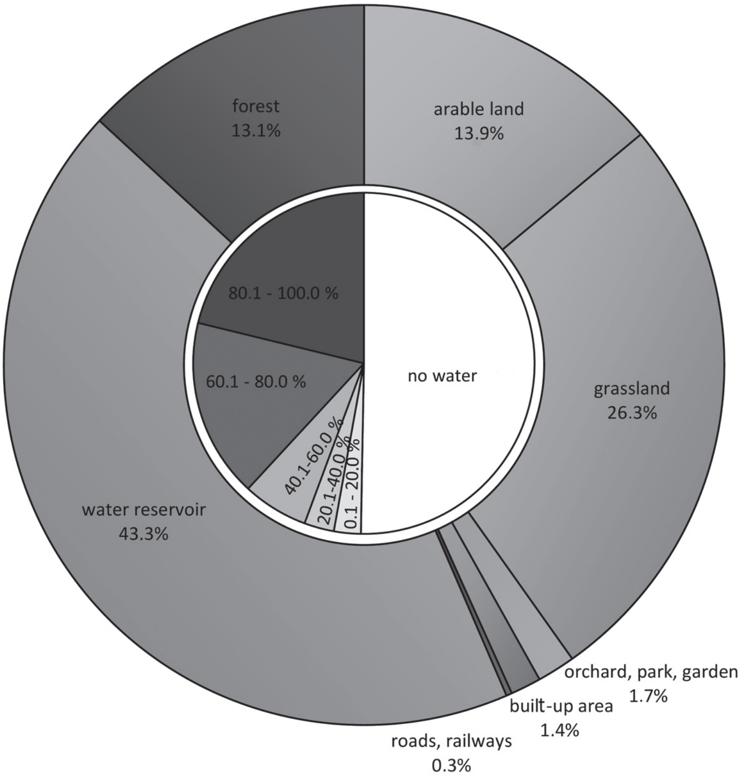

Figure 8 Survey of the current land use of the areas of the historical ponds in the Chrudimka River Basin (land-use classes in external circle, water coverage in inner circle).

Analysis of areas of historical ponds in the Chrudimka River Basin according to the current land use

The database of the historical ponds in the Chrudimka River Basin which was made was further analysed in the GIS environment. First of all, the current land use in the locality of the historical pond was identified. Modified and aggregated layers of the ZABAGED vector database were used for this purpose. Figure 8 outlines the exploitation of areas of the historical ponds in the Basin. The analysis also showed that in many cases of the current exploitation of the areas of the historical ponds, the land use is not clearly defined and that several categories of land use are represented. The chart shows the categories of the land use as the percentage out of the total area of the Basin. The central part of the chart represents the division of the areas of the historical ponds according to the percentage share of water area. On the basis of the land-use analysis, it was determined, among others, whether it is an entirely defunct pond, a pond existing today with (approximately) the same area or a pond existing in the locality, but with a smaller or larger area.

It is clear that the water areas have been preserved on 43.3% of the areas of the historical ponds and these ponds are thus considered as preserved. This category is not, however, entirely unambiguous, since the water area has changed in some of the preserved ponds. In the Chrudimka River Basin, the area has not been always reduced, but sometimes it was even extended (Adámek 2012:20). The reduction of the area of some ponds may have been caused by the need for the new farming land obtained by a partial drainage of the pond. In many cases, this may have been caused by a successive filling of the pond

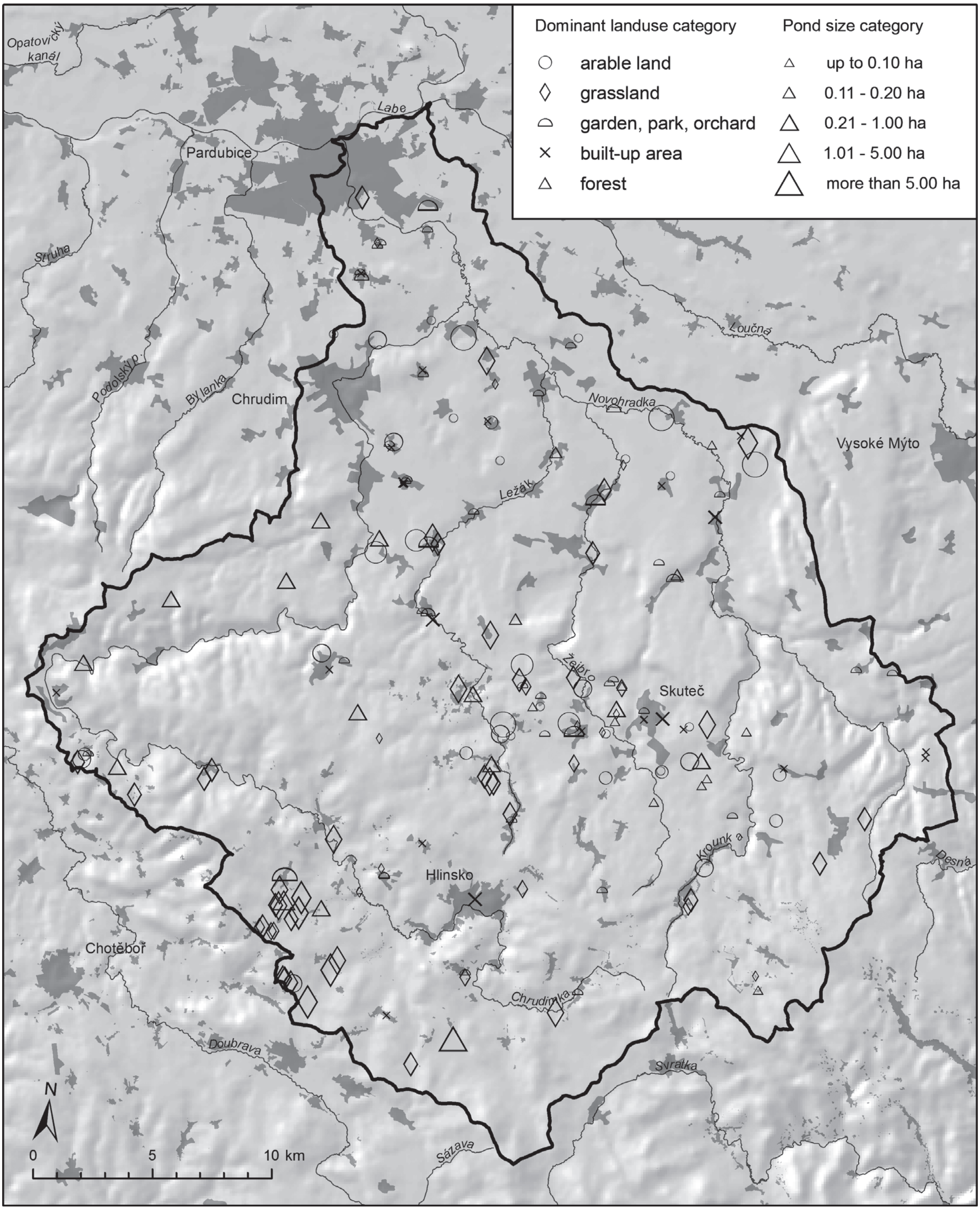

Figure 9 Current land use of the area of defunct ponds in the Chrudimka River Basin.

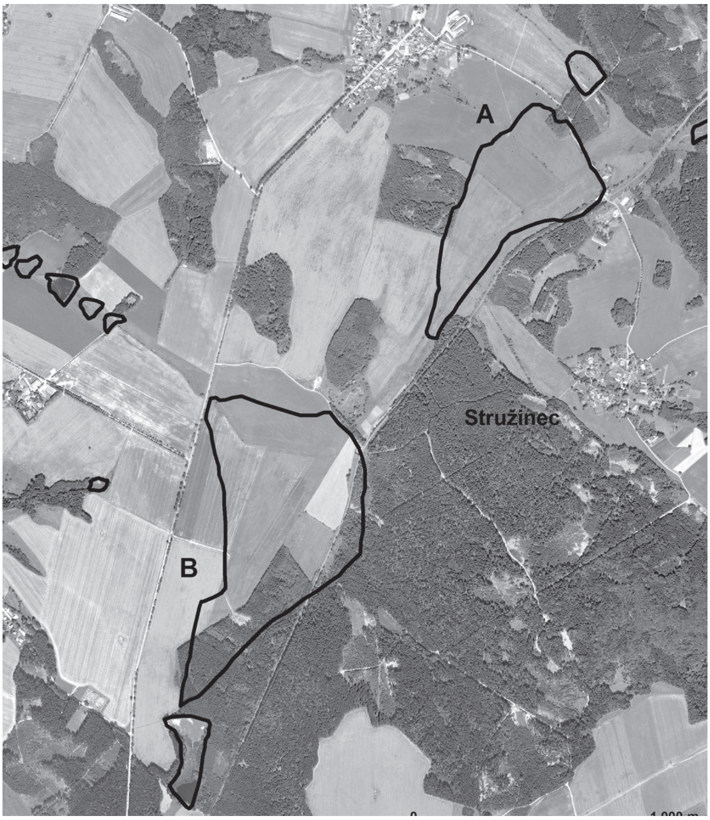

Figure 10 Defunct ponds near the village of Stružinec in the Chrudimka River Basin. Source: © Czech Office for Surveying, Mapping and Cadastre (COSMC).

with soil from deposits and erosion. The extension of the ponds indicates a convenient location of the original pond with the surroundings that permit such enlargement. The category 90.1 up to 100.0% comprises 40 ponds, out of which 7 with 100% of the water area and 6 with a currently extended water area. The case of the Hořička Pond in the cadastral area of Havlovice u Mířetic is the most visible. Its area is currently 29.7 ha, extended by 7.3 ha.

Out of the total number of 354 historical ponds, 178 ponds are defunct. However, a detailed research of the territory and the category of 7 other historical ponds with 1 up to 10% of the water area shows that the water area represents water courses, i.e. running water, which should also be classified in the category of defunct ponds. This category would then comprise 185 defunct water areas. Out of these defunct ponds, only 65 ponds have a clearly defined land use. In the case of the areas of the other historical ponds, the current land use falls in two and more categories.

As for the structure of the current land use of the areas of the historical ponds, in 21 defunct ponds, 100% of the area is used as arable land; in 15 historical ponds, 100% of the area is covered with grasslands; in 11 ponds, the whole area is covered with woods; in 10 historical ponds, the whole area is covered with gardens and orchards and only in 8 ponds, 100% of the area is the build-up area. Figure 9 shows the current land use of the area of the defunct ponds. The land use of other historical ponds, where the land use is classified as two and more categories, is expressed as the currently predominant land use.

Two large ponds near the village of Stružinec have been selected as the examples of defunct ponds. The Barchanecký Pond (B) is the largest defunct pond in the Chrudimka River Basin, with an area exceeding 48.5 ha. A relic of a dam, 160 m long, is still visible in the field. The dam used to be about 3 m wide and 5 m high (Adámek 2012:21). The current land use includes grassland, arable land and woods, each of them occupying approximately one third of the area. The second nameless pond (A), having an area of 25.76 ha, is the third largest defunct pond in the analysed river basin. Also in this case, the dam is still apparent in the field, with a road on it. The relic of the dam is 180 m long, the dam used to be 5 m wide and its maximum height may have been of approximately 6 m (Adámek 2012:22). Currently, it is grassland. Figure 10 shows the defunct ponds on the basis of an orthophotograph where B represents the Barchanecký Pond and A represents the nameless pond.

CONCLUSION

This study has shown that the Second Military Survey is the most suitable (available and transformed) historical basis for the creation of the database. The identification of the polygons of historical ponds from this source has its limits, e.g. identification of the area of the historical pond is sometimes difficult and has to be confirmed by a combination of other identifiers (colour, toponym, position of the dam).

The created layer of the polygons of the historical ponds has to be modified for further analyses, due to the mistakes during the creation and the subsequent rectification of the sheets of the Second Military Survey. A manual correction of the position of the historical pond is the most accurate method, advantageous for smaller territories, but it is time demanding and requires the use of other map bases (e.g. cadastral maps, orthophotos). From this reason, it is possible to use, for large territories, the automatic method of buffers offered by the GIS software. It appears that during the use of buffer of 10 or 20 meters, the difference between the manual correction of the position of the historical pond and the automatic correction using the buffers in the GIS environment disappears. With the help of the two methods, it is possible to specify the position of most of the historical ponds with the currently corresponding water area. In the database, such an area will not be classified as a defunct pond, but as a pond preserved with a various extent of the water area. However, in the regions with numerous ponds, the error rate of the automatic process increases, due to a potentially incorrect matching of the water area.

The corrected database may be further analysed as to the size, the elevation and the current land use of the areas of the historical ponds or as to the soil conditions.

Since the beginning of the 1990s, new water reservoirs have been constructed in the Czech Republic and the existing and defunct reservoirs have been renewed, cleaned from mud and revitalised, among others thanks to various subvention programmes. The information on their historical location, provided by this study for the analysed river basin, might be used as a basis for a further renewal and revitalisation of small water reservoirs, including the ponds. For the decision analyses, it would be suitable to create a spatial database, mapping the areas of the defunct ponds for the whole of the Czech Republic.

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Résumé

Identifikace a analýza ploch historických rybníků z dostupných mapových podkladů na příkladu povodí Chrudimky.

V České republice mají malé vodní nádrže velkou historickou tradici. Je spjata především s rybníkářstvím a stavbou rybníků, jejichž název se stal v minulých dobách prakticky jediným označením pro malé vodní nádrže (Vrána 2004) ať už plnily jakoukoli funkci. Rybníky se staly krajinným fenoménem Českých zemí. Dějiny výstavby rybníků v Českých zemích proto budily odjakživa pozornost historiků např. (Teplý 1937; Míka 1955; Hurt 1960; Andreska 1997). První vznikaly na našem území již v 10. století (Liebscher a Rendek 2010), největšího rozmachu však jejich stavba dospěla v 15. a 16. století v souvislosti s rozmachem ekonomicky výnosného chovu ryb, kterého se chopily významné šlechtické rody. O rozsahu této budovatelské činnosti svědčí odhad, celkového počtu rybníků v Českých zemích na konci 16. století, který hovoří o 75 000 (Vrána a Beran 2002) až 78 000 (Matoušek 2010) s výměrou přes 180 000 ha. Definitivní rozsah tohoto fenoménu všech nemůžeme postihnout, protože většina rybníků byla na konci 18. století a v průběhu 19. Století zrušena v důsledku přechodu na střídavé zemědělské hospodaření, zrušení nevolnictví, nerentability chovu ryb a pěstování řepy cukrovky. Z rybníků se tak stala nová orná půda, louky nebo lesy. V současnosti existuje na území České republiky přibližně 22 000 rybníků (Generel rybníků a nádrží České republiky 1995). Více než 2/3 malých vodních nádrží bylo tedy v průběhu dvou staletí zrušeno.

Tato studie ukázala, že jako nejvhodnější (dostupný a transformovaný) historický podklad pro vytvoření databáze je II. vojenské mapování. Identifikace polygonů historických rybníků z tohoto zdroje má své limity např. místy obtížná samotná identifikace plochy historického rybníku, která musí být následně potvrzena kombinací dalších identifikátorů (barva, toponymum, poloha hráze).

Vzniklou vrstvu polygonů historických rybníků je nutno pro další analýzy upravit z důvodů chyb při vzniku a následné rektifikaci listů II. vojenského mapování. Nejpřesnější metoda je ruční korekce polohy historického rybníku, která je výhodná pro malá území, ale časově velmi náročná a vyžaduje další využití mapových podkladů (např. katastrální mapy, ortofoto snímky). Z tohoto důvodů je možné pro velká území použít automatickou metodu obalových zón (bafru), které nabízí software GIS. Ukazuje se, že při použití baffru 10 nebo 20 metrů se ztrácí rozdíl mezi ruční úpravou polohy historického rybníka a automatickou korekcí pomocí obalových zón v prostředí GIS. Těmi to metodami je možné upřesnit polohu většiny historických rybníků, k nimž v současnosti existuje odpovídající vodní plocha. Tato plocha potom nebude v databázi klasifikována jako zaniklý rybník, ale rybník dochovaný v různém rozsahu vodní plochy. V oblastech hustě pokrytých rybníky ale poroste chybovost automatického postupu z důvodu potenciálního nekorektního přiřazení vodní plochy.

Při digitalizaci rybníků z map II. vojenského mapování (IIVM), bylo v povodí Chrudimky zjištěno 354 historických rybníků, které zabíraly plochu 617,4 ha. Zajímavé je rozdělení historických rybníků podle plochy, kdy 35% všech rybníků tvoří rybníky menší než 0,1 ha a jejich počet je 124. Tyto rybníky jsou v povodí v různých nadmořských výškách a jednalo se převážně o rybníky návesní v inravilánu obcí. Počet rybníků do 0,5 ha je 235 (66,3 %). Počet rybníků do velikosti 10 ha je 338, což je 95,5 %. Sedm rybníků bylo větších než 20 ha. U rybníků nad 0,5 ha se ukazuje, že jsou zřetelné nadmořské výšky, kde častěji leží rybníky v povodí Chrudimky. Jsou to lokality v nadmořské výšce od 250 do 330 m n.m., dále v rozmezí 370–420 m n. m. a v nadmořské výšce 550 až 630 m n. m.

Z celkového počtu 354 historických rybníků je zaniklých 178. Pokud ale detailně prozkoumáme území a kategorii dalších 7 historických rybníků, kde je v současnosti 1–10 % vodní plocha, uvidíme, že tato vodní plocha je vodní plocha vodních toků, tedy tekoucích vod a měla by být zařazena také do kategorie zaniklé rybníky. Potom by tuto kategorii tvořilo 185 zaniklých vodních ploch. Z těchto zaniklých rybníků má pouze 65 rybníků jednoznačné využití současní plochy. U ostatních ploch historických rybníků je využití těchto ploch v současnosti zařazeno do dvou a více kategorií.

Od počátku 90. let dochází v ČR k realizaci nových malých vodních nádrží, nebo obnově stávajících a zaniklých, jejich odbahňování a revitalizaci, i díky podpoře různých dotačních programů. Jako podklad pro další vývoj obnovy a revitalizace malých vodních nádrží, včetně rybníků, mohou sloužit informace o jejich historické lokalizaci, kterou v rámci zájmového povodí podává tato studie. Pro provádění rozhodovacích analýz by bylo vhodné vytvořit jako podklad prostorovou databázi mapující rozsah ploch zaniklých rybníků pro celou ČR.