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THEME

TECHNICAL AND INDUSTRIAL CULTURAL HERITAGE

11 December – International Mountain Day

International Mountain Day is a relatively new day, the UN General Assembly declared it in 2003. It logically follows on from the International Year of Mountains held from 11 December 2001 to 11 December 2002 on the initiative of the Food and Agriculture Organization of the United Nations (FAO). The event aims to raise awareness of the importance of mountains for the quality of human life and the natural balance on Earth. Its purpose is mainly to support the sustainable development of mountain areas and to warn about the possibilities and measures in the use of mountains, even at the cost of limiting tourism.

This issue is the same both on the Tibetan plateaus and in high altitudes of the South American Andes, both in the Alps and the Czech Sněžka Mountain.

The focus of the day changes every year. The theme of the first year was mountains as the most important reservoir of drinking water, since 80 per cent of the water on Earth comes from high mountains. Other years focused on, for example, the level of biological diversity, the threat of climate change, minorities and indigenous peoples living in high mountains, as well as the occurrence of many endemic mountain animals and plants.

Mountains are of fundamental importance for our life on planet Earth. Whether we live in the lowlands at sea level or high in the hills, we are still connected to them and they affect the quality of our lives more than we can imagine. 13 per cent of the entire human population lives in the mountains, including several specific traditional tribes. Stays in the mountains make up 15 to 20 per cent of global tourism. Mountain peaks cover 22 per cent of our planet and it can be said that they are actually the beginning and the end of all natural landscapes.

Despite this, there is considerable deterioration of their natural environment, not only due to climate change, but also due to the extraction of minerals, wars and armed conflicts, poverty and hunger.

International Mountain Day also has its own symbol (see picture). It consists of three equilateral triangles growing from an imaginary horizontal line, which represent the mountains and their wealth. The left one has a blue "diamond" on top, which symbolizes the glaciers and snow cover that give us water. The circle in the middle triangle indicates the raw material resources that we get from the mountains (coal, minerals, ore, etc.). The green area in the right triangle represents crops and all agricultural production from mountain and foothill areas.

Therefore, the goal of the event is primarily the protection of mountains, responsible approach to their natural resources and respect for nature as such. In our country, the celebrations of the International Mountain Day are traditionally joined by, for example, The Czech Association of Mountain Guides, which annually organizes for the public an ascent to the highest peak of one of the Czech mountain ranges, for example to Sněžka or Králický Sněžník.

VTEI Editorial

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Dear readers,

I'm sure you will agree with me that in the past weeks and months it has been impossible to avoid discussions about the provision of energy for the winter period and subsequently about the high prices at which it will be available. The topic has resonated across society, with concerns escalating further after damage to the Nord Stream undersea pipelines and "technical difficulties" in repairs to one of the nine turbines on existing pipelines from Russia. The prospect of a lack of heat for households and energy for businesses was a topic that put most other plans, ideas, and ecological resolutions on the back burner.

Households are starting to heat with coal, cogenerations with mazut, and the life of power stations, whether coal or nuclear, is being extended.

There are ongoing debates about the causes of the energy crisis, but according to information from State Office for Nuclear Safety chairwoman Dana Drábová, the original reason was probably that there was no wind in Germany for more than two months, and this caused a lack of electricity from wind farms. Combined with the repair of more than half of France's nuclear power stations and the limited operation of hydroelectric power stations due to the drought, we found ourselves in a situation that Vladimir Putin then used to punish Europe for its support of democracy and national independence.

Unpredictable nature then compensated for the lack of wind in Germany at least a little with an unusually warm October, which gave us time to refill the storage tanks, build LNG terminals, and for ships to arrive with liquefied gas. The situation has started to change slowly, but winter and energy bills are yet to come, and although Europe is no longer in danger of collapse, it will not be easy at all. Our Institute went through an unwanted experience when a gas pipe accident at the end of October shut down our heating and hot water for two weeks. Although the warm October helped us to keep the temperature in the offices at the level allowed by law and to continue working, it was definitely not a suitable environment for cutting-edge science and research.

Although the situation is starting to calm down, partly because we are getting used to it, in the whirlwind of events we forgot a little about the beginning of the hydrological year. The hydrological period that we are concluding can be classified as average. We are already beginning to subconsciously count situations that we would have previously considered extremes into the average – lack of snow, uneven distribution of precipitation, increased average temperature, high evaporation, practically permanent drought in southern Moravia and northern Bohemia, floods, and other phenomena. It shows how our thinking is adaptable and we gradually get used to exceptional situations, which we begin to consider normal.

Priorities connected, if not with survival, then certainly with existential problems and the limitation of comfort, also had an impact on the cultural life of our citizens. People have grown a little coarse and pushed culture into the background. The current VTEI issue tries to go against this trend, remind us of culture again and thus defy the saying "inter arma silent Musae", i.e. "the Muses are silent in war". The articles in it are devoted to research related to the preservation of our cultural heritage, naturally connected to water-related topics. However, it includes not only technical monuments such as water reservoirs and water works as historical heritage, but also mentions, for example, irrigation or fish stocks in the vicinity of heritage-protected areas.

I hope that, like me, you will enjoy a different perspective from the usual, purely pragmatic view of water management and begin to see the beauty of the work we are lucky enough to do.

Ing. Tomáš Urban
Director of TGM WRI, p. r. i.

Presentation of some of the results of a research project mapping the development of the construction of elevated water tanks in the Czech Republic

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Keywords: elevated water tank — terminology — typology — records — research

ABSTRACT

This paper presents a summary of some of the results of the research project, "*Water towers – identification, documentation, presentation, new utilization*", (DG18P02OVV010), which has been implemented since 2018 as part of the Programme for the Support of applied Research and Development of National and Cultural Identity for 2016–2022 (NAKI II) of the Ministry of Culture of the Czech Republic. In terms of content, it follows on from articles from previous years published in this periodical, but clarifies and supplements the issues of technical terminology and typology established at its inception based on the knowledge gained during the project. Furthermore, it presents general results of the records of the structures of elevated water tanks and focuses on a brief description of the historical development of these structures in our territory.

INTRODUCTION

At the beginning of the research project "*Water towers – identification, documentation, presentation, new utilization*" (DG18P02OVV010) it was necessary to address the issue of defining the technical terminology and typology of the structures of elevated water tanks. A group of authors elaborated and presented this topic in 2018 and 2019 in two issues of the magazine VTEI [1, 2]. In the course of the project, a number of new findings were attained, on the basis of which some of the technical terms were specified and the knowledge of the typology of these structures was expanded. This referred especially to a more precise delimitation of the object of our interest – i.e. elevated water tanks, and determination of the time frame of their construction.

One of the goals of the research project was to create records of elevated water tanks. We have managed to localise almost 1,500 existing and demolished structures, the classification of which is further described below. Thanks to the extensive research of structures both in the field and in archival and literary sources, we were able to fulfil the main objective of the project: to capture the historical, constructional, technological, and architectural development of elevated water tanks in our territory in relation to various types of water supply systems in which they served a variety of functions. A brief outline of the development, which is part of this paper, was created on the basis of the facts ascertained during the project, and can serve as a summary for its more detailed elaboration in the forthcoming book.

METHODOLOGY

Identification and localisation of elevated water tanks

The first step in the research was the identification and localisation of existing and demolished elevated water tanks in the Czech Republic. The primary source of data and information when creating the initial records was mainly the web database *Vodárenské věže (Waterworks towers)* [3]. At the beginning of the project there were 530 structures recorded, although these also involved structures which were not considered elevated water tanks according to the methodology of our project. These records were supplemented by the excerption of the database *Industriální typologie (Industrial typology)* of Výzkumné centrum průmyslového dědictví (Research Centre for Industrial Heritage), Památkový katalog NPÚ ČR (Monument catalogue of the National Heritage Institute of the Czech Republic) and others [4]. In addition, various map sources were used: *Základní vodohospodářské mapy* ČR *(Basic water-management maps of the CR*), publicly available maps from internet portals, and historic orthophotomaps [5]. Contemporary specialised literature, including regional and technical periodicals and newspapers, was also used [6]. The results of previous projects or research of the members of the research team were also taken into account [7]. An important source of information in terms of the existence and location of structures on railways were the activities of a number of museums and interest groups focused on the history of railway transportation in the Czech Republic.

ARCHIVAL RESEARCH ACTIVITIES

We mainly used archival sources to obtain information about elevated water towers. In particular, this involved construction documentation and related files. They can be used not only to obtain awareness about the structural form of elevated water tanks but also information about who had each structure built and when, how it was financed, who built it and how, and how it was structurally transformed, etc. In addition, these sources often provide broader information about the function of the whole complex of which the elevated water tank was part.

Construction documentation of municipal elevated water tanks was searched for in fonds of relevant authorities. These are usually urban and municipal archival fonds and also fonds of district councils. Here, depending on the nature of individual files, written sources are usually archived under the pressmark of the water department. Another important source of information was the agenda of awater management book and related collections of documents and plans, which is nowadays also archived in the fonds of district authorities. Documents of both aforementioned fonds are now deposited in the fonds of relevant State District Archives. In addition to this, construction files were also used; these historically originated under the responsibility of municipalities functioning as construction authorities. Nowadays, they are usually archived in the record office of contemporary territorially competent construction authorities.

Construction documentation related to industrial elevated water tanks was searched for mainly in the fonds of district councils, deposited in relevant State District Archives. Here, depending on the nature of the file, the documentation is usually archived under the pressmark of the trade licensing department (exceptionally also of the construction department). The aforementioned agenda of the water management book and related collections of documents and plans were also used. It was also possible to find construction and file documentation in archival fonds of given enterprises (stored in relevant State District Archives or State Regional Archives) and also in unofficial archives which were part of the heritage or originated by activities of owners or operators of given complexes and have not been shredded. When it was necessary, materials that historically originated under the responsibility of municipalities functioning as building authorities were also examined.

The main source of information about elevated water tanks on railways were archival sources from the fonds specialising in the construction and operation of railway lines in the territory of today's Czech Republic [8]. In some cases these were disorganised fonds requiring time-consuming research.

The main source of information about the few elevated water tanks used for agricultural operation built before the Second World War were the record offices of construction authorities. The mass construction of elevated water tanks in agriculture only began in the 1960s and information about them is usually traceable in the fonds of district national committees stored in relevant State District Archives.

Apart from construction documentation, a number of other archival documentation was also used and this helped us to also explain the economic-social context of the origin and operation of elevated water tanks in towns and villages. These are, for example, village chronicles, minutes from town authorities meetings, and station chronicles.

In the case of demolished structures, archival documents are often the only relevant sources of information about the appearance and history of individual structures. In this respect, it was also important for us to track down their historical appearance, usually stored in photographic collections of relevant archives, but often also in regional museums, etc.

Field research

In the case of some structures, field research was carried out. It was based, wherever possible, on the methods of constructional-historical research. The on-site research focused in detail on constructional and technological design of a structure and its spatial context, as well as on the identification of the wider context, i.e. knowledge about energy management, water sources and their subsequent distribution. Where possible, simplified documentation of the current state was created in the form of basic specialisation, including elementary geometric characteristics and photo documentation. In the case of some structures, their most frequent constructional-technical problems were analysed.

Fig. 1. Old Town Water Tower, which was mentioned as early as in the 15th century, forms an inseparable part of the panorama of the right Vltava riverbank (Photo: R. Kořínek)

TECHNICAL TERMINOLOGY AND RESEARCH TOPIC DELIMITATION

In accordance with the project results and existing laws and standards [9], we solely use the term elevated water tank, which refers to structures consisting of one or more reservoirs. These reservoirs, which serve for water accumulation, are placed at a certain height on supporting structures which were constructed for the purpose of bearing reservoirs, and the reservoirs here serve one of the defined functions of the elevated water tank [10]. They also include structures which could have been created by construction intervention into the structural design of the original elevated structure with the clear aim of converting it into an elevated water tank [11].

These are also multi-purpose structures which, apart from the function of an elevated water tank, also serve different functions unrelated to the waterworks operation, and which were designed and subsequently (not necessarily at the same time) constructed as one elevated structure. At the same time, there must be a condition fulfilled that this operation itself would require another elevated structure. The assessment of multi-purpose structures requires an individual approach.

In some factories – especially textile ones – we can see a reservoir placed above the roof in a separate part of the building. There was a fire escape staircase situated in this building which connected individual floors of the operation and the water accumulated in the reservoir was also mostly used for fire-fighting purposes. These structures do not correspond to our definition of multi-purpose structures (a staircase as such is not a tower-like structure by its nature) and with regard to the location of the reservoir on a structure which was not primarily designed to bear it, it does not correspond to the definition of an elevated water tank either, so we did not deal with them further.

Not even reservoirs which are situated either directly on roofs of structures (usually factories) or above their roofs on low elevated structures are considered as elevated water tanks because the predominant structures under them are not primarily designed to bear them.

An important task of the research was to state clearly from what period elevated structures of waterworks systems could be considered as elevated water tanks. As early as in the first half of the 15th century, towers with reservoirs on top floors were documented in waterworks systems, into which water was driven by piston pumps and then flowed gravitationally to public fountains or private houses [12]. However, the volume of these reservoirs was small without any space for creating any reserve [13]. Therefore they did not enable the supply of water in the case of unexpected situations, which could have included failures of a water wheel, pumping equipment, or discharge piping. The construction of the tower was also designed mainly with regard to ensuring the statics of relatively tall buildings, although the small volume of the reservoir itself

Fig. 2. The oldest preserved elevated water tank in our territory was built at the railway station in Rajhrad in 1838 (Photo: R. Kořínek)

Fig. 3. Bohumín elevated water tank is the first documented example of the use of reinforced concrete for these railway structures (Photo: R. Kořínek)

usually did not pose a major problem for its load-bearing capacity and stability. Water towers, which from the aforementioned period supplemented the panorama of many Czech towns *(Fig. 1)*, served only a pressure function within the distribution networks and we do not classify them as elevated water tanks in the scope of our research.

The same happened with towers which had been constructed for purposes other than waterworks, for example as defence towers in town fortification systems. Some of them had reservoirs integrated into them after their original function had ceased, which thus became part of the water supply system. These structures were not built for the purpose of bearing reservoirs and these, due to their small capacity, provided only sufficient water pressure in the pipeline, therefore these structures are not considered elevated water tanks either.

Elevated water tanks were mentioned for the first time in connection with the construction of steam-powered railways at the end of the first half of the 19th century. To operate steam locomotives it was necessary to ensure a sufficient amount of water. Filling their storage tanks in the station by pumping would take too long and would disrupt the traffic flow. Therefore it was necessary to create a corresponding supply of water in another way at the location of locomotive water-filling. As a result, such structures started to be built in those floors where there was a storage reservoir as a source of immediately available water.

In connection with elevated water tanks for the needs of steam locomotives, we have made a slight change in the terminology suggested in 2018. At that time we started to use the term railway elevated water tank. But after having examined these structures carefully, we stopped using this term. Water accumulated in elevated water tanks on the railway was used not only for filling steam locomotives but in some complexes with a similar kind of operation it was used for washing vehicles, washing locomotive boilers out, or for extinguishing purposes, and drinking water was accumulated here too. There were several ways water could have been used and to simplify the terminology of such an elevated water tank to just a railway elevated water tank would be imprecise and confusing. Therefore, we use the term elevated water tank and add a more detailed specification indicating what purpose the accumulated water was used for if this information is available.

Basic data from the records of elevated water tanks

Within the research and localisation, almost 1,500 existing and demolished structures of elevated water tanks have been recorded. 517 structures in total have been classified as systems supplying populations with water, out of which 475 structures still exist. For the needs of industrial complexes, 246 structures have been localised, out of which 156 structures exist. In agricultural complexes, a total number of 206 elevated water tanks have been identified, out of which 189 still exist. For the needs of railway operations, a total amount of 525 elevated water tanks have been recorded. Given the fact that the steam power operation was terminated in our country in the 1970s and 1980s and a lot of non-functional structures [14] have already been demolished, 316 of which have been preserved so far [15].

The construction of standardised spherical elevated water tanks (called Hydroglobes and Aknaglobes) was quite a significant phenomenon in the field of the construction of elevated water tanks. The importation of Hydroglobes (*Fig. 21*) started in the middle of the 1960s from the Hungarian People's Republic and about 200 of these elevated water tanks were set up. At first, they were used for the needs of agricultural complexes, later they were integrated also into waterworks systems, supplying population and complexes of industrial enterprises with water. Subsequently, they were supplemented with similar types of structures, Aknaglobes, of which about 250 were constructed. Approximately one third of all recorded elevated water tanks in the territory of the Czech Republic are formed by these standardised steel structures.

Outline of the historical overview of the development of elevated water tanks in the tracked period

The oldest elevated water tanks appeared in our territory in 1838 [16], when the first steam-powered railway was put into operation in the Czech lands between Břeclav and Rajhrad (*Fig. 2*). The rapid development of railway transportation caused their number to increase and these structures to be modernised, especially with respect to the application of new trends in the material and structural design of reservoirs and methods of water pumping. The use of bricked buildings with steel reservoirs with a flat and suspended bottom and the standardisation of buildings (including their equipment), which, moreover, often took over the architecture of other buildings within the station or the whole railway, was typical for this period. While the oldest of them were still built in the form of architectural styles of Empire and then Classicism, later on buildings started to appear reflecting historicist approaches. Their design included a wide range of structures, ranging from architecturally sophisticated objects to more austere structures built in a generally accepted style.

Modern reinforced concrete started to be used quite slowly on railways. With the exception of a unique structure of the elevated water tank in Bohumín, built in 1907 (*Fig. 3*), it became increasingly popular only during the 1920s. Its introduction to railways first brought a new solution for the accumulation of water in the form of two concentric cylindrical reservoirs with a flat bottom and a thin-walled shell. Later, it also expanded into the supporting structures designed on a circular ground plan in the form of closed skeleton systems in already completely separate buildings.

Elevated water tanks have played an important role since the 1880s, especially in the construction of urban water supply systems and industrial plants. Their construction took place at these sites until the Second World War.

Great emphasis was placed on the architectural design of elevated water tanks in towns in particular. Elevated water tanks became symbols of technical advancement and their appearance was to correlate with the most significant buildings of towns (their vertical form also usually became a new part of the town panorama). Development and methods of use of building materials, hand in hand with influences and transformation of architectural styles at the turn of the 19th and 20th centuries, gave rise to a wide range of elevated water tanks of great value. Their appearance was often formed by prominent architects and builders of that time.

The architecture of elevated water tanks in towns thus took on a natural form based on historicising styles, especially Neo-Renaissance, which created the appearance of modern towns at the end of the 19th century (*Fig. 4*). However, the external appearance of elevated water tanks and the search for their morphology were not autotelic at the beginning of their construction. They emerged from the special nature of their new purpose, which was the accumulation of the amount of water at the height of the supporting structure.

The construction design of elevated water tanks and their appearance were closely related to the shape of the reservoir, the material used for its production, and the way it is placed on the supporting structure. Circular steel reservoirs with a flat bottom used for the oldest elevated water tanks were placed on beams anchored in load-bearing walls onto which they transferred their load, and thus the construction design corresponded to the design of elevated water tanks of the time – prismatic structures on a square ground plan without a necessary extended upper space with the reservoir. The design of their facades could thus easily be adapted to the architectural trends of the time.

When, at the beginning of the 20th century, steel tanks constructed according to Professor Otto Intze's patent [17] began to be used, the result was the narrowing of the supporting structure and thus the technical nature of the silhouettes of elevated water tanks was accentuated for the first time when the ground plan of its floor with the reservoir exceeded the supporting part (*Fig. 5*).

Fig. 4. The Neo-Renaissance elevated water tank of the former Královské Vinohrady aqueduct is still a prominent feature of this part of the city of Prague (Archive of R. Kořínek)

Fig. 5. Libeň elevated water tank from 1904, with the characteristic extension of the shell around the Intze reservoir (Archive of R. Kořínek)

Fig. 6. The shape of the elevated water tank in Třeboň was designed by architect Jan Kotěra, who was also in charge of the design of the elevated water tank of Vršovice waterworks in Prague-Michle (Photo: O. Civín)

Fig. 7. The oldest preserved reinforced concrete elevated water tank in an urban environment was built in Pardubice in 1907 (Photo: O. Civín)

Fig. 8. Elevated water tank in Kolín, designed by architect František Janda in a functionalist style (Photo: O. Civín)

Fig. 9. Combined load-bearing structure of the elevated water tank in Chrast (Photo: O. Civín)

Fig. 10. One of the first elevated water tanks built in industrial complexes was Rudolf Rütgers's tar processing plant in Zábřeh nad Odrou (today part of Ostrava) [19]

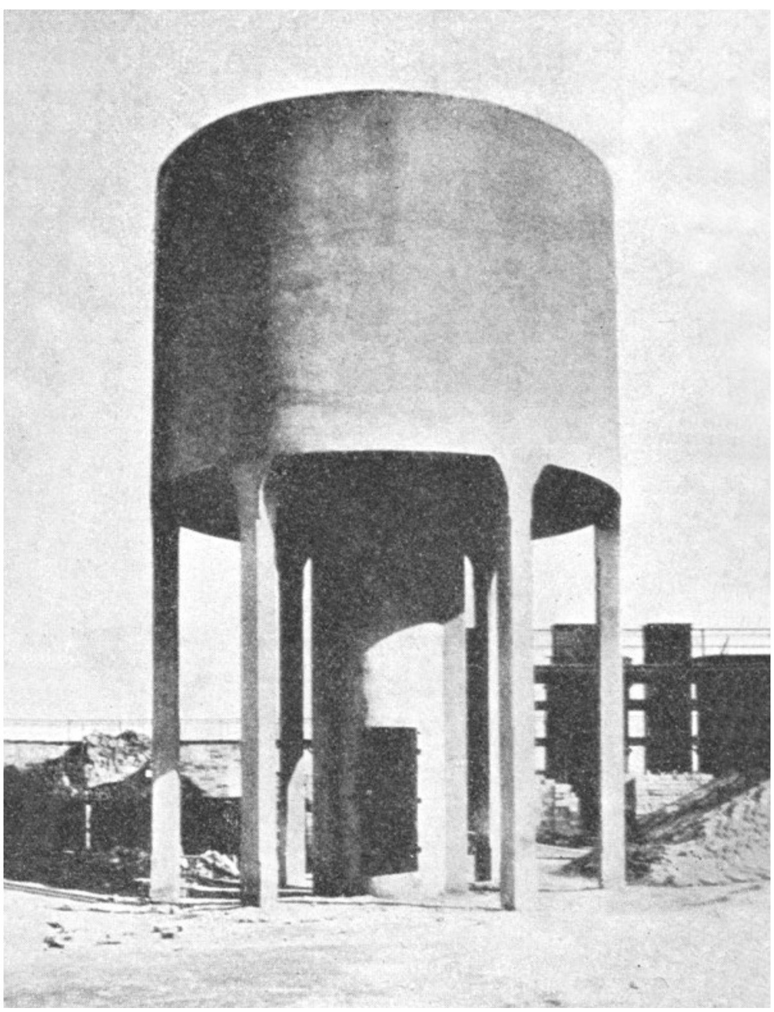

Fig. 11. The oldest elevated water tank in our territory, during the construction of which reinforced concrete was used, was located in Holešice from 1905 [20]

Fig. 12. The elevated water tank of the former glass factory in Bílina-Chudeřice is an example of the use of a subtle open reservoir-bearing structure (Photo: M. Postl)

Fig. 13. The reinforced concrete elevated water tank in Heřmanova Huť – Dolní Sekyřany was rebuilt as a lookout tower and is accessible to the public (Photo: O. Civín)

Fig. 14. An elevated water tank for the Michelin tyre factory in Prague-Záběhlice was built in a purely utilitarian style [21]

Fig. 15. The elevated water tank in Ostrava-Mariánské Hory is united with the surrounding buildings by a reinforced concrete skeleton with a combination of plastered surfaces, faced masonry, and openwork motifs (Photo: R. Polášek)

The transformation of the technology of the most important functional part of elevated water tanks – their reservoirs – thus also originated the beginning of the transformation of the understanding of the external presentation of elevated water tanks as purely technical structures. Hand in hand with the transformation of the approach to architecture and the related transformation of architectural styles (especially with the advent of art Nouveau), the decorative and artistic representation of elevated water tanks gradually faded away, and their appearance took on simpler forms which underlined their real purpose (*Fig. 6*). The technical nature of these structures was accentuated by the austerity of facades and practical design solutions, even before modern architectural trends which held an approach in which form followed the function were fully reflected in our country.

The emergence of modern building materials, especially reinforced concrete [18], at the beginning of the 20th century helped to gradually transform existing architectural forms. In fact, reinforced concrete immediately started to be used for all construction parts of elevated water tanks. The first use of reinforced concrete as the exclusive material in the construction of an entire elevated water tank in the urban environment in our country is paradoxically also connected with the use of open Art Nouveau architecture, which led to its somewhat bizarre appearance (*Fig. 7*). However, later constructions can be characterised by more austere forms. In contrast to the construction of water tanks in industrial complexes or as parts of water supply systems financed by industrial plants for their working-class housing, in our urban environment there are no documented elevated water tanks with open reinforced concrete supporting structures. Water tanks thus always became part of sophisticated architectural design only in connection with brick lining (*Fig. 8*) or, less frequently, in combination with independent supporting pillars and a closed connecting shaft (*Fig. 9*).

A slightly different development can be observed in the case of water tanks built for the needs of industrial complexes, although even here we can find some common features. To put it simply, even in industry the shape of elevated water tanks was logically also influenced by the form of the functional essence of the structure – the reservoir. The oldest elevated water tanks in industrial complexes documented from the turn of the 1880^{s} and 1890^{s} were thus constructed as masonry buildings (plastered or with facing masonry and the appearance reflecting either contemporary architectural styles or the nature of the premises) with steel reservoirs and flat or suspended bottoms (*Fig. 10*).

Elevated water tanks in industrial complexes usually also had an architectonic form which often reflected the appearance of the factory premises, especially if the water tanks were an integral part of the complex. In spite of that, it was in this area – which was logical – where the trend of utilitarisation manifested itself much earlier than in others and was influenced mainly by the use of reinforced concrete and technologies which, thanks to this material, allowed the design of the supporting structure in a specific way.

The emergence, or establishment, of reinforced concrete occurred much faster in industrial complexes than in towns (*Fig. 11*). Although even among industrial elevated water tanks we can find examples where the supporting structures from reinforced concrete were finished by masonry, much more often can we see uncovered open beam structures whose austere appearance complemented their utilitarian use of bearing the reservoir with water usable for industrial operation or production (*Fig. 12*). This type of constructional design can therefore be encountered exclusively in industry, although several of these elevated water tanks were built outside factory complexes as well. These were structures built for the needs of employees' housing. An example is an elevated water tank in a housing area called Kanada, built by Třinec Iron and Steel Works.

A similar approach can be seen in structures whose reservoir was supported by steel truss beams or rolled profiles.

In industrial complexes we can also find reinforced concrete elevated water tanks with a combined constructional design where the open part is complemented by a closed central shaft. The oldest preserved structure of this kind is an elevated water tank built in 1909 for the needs of a nearby brewery in Vlkýš, in today's cadastre of Heřmanova Huť (*Fig. 13*). In subsequent years, the village was expanding and today the water tank is part of its built-up area of independent houses and blocks of flats. The sign "BRAUEREI WILKISCHEN" on the reservoir shell reminds us of its industrial past. This structure, which was out of operation for a long time, underwent reconstruction and today it serves as a lookout tower accessible to the public.

Such trends in industry continued to occur simultaneously until the Second World War, and none of these approaches ever prevailed against the others. In the 1920s and 1930s we can still come across purely utilitarian (*Fig. 14*) and architecturally more sophisticated implementations of elevated water tanks (*Fig. 15*).

The multi-purpose structures of chimney water tanks [22], which started to be built in factory complexes at the beginning of the 20th century, acquired a very specific form of steel reservoirs based on the design of Professor Otto Intze's reservoirs and reinforced concrete reservoirs in the shape of a cylindrical or cone placed on a narrower base (*Fig. 16*). The biggest motivation for their construction was mainly to save financial costs compared to the construction of separate elevated water tanks with reservoirs of smaller cubic capacity, and probably also to save space in limited areas of factory premises [17]. Other multi-purpose structures in industrial complexes include, for example, cooling towers of coking plants or some tower structures of urban slaughterhouse cold rooms, which apart from bearing a reservoir also bore shower coolers.

The construction of water supply systems and elevated water tanks in villages had also already started before the First World War. These constructions took place mainly in areas where existing sources of drinking water were not sufficient at all or were polluted by industrial production or as a result of technically inadequate implementation of aqueducts (for example, in the form of an open storage reservoir). Investors in such structures were either various cooperatives, the municipalities themselves, or also cases where external investors were those who motivated the constructions. These rural water tanks were often interesting structures too, becoming dominant features of villages and the surrounding landscape, and there are even examples of unexpectedly modern designs and architectural solutions or the early use of advanced building materials (*Fig. 17*).

Massive development of the construction of elevated water tanks in villages started only in the period of the First Republic in connection with the generous state and provincial policy of subsidising group water supply systems of which they were part. In contrast, until the end of the Second World War, elevated water tanks serving the needs of agriculture were quite exceptional.

Elevated water tanks could also be found as parts of water supply systems, which cannot be unequivocally included in any of the distribution networks described so far. These were, for various reasons, located in complexes which had a specific kind of operation and were usually closed, although they could extend beyond their original boundaries over time. They were often created outside urbanised areas where it was not possible to connect with existing water supply networks in the surrounding areas. These include, for example, waterworks in the premises of health care establishments (*Fig. 18*) or waterworks serving the army, but also several public facilities or specific kinds of operation (*Fig. 19*) as well as waterworks at manor houses (*Fig. 20*).

The construction of elevated water tanks in the second half of the 20th century was carried out in the spirit of the search for simplified constructional and economically favourable solutions in accordance with the implementation of a standardised structure and design process. While, for example, in neighbouring Germany the attention regarding building elevated water tanks was focused on processing reinforced concrete [17], in our country the concept of steel structures achieved dominance. So, in Czech territory, Hydroglobe elevated water tanks with steel structures became more widespread; they were imported from Hungary from the 1960s [23] and their typical spherical tanks became new dominant features of our landscape (*Fig. 21*). Thanks to their availability and simplicity

Fig. 16. In 1942, an 80-metre high chimney with a reinforced concrete reservoir with a volume of 300 m^3 was built for Josef Sochor's Mechanical weaving and textile printing works in Dvůr Králové nad Labem (Photo: M. Vonka)

Fig. 17. As early as 1914, an elevated water tank was completed in Bezno with features typical of functionalism, which did not become more widespread in our country until later (Photo: R. Kořínek)

Fig. 18. The elevated water tank of Dobřany psychiatric hospital was built at the time of the construction of the hospital between 1876 and 1883 (Photo: R. Kořínek)

Fig. 19. Open reinforced concrete supporting structures were used in our territory for the first time for the construction of the elevated water tank of Opava wastewater treatment plant (Photo: R. Kořínek)

Fig. 20. An elevated water tank also formed part in the water supply of Sychrov Castle park, where the supporting structure on a circular ground plan was used in our territory for the first time (Photo: O. Civín)

Fig. 21. The first Hydroglobe elevated water tank in our territory was built in Borotice (Photo: R. Kořínek)

Fig. 22. The elevated water tank found in Brno-Kohoutovice since 1969 was designed by the architect Tomáš Čeroušek (Photo: O. Civín)

Fig. 23. The shape of the elevated water tank in Ohrazenice proves that it still makes sense to look for original and decent solutions for these structures (Photo: O. Civín) [25]

Fig. 24. The elevated water tank in Kladno from 1933 underwent a challenging conversion and its top floor today serves as a meeting room for the local waterworks company (Photo: M. Vonka)

of construction, they caused the spread of elevated water tanks into newly built agricultural complexes and became an important part of the further development of aqueducts intended for the water supply of the population. Later, they were supplemented with typologically similar structures called Aknaglobes.

Nevertheless, masonry and reinforced concrete structures were still being built, albeit to a much lesser extent. Projects of elevated water tanks prevailed in the construction of which prefabricated reinforced concrete components were used. From time to time, a constructionally, architecturally, or technologically unique structure emerged from a uniform range of structures, which is a phenomenon that can be found in all areas where elevated water tanks found their use (*Fig. 22*) [24].

Compared to previous years, at present there are significantly less elevated water tanks being built, with steel standardised structures prevailing among the new ones (although one successful exception can be found – see *Fig. 23*). In water supply systems, elevated water tanks are nowadays often replaced by other technical solutions, but these do not always offer such a full range of operational possibilities as elevated water tanks. To a large extent, these structures are disappearing on railways. In recent years, however, projects focused on the conversion of elevated water tanks have been successful, which helps to find new uses and lives for them (*Fig. 24*).

CONCLUSION

In the course of the research project "*Elevated water tanks – identification, documentation, presentation and new use*", new facts were identified which helped us specify some of the originally proposed technical terms and expand our knowledge of the typology of these structures. By means of their long-term research, we could achieve a more precise delimitation of the object of our interest and determination of the time frame which we consider as a period of construction of elevated water tanks. These facts were also an important starting point for the systematic monitoring of their development.

Elevated water tanks started to be built in our territory at the end of the 1930s in relation to the need to create a sufficient supply of water for steam-powered operations on the railways. Almost 50 years later, their vertical forms appeared in urban water supply systems and soon expanded into industrial complexes. In the 20th century, they also started to be built in villages and the last place where they were widely used was the agricultural sector. They have thus become an integral and indispensable part of a wide range of various water supply systems involved in the distribution of drinking and non-drinking water.

Structures of elevated water tanks have undergone constructional, architectural, and technological development as part of the development of water supply systems. At the beginning of the 20th century, masonry used for supporting structures was supplemented with steel and reinforced concrete in particular. The latter was also used for the construction of storage reservoirs where, especially in urban and rural environments, it completely replaced the use of steel reservoirs. However, it was not for good – steel returned in the second half of the 20th century because it enabled various design possibilities and simplification of construction and, finally, has become (almost) the only material currently used for load-bearing parts as well as the reservoirs. The development of these structures in our territory was presented in a summarised form within the scope of the periodical VTEI; more details will be presented in a forthcoming book, which will be one of the final results of this project.

Acknowledgement

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[12] For more information see e.g.: JÁSEK, J. *Klenot města: Historický vývoj pražského vodárenství.* Prague 1997.

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[25] the elevated water tank in Ohrazenice celebrated two successes thanks to its unique architectural conception – it won 2nd place in the 2002 Building of the Year in the Liberec Region competition in the category of the public prize and became the 2020 Water Management Building announced by Svaz vodního hospodářství ČR, z. s., and Sdružení oboru vodovodů a kanalizací ČR, z. s.

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Irrigation – rediscovered heritage, its documentation, popularisation and protection based on the example of historical meadow irrigation systems

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Keywords: irrigation systems – meadow irrigation – monument preservation – UNESCO heritage – industrial heritage – popularisation – education – digitisation

ABSTRACT

Irrigation systems were built and have operated mostly as part of a larger or smaller functional complexes. Their significance, also from the point of view from potential heritage protection, thus increases with the identification and documentation not only of solitary structures but, in particular, of entire systems / functional complexes with descriptions of interrelationships between them. Independent objects or structures do not need to be particularly exceptional, although their involvement in the wider functional complex can create a uniquely undertaken solution. In the field of water management, criteria such as typological value, value of technological flow, authenticity of form and function, value of technological and systemic links with an overlap to agriculture and industry are especially important. This article provides information on possibilities of using traditional methods of historical and archive research and documentation of localities, and at the same time using modern tools for systems over a more extensive area, including methods of digitisation and processing of documentation.

INTRODUCTION

Technical and industrial cultural heritage represents a relatively wide and, at the same time, diverse group of buildings that represent examples of the development of human civilization concerning technical and technological progress in the use of land resources and the construction of settlement infrastructure. Historical irrigation systems are an important but, until recently, rather ignored part of this type of cultural heritage. These buildings have been the subject of increased interest in monument protection in the Czech Republic since approximately the end of the 20th century. Their importance has generally grown in particular in the last decade in connection with climate change, which requires the investigation of effective solutions and responses to its impacts. Historical irrigation systems are coming to the fore when it comes to the assessment of potential for their renovation, reconstruction or, on the other hand, removal and replacement with more up-to-date technologies. From this point of view, and the point of view of the connection with the cultural heritage of the Czech Republic, it is important to identify and document in a timely manner possible heritage values of such objects and whole functional complexes, as well as define criteria and possibilities for their protection. In relation to this it is also important to strengthen education of this kind of industrial heritage, both among the professionals and lay public.

In 2020, the project *"Irrigation – rediscovered heritage, its documentation and popularisation"* was initiated and financed within the "Programme of applied research and development of national and cultural identity" of the Ministry of Culture for the period 2020–2022. The project is focused on issues of irrigation as one of the sectors of water management and landscape management in general terms.

An integral part is the focus on industry in connection with the implementation of irrigation systems, structures and facilities, which can be added to the industrial heritage of our country.

The aim of the project is to contribute to the achievement of the specific goals of this programme, which focus on the integration of the results of cultural heritage into educational processes, including the development of tools for documentation and record-keeping of the most endangered typological groups of movable and immovable cultural heritage. In particular, this project aims at preparing and implementing thematic exhibitions, supplemented with a reviewed catalogue, creation of a specialised digital database, and digitally available educational and teaching materials on the given topic. In the case of development and testing of suitable documentation processes, attention was focused on verification of possible use of UAV (Unmanned Aerial Vehicle) systems, thermal images of the surface, and landscape structures, GIS tools and 5G DTM for documenting objects, and hardware & software for digitisation of archive materials and visualisation of structures, systems, equipment, and so on.

The objective of the article is to present methodological procedures and functional tools, which have been selected, tested, and verified for use during the documentation and description of structures, objects, and their functional complexes using the example of one of the main typological groups; these are meadow irrigation systems using surface canals and detailed distribution and drainage systems which are connected to them, supplemented with necessary technological equipment, especially sluice gates, culverts, etc. This is one of the oldest methods of irrigation, which has started to be heritage protected not only at a local level but also globally.

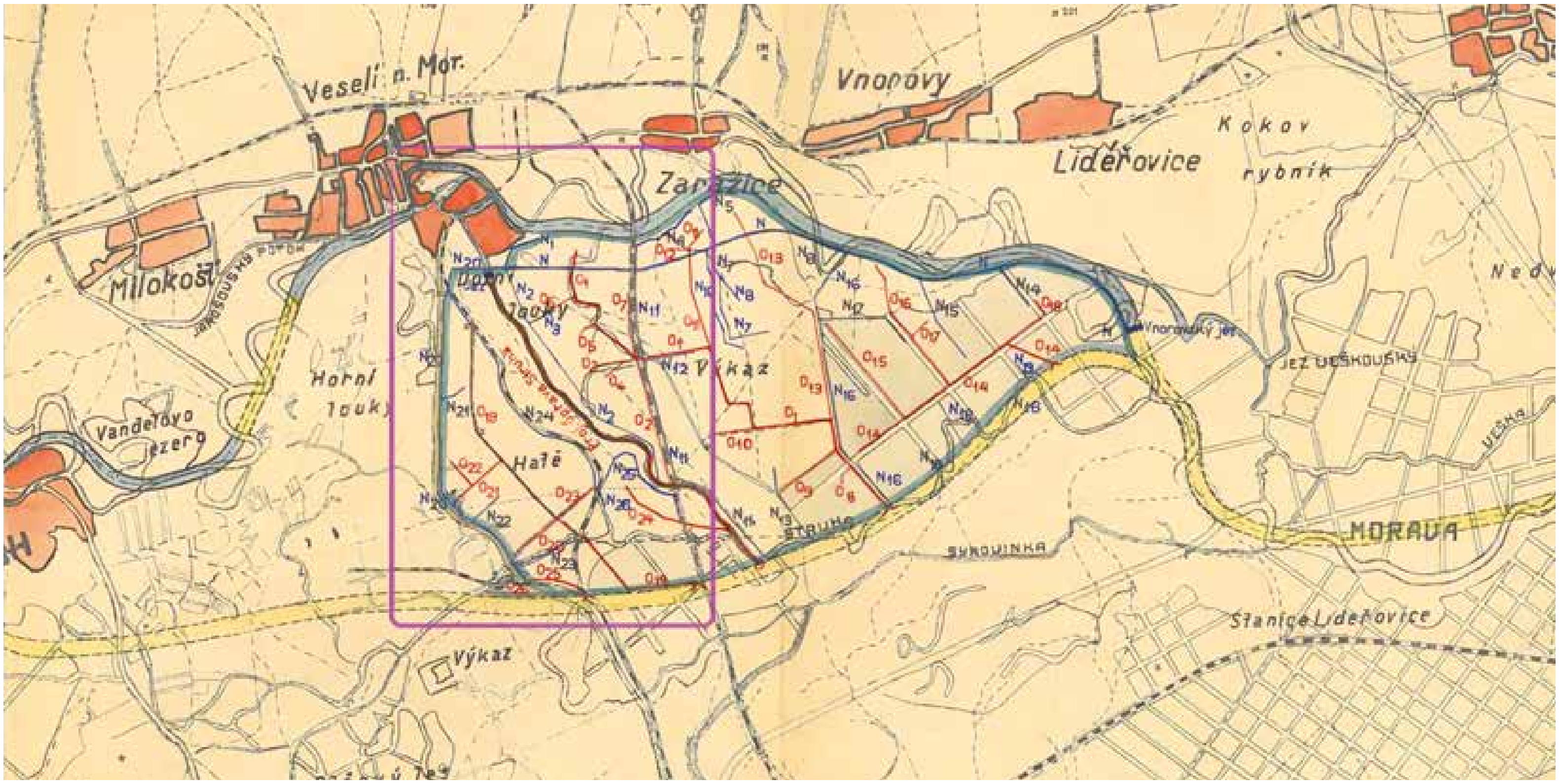

Fig. 1. Demonstration of digitised drawings of project documentation for the implementation of an irrigation system through open ditches along the Morava river in the surroundings of Veselí nad Moravou in the 1930s (areas presented in *Fig. 2* are highlighted in purple, i.e. detailed investigation of the current state of the system and objects)

METHODOLOGY

Generally speaking, in order to achieve the goals of similar research, it may be done via archival work, processing available analyses of input materials (especially historical documents and plans), but also current research of irrigation items and systems. Research of the chosen systems was carried out by both fieldwork with pre-prepared mapping input, and by using modern UAV technologies. The data was analysed and visualised with the help of GIS tools. The processing of all obtained input documents enabled the creation of map sets and small maps for individual territories. These documents display in detail their location and condition of preserved and extinct irrigation systems, identification of their cultural-historical value, potential for restoration and other possible uses, as well as risks resulting from their preservation and use, which concerns each area of interest.

In order to fulfil these aforementioned framework procedures, the research work was divided into three stages:

- compilation of research and archival work, processing of technical documents, overview of irrigation state
- detailed fieldwork – record-keeping, description and visualisation of irrigation systems
- processing and presentation of project outputs

A practical solution according to the framework methodology was thus focused on the collection of inputs, archival investigations and processing of information, documents, and plans for irrigation structures, objects, and systems. The first stage involved the research of specialised literature which deals with the history and technological irrigation systems in the Czech Republic and neighbouring countries in the context of heritage preservation and protection of industrial heritage. In connection with the description of historical development, the typology of irrigation systems, including diagrams, was carried out. For defined areas of interest, an effort was made to gather all available materials, usually in the form of historical, technical documentation and plans, but also projects formed with the purpose of possible renewal of some segments of the system, as well as the most detailed descriptions of the original parameters of irrigation systems of interest. The materials gathered were continuously digitalised in order to secure their preservation in aggregated form, not only for future historical research and use for teaching in specialist schools, but also for informing interest groups, associations, and the wider public.

Archives for the area of the Czech Republic concerning modern irrigation systems of various typologies and generally also water management activities (under which irrigation projects falls), can be found in various location. There are archives at the central level, both domestic (National Archives of the Czech Republic in Prague, Moravian Provincial Archives in Brno, Silesian Provincial Archives in Opava) and international (especially Allgemeines Verwaltungsarchiv and Finanz- und Hofkammerarchiv in Vienna for the period up to 1918). In addition, there are regional and district archives, as well as possibly the archives of institutions and personal collections of water management specialists. The implementation of irrigation measures was undertaken at a national level by state and provincial bodies, at the regional level by regional and district authorities, and at a local level by municipalities and water organisations (cooperatives), associations, and other professional institutions.

Simultaneously, the relevant primary and secondary professional literature and published outputs were also analysed, as well as work with map data. Sources which dealt with water law, water literature, and the development of approaches to amelioration and irrigation were most often located. In addition, attention was focused on publications on water management in rural areas with a historical context. One of the most important research topics is the question of genesis, operation, and importance of so-called water

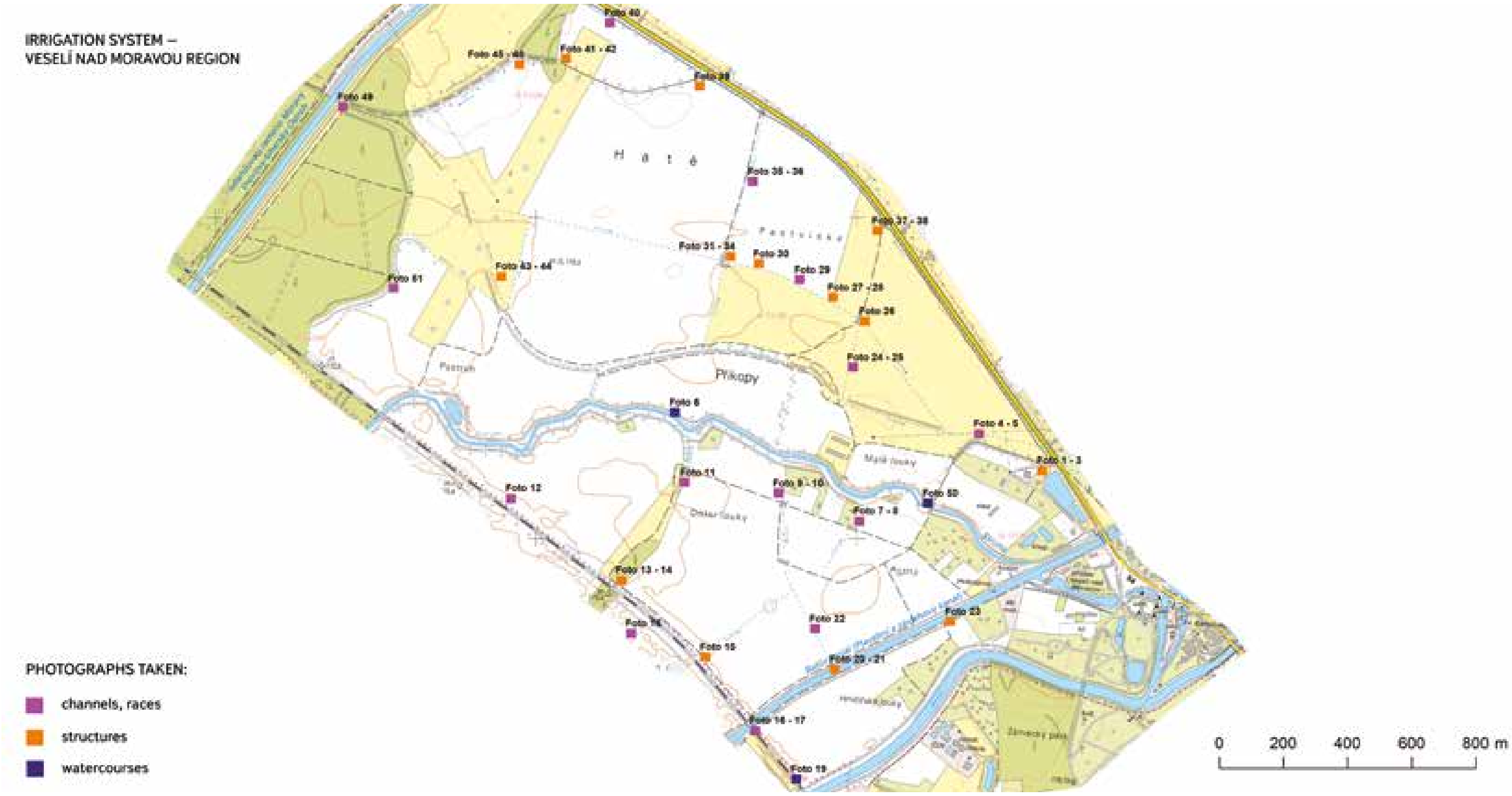

Fig. 2. Example of location processing of individual objects and selected important elements of the irrigation system in the surroundings of Veselí nad Moravou on the basis of current field investigations, ZABAGED® data

cooperatives, which have been in existence since the 19th century in order to regulate water courses and conditions at a local, regional, and transregional scale. The research results were used as proof of the historical approach to solving the issue in question and also simultaneously analysed in terms of the functionality of competent powers and potential for the current period.

Irrigation issues were researched at the cartographic level. The research of cartographic maps of the time of land registry and topographical nature was undertaken in order to study cartographic depictions of irrigation systems. Their spatial dislocation and accumulative hubs was also mapped.

RESULTS AND DISCUSSION

In modern terms (practically speaking from the 19th century), irrigation systems in the Czech lands have undergone huge development. The basic prerequisites enabling the implementation of modern irrigation systems in were mainly favourable legislative, finance, and expert technical conditions. Education and promotion also played an important role. The crucial legal regulation which defined water management in the western part of the Habsburg Empire was the Imperial water act of 1869. This formed the basis for more detailed legislation in the individual countries of the monarchy. These legislative documents were only part of the whole, which enabled the development of water management in the sector of regulation and amelioration. Other pillars were financial support, the establishment of an amelioration fund, and other subsidies. The final pillar was the education, propagation, and transfer of experience as well as the results of research which took place at the time. Water cooperatives became necessary tools for the development of amelioration and irrigation. The system created, with changes and modifications, was preserved and functioned well in the Czech lands practically speaking until the social changes after 1948. In 1955 a new water law was adopted, the first water management plans were assembled, water cooperatives gradually disappeared and, at the same time, the United Agricultural Unit (JZD), Machine Tractor Station (STS), and other parts of socialist agriculture were formed. At the time, the traditional irrigation of meadows was gradually abandoned and finally disappeared.

This irrigation, however, represents one of the main typological groups of irrigation with a long term history – irrigation of agricultural land with meadows with fodder for food production. The method was carried out mainly by basin irrigation using various water supply, distribution, and drainage systems. These are historically the oldest irrigation systems in Europe [1–4], some of which have survived until the present day. In many locations, work has taken place or is taking place to reconstruct the systems and to preserve and protect them as a part of cultural heritage for the future [5, 6].

Leibundgut and Kohn [3] present an overview of 116 historical irrigation systems discovered in Europe, from which the majority can be considered meadow irrigation. Geographically this applies in particular to the following countries: Germany, the former Austro-Hungarian Empire, England, Spain [7, 8], Portugal [10], France, and Italy. The implementation of meadow irrigation was not an exception even in countries where problems with a lack of water would not be expected, such as Norway, Denmark, Switzerland, Andorra, Iceland, and even Greenland [2–3].

Outside European countries, we can mention that the modern development of irrigation systems in the 19th century took place to a great extent in the United States of america. It concerned large areas of newly settled western states (e.g. [10]).

Reasons for installing meadow irrigation systems should be divided according to the altitude of the given area into the following basic zones: high mountainous landscapes, mountainous landscapes, uplands, lowlands, and hilly landscapes (hilly area). In high altitude areas, the need for irrigation was connected

Fig. 3. Example of location processing of individual objects and selected important elements of the irrigation system in the surroundings of Veselí nad Moravou on the basis of current field investigations (on *Fig 2*, these are No. 3, 23, 26, 48)

with the need to provide fodder and allow vegetation to regrow more quickly than would have been possible under local conditions – irrigation systems in this way allowed the soil to warm up earlier. In the lowlands, it was necessary to artificially regulate the inflow of water in different vegetation periods, meaning leading it away from the land, e.g. during summer floods, or, on the other hand, bringing in water in late spring.

A number of irrigation systems were also constructed in the Czech Republic [11, 12]. Many of them have been preserved in varying states of disrepair and damage. Nevertheless, some systems with continuously repaired selected technological structures for the distribution of water (sluice gates, culverts) further serve as part of anti-flood protection systems (typically the Morava river floodplain). Some parts of this functional complex are completely preserved and continuously maintained and serve new purposes. An iconic part of the historical multifunctional complex in the Pomoravi region is the Baťa Canal.

Within the practical parts of the research (documentation of historical meadow irrigation systems in the Czech Republic), the following areas and locations were selected on the basis of literature-based research and discussions with experts in the field and those members of the public who remember such systems:

- the Úpa and Metuje rivers basins
- the surroundings of Jevíčko and the area of Malá Haná
- the Pomoraví region from the surroundings of Chropyně through the Uherské Hradiště and Veselí nad Moravou regions to the Strážnice region.

Example identification of irrigation structures and objects in historical sources and the current landscape

The example below of the surroundings of Veselí nad Moravou presents the process of digitisation of historical project and map sources *(Fig. 1)*, the result of the subsequent field investigation and identification of objects of the former irrigation system *(Fig. 2)*, and the determination of their current state and purpose *(Fig. 3)*.

Fig. 4 is an example of information processing about the alignment and location of surface distribution identified from historical documentation. The source for the analysis of the alignment of the channel network is the Fundamental Base of Geographic Data of the Czech Republic (ZABAGED®), mapping the current state of the landscape, and preserved project documentation of water management modifications from the mid-1930s. Watercourse alignment from the second military mapping was also used for visualisation. The analysis shows that not all water distribution channels have been implemented – on *Fig. 4*, these are marked as "(plan?)".

New field mapping and subsequent computer processing technologies that have been tested for documenting the heritage of historic meadow irrigation are presented in the following sub-chapters.

Possibilities of using the digital terrain model (DTM) to identify irrigation structures and objects

The fifth generation digital model of relief (DMR 5G) currently provides the most accurate representation of the relief of the entire Czech Republic. This is a dataset that was acquired as part of airborne laser scanning. It is formed by a cloud of points of known height, unevenly placed so that relief representation corresponds to reality as closely as possible. However, it should be noted that the elevation accuracy of the DMR 5G dataset is a variable dependent on terrain shape and vegetation. It ranges from a few centimetres in open terrain to decimetres in rugged forested terrain. Despite these inaccuracies, the DMR 5G dataset offers suitable possibilities for identifying specific terrain forms. Within this project, the Ratibořice site along the Úpa river was chosen for initial testing of its possible use.

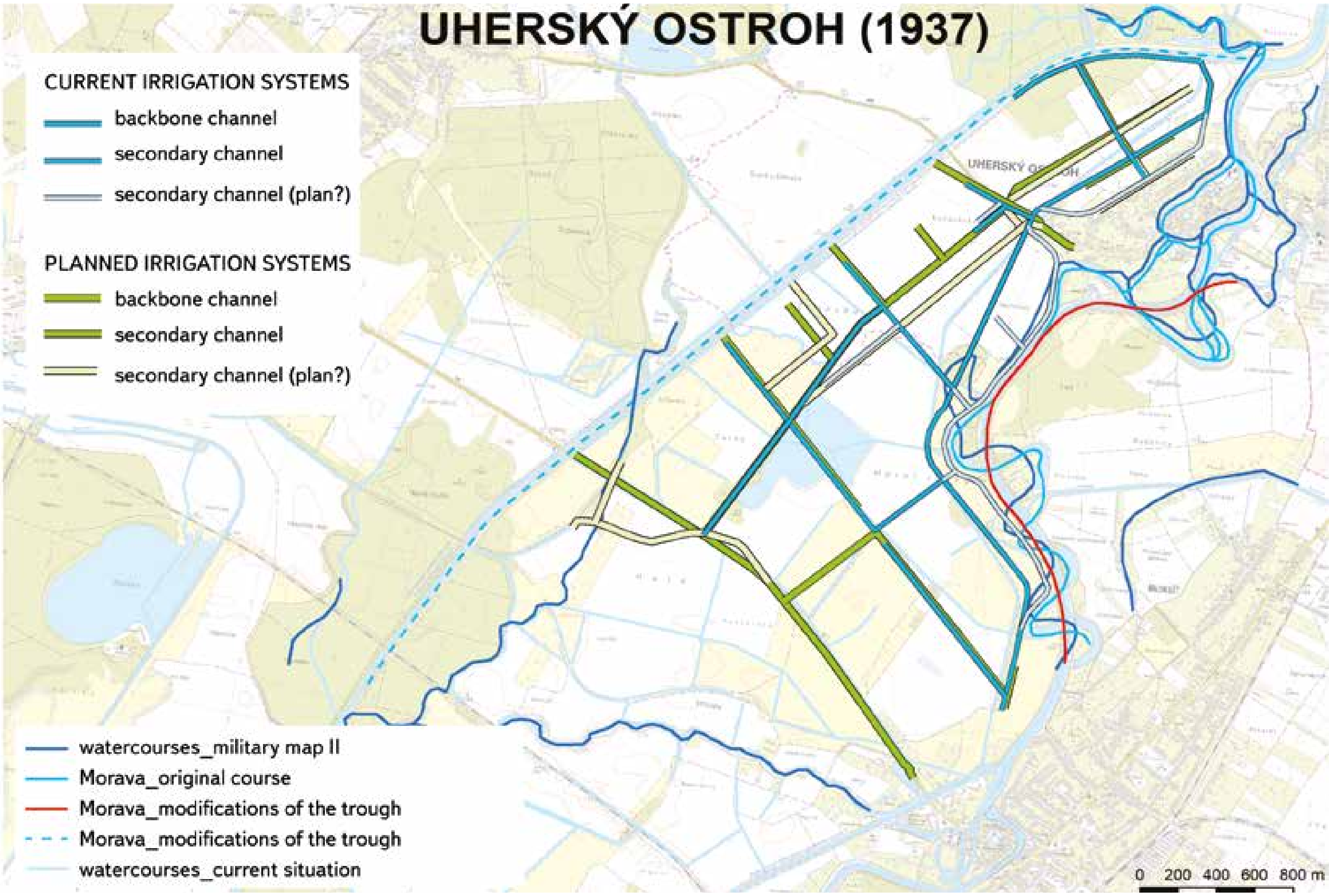

Fig. 4. Location of priority and type-related structures in the Morava river floodplain near Uherský Ostroh, ZABAGED® data

Relevant map sheets were selected from the DMR 5G dataset and, in the ESRI ArcGIS 10.7 environment, they were converted into point layers and then into TIN (Triangulated Irregular Network), which is a plastic DTM. This terrain model was used to transfer the linear layers of the irrigation systems (from the Research Institute for Soil and Water Conservation application), which made it possible to search for corresponding terrain forms.

Fig. 5 shows a detail of the area near Ratibořice in the valley of the Úpa river, where irrigation system elements are demonstrably present. Comparison of the DTM, basic 1 : 10,000 maps, and aerial imagery demonstrates that the use of the DMR 5G dataset to identify irrigation system elements – or at least parts of them – is feasible and will therefore be used to the greatest extent possible during processing of all pilot sites.

DTMs can be used for initial analyses to identify the location of individual elements of former irrigation systems. Given the relatively limited accuracy of these data, it is advisable to use photogrammetric data taken by drone for further detailed assessment.

Detailed spatial information obtained from aerial photogrammetry (UAV) is used for subsequent 3D modelling of the virtual form of objects. The DTM is also used for this purpose.

The calculation of the DTM was carried out for selected sites of historically significant irrigation structures and systems in various location: The Břeclav, Hustopeče, Znojmo, and Hodonín regions (southern part of the Pomoraví region); near Chropyně, in the area of Malá Haná; in the Litoměřice, Poděbrady, Pardubice regions; and in eastern Bohemia in the area of Česká Skalice – in Ratibořice and in the Znojmo region (*Fig. 6*).

DMR 5G data n of the Czech Office for Surveying, Mapping and Cadastre was used for the calculation. The input text files were converted to a point layer from which the triangulated irregular network (TIN) was computed (which can be converted to a raster with arbitrary resolution).

Approaches for preserving and protecting irrigation heritage

The thematic study by Douet [13], focusing on water management as part of World Heritage, states that the water management infrastructure of the pre-industrial period is relatively well represented on the UNESCO list. This is in contrast to the cultural heritage of the so-called modern water management of the 19th and 20th centuries.

This basically also applies to the representation of historical irrigation systems. From the pre-industrial period, systems of irrigation channels that are registered as part of world cultural heritage are mainly in Middle Eastern countries (Iran, Oman, United Arab Emirates), called aflaj irrigation systems. In addition, there are irrigation systems for rice terraces in the Philippines, Bali, and China, olive trees and vines in Palestine, and ancient irrigation complexes of various types on the American continent in Mexico, and aqueduct structures that served not only to distribute water for human consumption but also for irrigation.

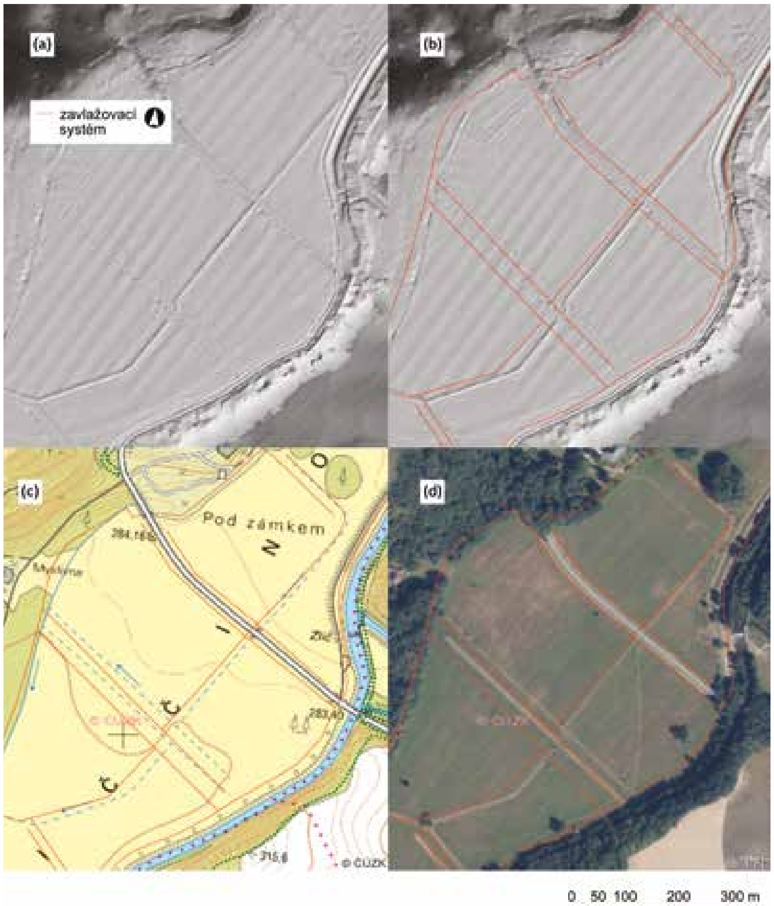

Fig. 5. Example of differentiation of the remnants of meadow irrigation by furrows and channels in the Úpa river floodplain above Česká Skalice. Demonstration of the use of the TIN DTM at the site to determine the location of the individual parts of the irrigation system: (a) TIN DTM; (b) TIN DTM, indicating the course of the irrigation system (in red); (c) extract of the basic 1 : 10,000 map, indicating the course of the irrigation system; (d) aerial image extract, indicating the course of the irrigation system. ZABAGED® data

This monument type fully fulfils, among others, criterion (v) from the criteria for the identification of World Heritage Sites which are contained in the revised Operational Guidelines for the Implementation of the World Heritage Convention [14]. Based on the support and justification of the selection criterion (v), sites can be proposed for inclusion that are outstanding examples of traditional human settlement, land-use or sea-use, which is representative of human interaction with the environment.

In connection with a systematic approach to assessing the heritage significance (or potential) of historic irrigation systems, the approach taken by Spain could be mentioned as one of the few using an assessment methodology designed for historic water management structures. The methodology involves a range of criteria and variables that form the categories of so-called intrinsic value, cultural heritage value, and value of potential and feasibility. This methodological approach has also been used for the evaluation of historical irrigation systems [15, 16], drainage tunnels, and so-called qanats [17].

In the scope of Central Europe, Germany and Austria are countries with long-standing and extensive care for industrial heritage [18–19]. These countries are also one of the initiators who try to protect intangible cultural heritage related to traditional practices of maintenance and operation of meadow irrigation. As of 2022, a proposal was made to inscribe these practices onto the UNESCO World Heritage List.

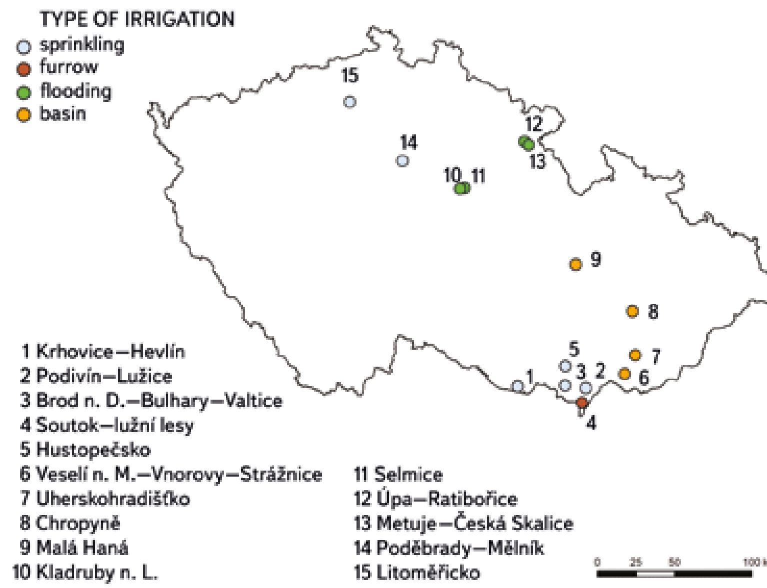

Fig. 6. DTM calculation areas for historically significant and documented irrigation sites, with differentiated irrigation types

Regarding the Czech Republic and state heritage preservation and care, represented by the National Heritage Institute, industrial objects are dealt with by the Methodological Centre of Industrial Heritage in Ostrava (MCPD), which was established as part of the National Heritage Institute for this purpose. Within their methodological activities, the MCPD issues methodological guidelines for the identification, classification, evaluation, and protection of this type of monument [20]. At the same time, it carries out continuous extensive research on individual types of technical and industrial structures in various sectors, with the aim of identifying and documenting significant monument buildings as well as typical examples of important milestones in the technological development of the water management sector. At present, some objects historically connected with irrigation can also be found among the cultural monuments of the Czech Republic. These are, in particular, Opatovice Canal and the old pumping station Paseky in Šilheřovice, near Opava. The entire former irrigation system is practically protected as part of the extensive area of Babiččino údolí (Granny's valley) national cultural monument, in the area of the Ratibořice Chateau near Česká Skalice and the related section of the Úpa river. Unofficial industrial monuments involve the functioning Baťa Canal, among other things, as part of the water distribution system for irrigating meadows in the Pomoraví region.

CONCLUSION

Irrigation structures were built and operate mostly as part of a larger or smaller functional complex. Their significance, also from the point of view of potential heritage protection, lies in the identification and documentation not only of solitary structures but mainly of entire systems/functional complexes with descriptions of interrelationships between them. Independent objects or structures do not need to be particularly exceptional, although their involvement in a wider functional complex can create a uniquely undertaken solution. In this water management field, criteria such as typological value, value of technological flow, authenticity of form and function, value of technological and systemic links with an overlap on agriculture and industry are especially important. Historic irrigation systems can thus acquire significance from the point of view of heritage preservation, even though they usually do not contain traditionally viewed heritage values (architectural, art-historical, and others) either at all or only partially.

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On the issue of authenticity of water management structures

MICHAELA RYŠKOVÁ

Keywords: authenticity — industrial heritage — water management

ABSTRACT

Authenticity, in the sense of credibility or truthfulness, is one of the key categories of heritage management. This paper deals with the issue of authenticity in relation to industrial heritage, specifically water management structures. In the case of these structures, emphasis is usually placed on the authenticity of function, but two further types of authenticity are equally important: authenticity of material substance or form (in relation to the original design and the structure built on its basis), and, on the other hand, authenticity as a consequence of historical development. This paper presents an analysis of four model examples of water management structures that are either legally protected heritage sites or have been proposed as candidates for heritage protection. The analysis of their heritage values provides insights into the individual categories of authenticity and enables the formulation of principles for managing sites of heritage value.

INTRODUCTION

One of the most challenging heritage management categories to grasp is represented by the issue of authenticity of monuments in the sense of their credibility and truthfulness. Defining the concept and setting sub-categories is essential for the determination of the approach for monument management and is the subject of long-standing discussions among experts. This was inspired by a book called *Moderní památková péče (Modern heritage protection)* from 1903 written by Alois Riegl [1].

Petr Kroupa explains two basic principles of heritage management via the relationship between authenticity and time: *"With the emergence of practical heritage management in today's sense, two basic and diametrically opposed concepts have clashed in practice and in theoretical reflections on monuments to this day. The first one is based on the appreciation of traces which time has left on the original material of a work and demands them to be respected. The other one regards a fully-fledged life of a work of art only in terms of the 'authenticity' of its historical substance (i.e. in the form released from the artist's hands at the time) and demands traces of the elapsed time to be deleted and the initial integrity of the work to be restored"* [2]. These two approaches, analytic and synthetic, pervade the history of heritage management and are essential for both heritage assessment and authorisation of the level of intervention and determination of methods for the management of monuments, which involve conservation, restoration, renewal, or reconstruction (in the sense of renewing extinct structures, parts and elements).

Following these two approaches, Kroupa also distinguishes these forms of authenticity:

- Authenticity which is linked to the creation of the work: authenticity of the place of creation and environment, authenticity of forms created in historic time (i.e. in the time frame from its creation to its completion), authenticity of the modification of the surface form, authenticity of the creative idea, authenticity of function, material and expression (i.e. aesthetic effect).
- Authenticity of the life of the work, i.e. how it is connected with the time elapsed since its creation: authenticity of historical transformations of material substance, authenticity of age, and authenticity of historical transformations of function [2].

It is obvious from this overview that authenticity can acquire many sub-forms which may, or may not, be represented in individual cases and that some of them can even contradict (authenticity of material and authenticity of historical transformations of material substance, authenticity of function and authenticity of historical transformations of function, etc.). Heritage management most often deals with the authenticity of material and authenticity of form.

In the international context, the formulation of general criteria of authenticity is related to the need to set unified conditions for the inscription of monuments on the World Heritage List. In this context, in the 1970s, the authenticity of form, material, method, and environment was set as the basic one [2, 3]. Efforts at specification and elaboration resulted only later in the extension of the term by other categories. A document on authenticity from 1994 mentions form and design, materials and material substance, use and function, traditions and methods, location and environment, spirit and feelings, and other internal and external factors in connection with authenticity [4].

The complexity of the issue of authenticity takes on new dimensions in relation to industrial heritage. But individual categories of authenticity remain valid. As in the case of traditional assessment, the emphasis is put on preserving everything in its original unaltered condition (not affected by degrading modifications). Nevertheless, even a series of gradual modifications related to the technological development of the particular field can also be valuable [5]. The criterion of the authenticity of function is an important factor because objects of technology or of industrial heritage deprived of their purpose, first, become non-transparent (with the loss of the knowledge of the given technology) and, second, are doomed to extinction. Conversion, i.e. transformation of objects to find a new use for them, is usually associated with significant interventions into the authenticity of their material and form.

The first two methodologies also deal with the question of evaluating factors of heritage management in relation to industrial heritage. The first general *Methodology for the Evaluation and Protection of Industrial Heritage from the Perspective of Heritage Management* [5] deals with general issues: what industrial heritage is, how it should be evaluated and protected from the perspective of heritage management, and what measures can be taken in order to preserve it for the future. The issue of evaluation is crucial, especially as far as specific categories are concerned, which can be as valuable or even more valuable than traditional evaluation criteria. The main criteria for evaluation are as follows:

- typological value (taking into account whether it is an early or late use, wide--spread type or unique solution)
- value of technological flow (assessing a set of key operations, represented by specific objects or technologies, which ensure the production process from raw material input to the final product)
- value of systemic relations, which deals with the position of the object or technological flow within wider transport or production relations

At the same time, it transfers traditional evaluation categories (architectural, urban, art-historical, value of age and authenticity) into the field of industrial heritage. Similarly to the traditional objects of interest of heritage management (architecture, painting, sculpture), the evaluation of industrial heritage distinguishes between the authenticity of the original state (in the sense of the initial project and its realisation) and the authenticity created by gradual development, formed by quality-valuable changes and modifications closely related to the development of the field [5].

The follow-up *Methodology for the Classification and Evaluation of Industrial Heritage from the Perspective of Heritage Management – Water Management* [6] was created in cooperation with several institutions: TGM WRI, the National Heritage Institute, Palacký University in Olomouc, and the Institute of History of the Czech Academy of Sciences. It presents a clearly arranged typology of the most significant water-management fields as a basis for the orientation in the topic of water management, and applies evaluation criteria for water-management structures [6].

METHODOLOGY

During the preparation of both methodologies, a wide range of examples of heritage protected structures and of their renovations and conversions was gathered, which can be analysed in terms of the evaluation of their authenticity. For the purpose of this text, model examples of heritage protected water-management structures or structures proposed for protection have been chosen, which are evaluated in terms of heritage sub-values, including authenticity.

RESULTS – OVERVIEW OF MODEL EXAMPLES

Prague, water treatment plant in Podolí

The water treatment plant in Prague-Podolí was built in two stages from 1923–1929 and 1952–1965 (*Fig. 1–4*). The author of the architectural design was architect Antonín Engel, while structural systems of the older part (northern hall) were designed by Bedřich Hacar and František Klokner. Both stages are

Fig. 1. Prague Podolí water treatment plant, north part (Photo: M. Ryšková, 2022)

Fig. 3. Prague Podolí water treatment plant, filtration hall, current condition (Photo: PVK Archive, 2018)

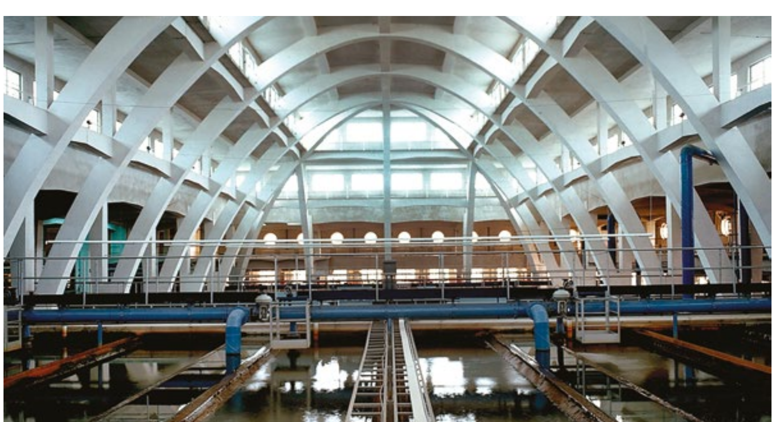

Fig. 2. Prague Podolí water treatment plant, filtration hall, current condition (Photo: PVK Archive, 2018)

Fig. 4. Prague Podolí water treatment plant, clarifiers (Photo: PVK Archive, 2018)

linked together by characteristic monumental architecture whose surface is rendered in traditionalistic morphology, typical for Engel, and modern construction principles.

At first, water was collected from a river and three wells and treated with the triple sand filtration of the Puech-Chabal system. Methods of treatment were soon improved in connection with the transition from the production of non-potable to potable water by the introduction of a coagulation line (1931), the Wabag system (1943), etc. At present, two-stage separation technology is used. Only filter field casings remain from the original technology [6–8].

The value lies at architectural and urban level, in the value of the technological flow and functional complex (the process contains all elements of water treatment technology). The authenticity of function and, in relation to the construction fond, the authenticity of form and material, are also preserved.

In the benchmark study of water industry structures (including waterworks, sewerage, and wastewater treatment), it was presented as one of fifteen model examples representing universal values of world heritage, especially regarding the expressiveness of architectural forms and progressive construction systems as an expression of the contemporary significance of waterworks structures [9].

Hořín lock

Hořín lock was built from 1903–1905 as part of the lateral canal of the Vltava river, which was to ensure the navigability of Vltava to Prague (*Fig. 5–9*). Its aim was to equalise the ten-metre height difference between Vraňany and Hořín. It consists of a small and a large lock chambers and there are two bridges with segmental arches over the lower lock head (*Fig. 5*). The author of the architectural design was František Sander and of the technical solution, Antonín Smrček. The construction was carried out by the Lanna company. The expressiveness of the architectural rendering is based on the concept of the imaginary gate of the Vltava river, and it can be traced in other similar structures too; a parallel can be found, for example, in a lock chamber in Viennese Nussdorf by the architect Otto Wagner [6, 10].

In order to ensure sufficient parameters for the navigation of large passenger ships, as well as oversized cargoes and taking into account commitments of the Czech Republic within the European Union regarding the navigation of waterways, from 2019–2021 the lock was rebuilt: The bridge over the lower lock head of the large lock chamber was replaced, both lock heads were extended, and a new gate was installed. In connection with the large lock chamber being extended by 1 metre and the original underpass height being increased to 7 metres, the original reinforced concrete bridge frame was replaced by a steel truss frame whose elevation is ensured by hydraulic pistons [6, 11].

The value of the work lies at the architectural, urban, and technical level, as well as in its position within the functional complex of the lateral canal. The authenticity of function has been preserved at the cost of the loss of the original supporting structures of one of the two lock chambers, and thus also at the cost of disruption of the form and material substance of the work as a whole. A negative impact on the northern facade, visually oriented towards

Fig. 5. Hořín, lock chamber of a lateral canal of the Vltava river (historical postcard, author's collection)

Fig. 7. Hořín lock, new moveable bridge (Photo: O. Hrdlička, 2021)

Fig. 6. Hořín lock, new moveable bridge (Photo: O. Hrdlička, 2021)

Fig. 8. Hořín lock, situation after modification of the right large lock chamber and replacement of the bridge over it (Photo: M. Ryšková, 2021)

Fig. 9. Hořín lock, view from Mělník chateau (Photo: M. Ryšková, 2021)

Fig. 10. Písek, New bridge, cylindrical weir, and hydroelectric power station, overall view (Photo: Z. Kohlíček, NPÚ, ÚOP České Budějovice)

Mělník, lies in the disruption of the symmetrical composition, which is, from the visual point of view, significantly mitigated by transferring the original stone cladding and architectural details to the new structure (and adding the cladding while maintaining the material and the way it is processed).

Písek, New bridge, cylindrical weir, and hydroelectric power plant

A bridge with a cylindrical weir was constructed from 1938–1943 and a power station from 1948–1957, according to the project of architect Adolf Beneš. The power station was equipped with a Kaplan turbine from Šmeralovy závody, n. p., in Brno, with an output of 494 HP, and it was put into operation in 1951 (*Fig. 10–11*). As part of modernisation, the switch and control rooms were replaced while the generator with the excitation system and the Kaplan turbine have been preserved [12, 13].

The set of the cylindrical weir, power station, and bridge is important from the architectural, urban, typological, and technical points of view. In addition, it is a preserved functional complex which increases the sub-values of its individual parts as a monument. The typological value is associated with the cylindrical weir, which is one of only a few weirs with this structure in the Czech Republic. The authenticity of function and the authenticity of the original form and material in terms of construction and design have been preserved. The authenticity of the equipment of the hydroelectric power station is reflected in the requirements of contemporary operation. The replacement of the switch and control rooms is a compromise which is applied to heritage protected hydroelectric power stations as well.

Plzeň, municipal waterworks filtration

The industrial development of Plzeň led to the construction of new municipal waterworks, which were put into operation in 1889–1890. Problematic water quality resulted, as early as 1908, in negotiations with the Paris company Puech-Chabal about the construction of a new filtration station (*Fig. 12–14*). Construction was carried out from 1924–1926. The filtration station, with a total area of 5,000 m^2, was equipped with three stages of roughing filter with so called upper washing, i.e. washing impurities off the surface, and one layer of pre-filters. The author of the architectural design was Plzeň architect Hanuš Zápal, and construction was carried out by Prague company, Müller a Kapsa. The filtration process was completed by older slow filters and, in 1933, coagulation and chlorination processes were added. When operation terminated in 1997, the filtration building was

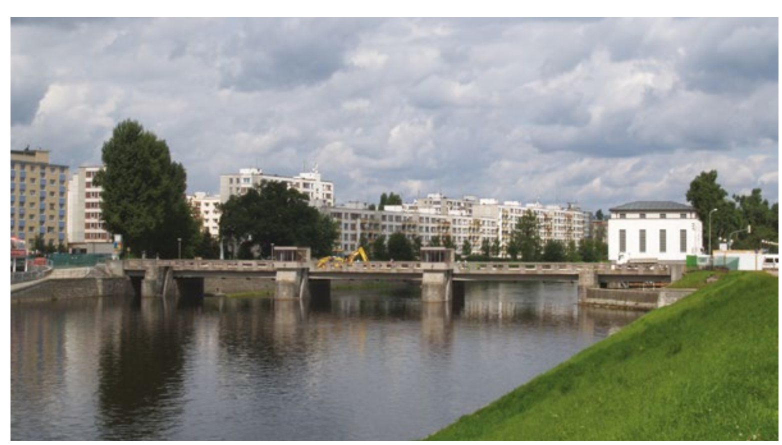

Fig. 11. Písek, cylindrical weir (Photo: J. Drozda, NPÚ, ÚOP České Budějovice)

preserved and, since 2015, it has been used as a fish storage tank. Gravel and sand were extracted from some pools and the original piping was used for the central distribution of air. In accordance with regulations and requirements of the Regional Veterinary Administration, an operational corner was installed [6, 14–17].

The filtration station of the Puech-Chabal system represents the so-called fourth era of waterworks systems and, in the territory of the Czech Republic, it has been documented only in three constructions: in the waterworks of the Psychiatric Hospital in Prague-Bohnice (1925); in the municipal river waterworks in Plzeň (1924–1926); and in the waterworks in Prague-Podolí (1922–1929). In 1943, the waterworks in Podolí replaced the Puech-Chabal filtration via the introduction of the Wabag system. In Bohnice, the filtration system was decommissioned in 1972 and the filters were filled in with soil. The Puech--Chabal filtration of Plzeň waterworks therefore represents the only preserved example of this system in the Czech Republic [6].

Its value lies mainly in the typological importance and in the authenticity of material and form, in terms of both technology (filtration system) and construction (including a number of original structures and also details – paving, tiling, mosaics). The function of the structure has been changed.

DISCUSSION – ANALYSIS OF MODEL EXAMPLES

Water management structures usually fulfil the functions for which they were built and rarely are they used for other purposes. The preservation of the authenticity of function is conditioned by modifications, necessitated in particular by changes in technology, increasing performance requirements and other parameters, or changed requirements for safety, hygiene, etc. These modifications are legitimate tools for maintaining functionality [6]. Selected model examples confirm these principles. They differ in terms of the impact on other forms of authenticity and heritage value.

The superiority of the authenticity of function does not imply being subjugated to other forms of authenticity. On the contrary, heritage management must precisely judge other values of the work and aim for a compromise acceptable to both parties – both operators and heritage protection.

Monuments must also be considered as evidence of the time in which they were created, in a wide range of meanings. In the case of industrial heritage, these are mainly examples of the development of individual technical or production fields. Therefore, the evaluation of typological significance must be accepted as the key one. In practice, it means the individual aspects to be included in the typological development of the field. The value naturally increases with the authenticity of material and form, which carry in themselves direct information on the constructions and materials of the time, as is shown in the example of the unique preserved Puech-Chabal filtration in Plzeň municipal waterworks. Only exceptionally is it possible to combine the requirements of the operation or (new) use with the typological characteristics as appropriately, as occurred in this case.

In contrast, in the case of the waterworks in Prague-Podolí, the authenticity of technology is a result of development. The process of its changes can be perceived as a sequence of qualitative valuable improvements which document a gradual improvement of the water treatment process, which occurred in the 20th and 21st centuries. Current technology will be evaluated in the future as one of the stages in water treatment development. On the other hand, due to the extraordinary architectural value of the original design and its realisation the authenticity of construction is related to the creation of the work.

The lock in Hořín is an example of a compromise which tries to mitigate the effects of the superiority of authenticity of function over other forms of authenticity and other heritage values. Adaptation to the size of current vessels has been resolved by modification of the lock chamber and replacement of the bridge over it. The new steel structure of the bridge departs from the authenticity of material and, also, partially from the authenticity of form. Its

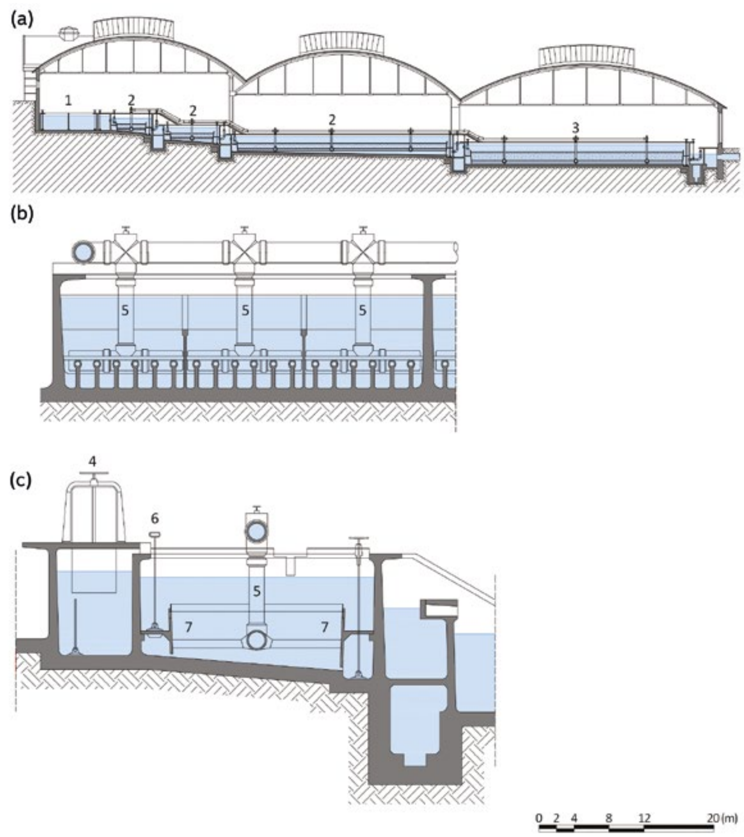

Fig. 12. Plzeň – Puech-Chabal filtration station: A – cross-section of the filtration building; B, C – longitudinal and cross-section of the roughing filter of the 1st stage, 1 – reservoir, 2 – roughing filters, 3 – pre-filters, 4 – sluice gate, 5 – blowing pipe, 6 – cleaning flap, 7 – hydraulic gate. Diagram by Radek Míšanec, 2022, according to: *Pamětní spis Vodárna města Plzně (Commemorative file, Plzeň municipal waterworks)*, 1926; diagram created for the publication *Methodology for the Classification and Evaluation of Industrial Heritage from the Perspective of Heritage Management – Water Management*)

Fig. 13. Plzeň – Puech-Chabal filtration station, interior (Photo: M Ryšková, 2019)

goal is mainly to preserve architectural values of the work. a negative impact on the authenticity of the work as a whole is mitigated by preserving a smaller lock chamber including its bridging in the current form.

The significance of the typological value and its close connection to the value of authenticity can be documented by the example of the cylindrical weir in Písek. This is one of only a few cylindrical weirs in the Czech Republic. The weir cylinders are outdated and a study of a planned renovation aimed for the replacement of the weir structure with a simpler contemporary solution in terms of operation,

Fig. 14. Plzeň – Puech-Chabal filtration station, exterior (Photo: Michaela Ryšková, 2019)

with the assumption that from a visual point of view this change will manifest itself only to a limited extent. However, heritage value and authenticity are not only connected to the external appearance and any change would have a crucial impact on the heritage values of the work: typological value and authenticity of form and material. If it is not possible to preserve the original elements due to their wear and tear (and in the case of cylindrical weirs these elements especially involve riveted cylinders), their replacement with copies of the original elements should be an adequate substitute. Although replacement causes loss of the original material substance, authenticity of form remains preserved, which is also evidence of a construction type preserved in only a few cases.

CONCLUSION

The heritage value of each item or of a whole is always a set of sub-values. The value of authenticity, which involves various forms, is one of the key values. Although, in the case of water management structures, it is the authenticity of function which is accentuated, it is also important to consider and protect its other forms which, in particular, include authenticity of material substance or form in relation to the primary project and its realisation, or authenticity as a result of historical changes, which occurred during its use.

Nevertheless, in terms of the meaning of the word "authentic", i.e. "truthful" or "credible", it is necessary to refuse such interventions in the essence of the monument which unjustifiably – for example to simplify operation or due to the poor condition of the object – destroy authentic material or form, arguing that this change will not visually manifest itself. Equally unacceptable in principle are shape imitations whose goal is to hide such changes or to resemble extinct forms. To put it simply, authenticity of monuments cannot be preserved when new materials and constructions are used and when "preservation" of the original form is only external. It is better to prevent serious disrepair through regular maintenance and partial repairs, which will prolong the life of the work and prevent costly total renovations and reconstructions.

Therefore it is necessary to weigh the legitimacy of each intervention and the level of its impact on heritage values as a whole. If a change cannot be avoided (e.g., it is provoked by safety requirements or to maintain function), then it must be accepted as a new layer in the "life" of the work, as another of its historical transformations. Construction changes can be made in such a way that a new, visually recognized layer is created in the development of the work, comparable in quality of design and execution to older layers. Exceptions may be cases where the necessary change of a constituent part would have a fatal impact on other heritage values of the work as a whole and the goal is the mitigation of this impact.

In the case of technical equipment, key elements or selected representatives can be left in place after decommissioning as a reminder of earlier phases of development, or they can be deposited in a relevant museum.

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Fish stocks of water elements in heritage protected complexes

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Keywords: cultural monuments — historical gardens — water elements — ponds — fish stocks — water quality — biomanipulation

ABSTRACT

The aim of this article is to present the results and conclusions of research which focused on recommending an appropriate approach for the creation and maintenance of fish stocks in various types of water elements, from small ornamental pools to formal water elements and large close-to-nature fish ponds. These elements form part of cultural monument complexes and heritage protected settlements (especially historic gardens and chateau parks, religious complexes, village and urban heritage reserves). Detailed results are described of a two-year investigation of various types of water elements located in Kroměříž gardens, Červené Poříčí Chateau, and the former monastery in Osek, near Teplice, as examples of cultural monuments and their water elements. Issues of possible management of fish stocks, modifications of the aquatic environment to ensure stable conditions for fish farming, and the reduction of negative interaction of pollution and excessive or inappropriately chosen fish stocks and aesthetic perception of water elements are discussed. The results of the field investigations have shown an unsatisfactory state of virtually all locations due to water eutrophication, overgrowth of vegetation in some water elements, unregulated interventions in fish stocks, and uncontrolled fishing resulting in the reduction of predatory species population and the occurrence of invasive species. At the same time, a relatively low awareness of the possibilities of regulating fish stocks and of the principles of sustainable maintenance have been found.

INTRODUCTION

Leaving aside ancient civilisations and traditions, targeted breeding of animals and, in particular, fish in water elements in gardens has been documented since the Middle Ages. Fish tanks in gardens served not only to provide a ready-made stock of fresh meat for cooking but there are written reports preserved also mentioning the construction of fish-breeding reservoirs which are purely ornamental [1]. Parts of gardens were stone water tanks from which richly decorated pools and fountains of the Renaissance and Baroque eras originated. The existence of pools for fish and aquatic bird breeding is mentioned In some of our significant Baroque gardens, such as Ostrov nad Ohří, Květná zahrada (Flower garden) in Kroměříž, Libosad in Jičín, and Český Krumlov garden. Fish of natural colour were poorly visible in the water, so preference was given to the breeding of colourful forms, especially Prussian carp (or goldfish, *Carassius auratus*).

The breeding of certain species of fish and water birds has brought about increased demand for water purification and aeration. If an abundant water source was available in an elevated location where the flow-through system did not demand water pumping, i.e. it could be in operation continuously, there was no problem maintaining the desired water cleanness. It was then possible to breed birds and more demanding fish species, such as trout in the pool of Císařský mlýn in Prague under the reign of Rudolf II. If it was possible to turn on water elements, or their dynamic parts – such as water jets – for a limited time only, it was necessary to breed fish which were not so demanding with regard to the oxygen content in water, e.g. carp. So-called "Pstruží rybníky" (Trout ponds) in Kroměříž were stocked with carp because the water source for these ponds were wells from which water had to be pumped, so water jets were probably only in operation when visitors were in the garden. In large ponds in the garden, domestic fish species were certainly bred, but specific archival documents that have been preserved are only those referring to fish stocks for kitchen use. In the chateau park of Český Krumlov, during the 17th and the first half of the 18th centuries, carp breeding is documented in Velký zámecký rybník (Great chateau pond), which was supplied with water from an aqueduct that took water from the Polečnice river. There was a separate small reservoir (Pstruží rybník) established in the garden for trout breeding, which was supplied with colder and cleaner water from the nearby wood called Dubík.

It is evident from the aforementioned information that domestic fish species farming was probably quite common in the majority of all informally established water elements in landscape parks. From at least the 18th century, preference was given to colourfully distinctive fish species in regular pools. Breeding of domestic, especially nobler kinds of fish (e.g. trout species) was documented in these reservoirs from the 16th century. Fish stocks in water elements are connected in the modern era, i.e. from the 19th century, with the development of the ornamental fish sector.

The beginnings of ornamental (decorative, aquarium) fish breeding – i.e. breeding for non-consumable purposes – are usually associated with medieval China, where, after centuries of experiments, the so-called goldfish and its veiled form – the veiled fish – were bred from *Carassius auratus* [2]. The first records of their import into Europe are from the 17th century. It was not until the first half of the 18th century that the veiled fish became more widespread in Europe, when its reproduction was successful in the Netherlands (1728). From the 18th century, goldfish breeding became prestigious in royal houses, later they started to appear as decorations in noble mansions and bourgeois houses. These oldest aquarium specimens were imported into Europe, into Germany and subsequently also into Czech lands, in the 1870s and 1880s. At the time when goldfish breeding became a form of mass interior decoration, it started to be used similarly in the exterior – especially by the aristocracy in chateau garden ponds. In Western Europe, where it was more common, goldfish were also present in the wild where they escaped either from garden ponds or they were added there deliberately. Goldfish successfully interbred with *Carassius carassius* which was common in southern England, Scandinavia, and continental Europe in the area from the Rhine river towards the east. *Carassius auratus* and its forms were more suitable for the exterior, for ornamental ponds where they were bred similarly as tench and its colourful forms or Nishikigoi fish (*Cyprinus carpio haematopterus*) [3, 4]. Their breeding in our country at the turn of the 19th and 20th centuries was documented, among other things, by *"the exhibition unique in the richness and variety of the exhibited live pond, river and ornamental fish[...], such which have never been seen in Czech exhibitions before"* which took place on the initiative of the Agricultural Council in Prague in Kolín in 1908. Part of an extensive programme was also an exhibition of the aforementioned decorative fish breeding. During the 20th century, including the decades after 1989, breeding of other fish species and their ornamental forms were introduced, such as golden and blue orfe, various types of sturgeon and, in particular, various variants of "koi" carps [5].

Consumable fish breeding has a very special place in our history, and is closely connected with the centuries-old tradition of constructing artificial reservoirs (ponds) whose main – but not sole – purpose was to breed and produce fish. Pond management was one of the key forms of aristocratic entrepreneurship. Families who became especially famous for building extensive pond systems were the Pernštejn (Pardubice, Poděbrady, southern Moravia regions) and the Rožmberk (Třeboň region). The boom era for the fish trade occurred in the 15th and 16th centuries. The advantage of investing in pond management was related, among other things, to the discovery of three-stage carp farming (in fish fry ponds, fish juvenile ponds, and main ponds). From the Thirty Years' War, and especially in the second half of the 18th century, there was a rapid reduction in pond water areas and also a decline in fish meat consumption. The economic potential of pond management of extensive fish farming faded away and prices of fish, especially of carp, stagnated due to overproduction. This manifested itself in lower investment in pond maintenance and related lower yields. More profitable sectors of food production came to the forefront (beer industry, grain, forage and, later, sugar beet growing, cattle breeding, etc.).

The decline of pond management and lower general interest in traditional kinds of fish as an integral part of inhabitants' diets lasted till the middle of the 19th century. At the time of the culmination of the decline, the species diversity of pond fish changed. At the end of the 17th century and during the 18th century, the carp, which had had a dominant position among fish so far, gained strong rivals in the form of "secondary fish species", such as tench, pike, crucian carp, perch, loach, pikeperch, burbot, trout, and also "white fish species", especially roach and rudd. As they became more popular among consumers, they were stocked in ponds next to carps and pikes, and special-purpose breeding ponds started to be founded (trouts, pikes). Many carp ponds were converted into mixed ponds. The better quality of the predatory pikeperch of Eastern European origin led to it starting to be preferred to traditional pond pike breeding in many places (e.g. in southern Moravia), which continued throughout the whole of the 19th century until the original carp–pike link returned. At the beginning of the 19th century, carp, pike, and pikeperch were

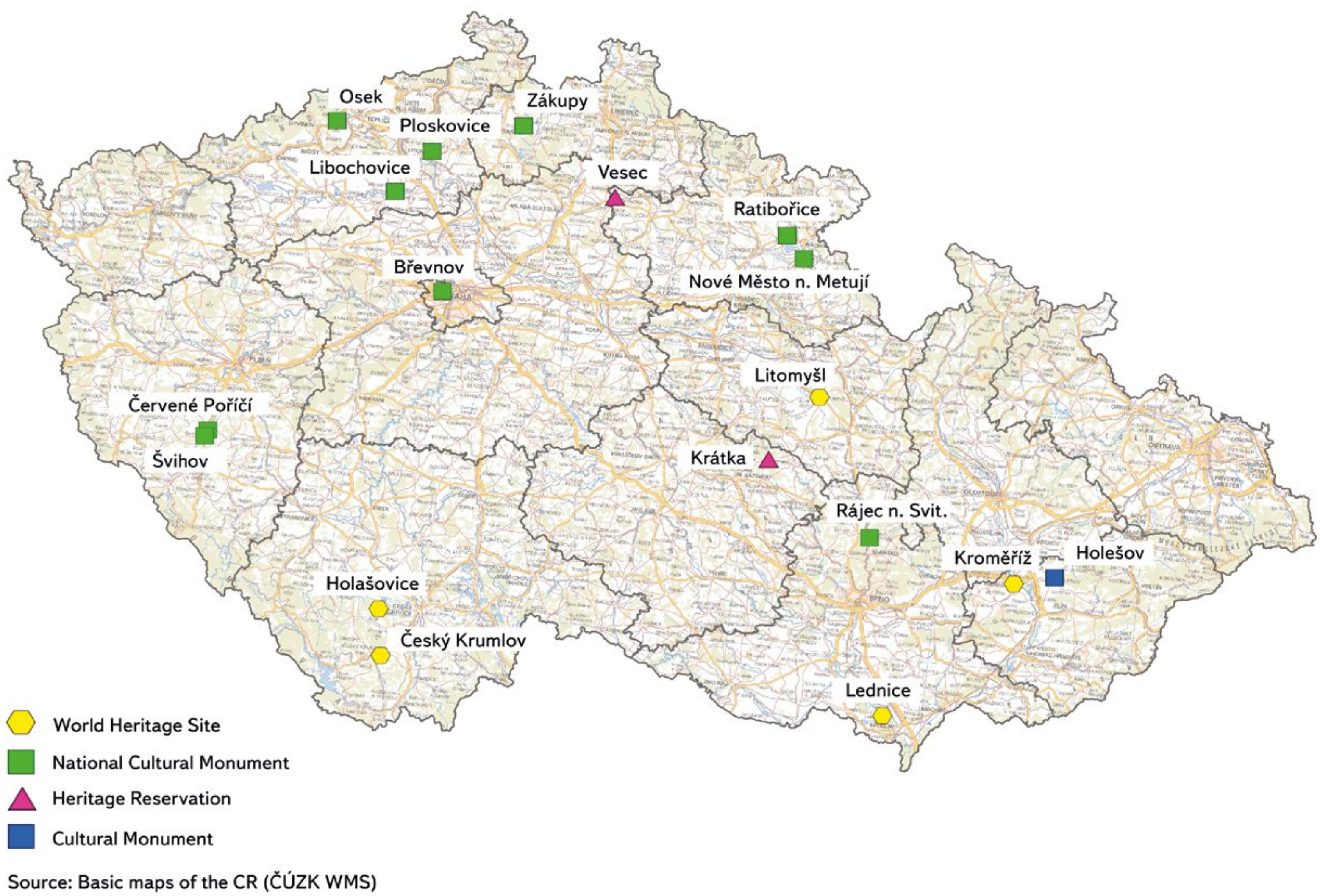

Fig. 1. Selected locations of detailed monitoring in 2017 and 2018

evaluated as the most important kinds of fish. In the meantime, the economic significance of tench as the main "secondary fish" at the expense of previously preferred crucian carp also grew. This development was documented in examples of Moravian pond management but it is applicable, with slight regional deviations, for the rest of the Czech lands too.

There was a turnaround in terms of pond management in the third quarter of the 19th century, when the process of pond cancellation culminated and when, at the same time, demand for fish meat increased, the price of which rose many times in the meantime. New circumstances forced owners of manors to use remaining areas more effectively and to slightly increase them. The return to profitability of the traditional industry was facilitated by structural changes in agricultural business, new trends in fish farming coming from Western Europe, and, above all, the recognition of the national economic importance of fishing, manifested, among other things, in the form of fishing laws (Reich 1885, Moravian 1895) and the establishment of branch associations. Carp breeding – as the key commodity of the Czech lands – was put on a scientific basis thanks to the efforts of Tomáš Dubisch in Těšín (chamber) ponds and Josef Šusta in southern Bohemia (Schwarzenberg) ponds [6]. Their innovative approaches, cultivation, and introduction of new species of fish (i.a., Theodor Mokrý bred a new species of mirror carp known as "modrák" – coloured in blue – at a manor in Lnáře), food care, and condition of ponds, as well as the recognition of patterns in the relationship between fish and their environment, significantly helped to improve the efficiency of fish production [7]. Their efforts represented a critical turning point in artificial breeding of freshwater fish, with international significance which achieved the organisation of pond management within the whole Central European territory. Further development of the production fish industry in the Czech lands has been already well documented and described in many publications by several authors (e.g. [8–10]).

The aim of this article is to present the results and conclusions of individual parts of the research which focused on recommending an appropriate approach for the creation and maintenance of fish stocks in various types of water elements, from small ornamental pools to formal water elements and large close-to-nature fish ponds. These elements form part of the areas of cultural monuments and heritage-protected settlements (especially historic gardens and parks of castles, monasteries, village and urban heritage reserves). The research took place between 2016 and 2019 as part of the DG16P02M032 project *"Non-invasive and economical techniques of water elements environment quality and maintenance solution in the frame of historical monuments care"* within the NAKI II programme of the Ministry of Culture [11].

METHODOLOGY

The research sub-part was to contribute to answering the following questions:
— What is the current composition, quantity, and density of fish stocks in water elements of interest?
— How extensive is the presence of invasive fish species?
— Is it possible to improve the aquatic environment, stability of fish stocks and, in general, aesthetic perception of these water elements by modifications of fish stocks (reduction by hunting and adding predatory species)?

Based on the formulation of these research questions, the methodology of the research was prepared. This primarily involved the selection of suitable locations for detailed investigation and possible experimental work with fish stocks. The investigation team selected 18 national cultural monuments and

Fig. 2. Photo-documentation of fish stock during field investigations

heritage reserves, where the selection was based on previous knowledge. Survey investigations and visits to many these sites and reserves was between 2012 and 2014 [12], with detailed one-off research at about 60 locations from the list of national cultural monuments and heritage reservations carried out in 2016 [13]. Fish stocks of the water elements of these 18 locations were repeatedly examined and described in detail (observations, electrofishing, net fishing). Repeated investigations of the aquatic environment, i.e. point sampling of water, phytoplankton, phytobenthos and zooplankton, were also carried out to answer the research questions. Water elements at these locations represented practically all available types of formal and informal elements, including reservoirs used for commercial and sport breeding of market fish species. *Fig. 1* shows an overview of the selected locations. Investigations and sampling were carried out on a monthly basis from March to November/December from 2017 to 2018. The aforementioned one-off research, carried out in 2016, took place during summer when the worst conditions can be expected in terms of oxygen balance and other manifestations of possible eutrophication.

Repeated field investigations involved the measurement of physical-chemical characteristics of water directly in situ (Hach Lange Hq40d devices, telescopic water samplers and other aids, plankton nets, Secchi disk, aluminium geodetic levelling rod) and the aforementioned sampling. The samples were used in laboratories to determine, via standardised procedures, the composition of nutrients, organic substances, concentration of chlorophyll and pheopigments, as well as microbial indicators and trophic potential of water. Sampling and analysis of sediments was carried out once (organic content, microbial contamination). Apart from this, bioseston (kinds of phytoplankton), zooplankton, phytobenthos, and zoobenthos communities were analysed using standardised procedures.

RESULTS AND DISCUSSION

Investigation of fish stocks, in particular evaluation on the basis of fish harvest, was carried out during the first year (2017) in all selected locations where fish were reasonably expected. In the cases when monitoring with the use of electrofishing or net fishing was not possible or feasible (fountains, ornamental tanks), fish were registered only on the basis of observations. Of the selected locations, fish occurrence was confirmed in reservoirs of Kroměříž Chateau – reservoirs called "Přední Pstruží" and "Zadní Pstruží" in the Květná zahrada (Flower garden), and ponds – Dlouhý, Chotkův and Divoký rybník in the Podzámecká zahrada (Garden below the chateau), Lednice Chateau (ponds Růžový and Zámecký rybník in the chateau park), Ploskovice Chateau (pond in the chateau park), Červené Poříčí Chateau (pond in the chateau park), Rájec-Jestřebí Chateau (two ponds in the chateau park), in Litomyšl ("Pstruží" reservoir in the chateau park and ponds Hluboký and Růžový rybník within the local watercourse basin above the chateau), Holešov (reservoir in the chateau park), Osek Monastery (ponds within the monastery complex), Břevnov Monastery (reservoirs within the complex), Český Krumlov Chateau (reservoir in the chateau park), and in Holašovice village heritage reserve (village square pond).

In 2018, repeated investigations were carried out in locations which were selected as crucial at the beginning of the season for further evaluation of the impact of fish stocks on the quality of the environment in evaluated reservoirs. Monitoring via the use of electrofishing was carried out in reservoirs of Kroměříž Chateau (Divoký rybník – Wild pond), Lednice (Růžový and Zámecký rybník – Pink and Chateau pond), Ploskovice (pond in the chateau park), Červené Poříčí (pond in the chateau pond), Rájec-Jestřebí (both ponds in the chateau park, ornamental pool below the chateau), Litomyšl ("Pstruží" reservoir in the chateau park), Český Krumlov (reservoir in the park), monastery in Osek (reservoirs in the monastery park complex), and Holašovice village heritage reserve (village square pond). Monitoring of the stock during fish harvest was carried out in Dlouhý rybník – Long pond (Podzámecká zahrada – Garden below the chateau in Kroměříž). *Fig. 2* documents the investigation of fish stocks in the field.

Results of field investigations of the composition of fish stocks of water elements in sample locations

Based on the detailed results, we present examples of several locations with typical fish stock composition, standard care of them and, in general, typical characteristics of the aquatic environment and management of water elements. In the case of the water elements mentioned below in Podzámecká zahrada – Garden below the chateau, this was the state before extensive reconstruction, which included the cleaning and restoration of water element structures and associated channels in the garden in subsequent years.

Kroměříž — Květná zahrada (Flower garden)

In the complex of the Květná zahrada in Kroměříž, there are a lot of water elements out of which the most significant, in terms of their area, composition of the garden, as well as fish breeding, are two formal ornamental reservoirs, for the purpose of the project named as "Zadní Pstruží" and "Přední Pstruží" and a formal pool with an aviary called "Ptáčnice".

Fig. 3. Overgrowing of the "Přední Pstruží" reservoir with Amphibious Bistort (*Persicaria amphibia)*

Tab. 1. Fish stock (fish adding and harvesting) of Dlouhý and Chotkův rybník in 2017

Fish species	**category**	**Dlouhý rybník**				**Chotkův rybník**			
		adding		**harvesting**		**adding**		**harvesting**	
		[pc]	**[kg]**	**[pc]**	**[kg]**	**[pc]**	**[kg]**	**[pc]**	**[kg]**
common carp *(Cyprinus carpio)*	K1	6,000	130			5,000	100		
	K2	2,000	400					2,560	290
	K2+3			1,400	2,150			200	195
grass carp *(Ctenopharyngodon idella)*	Ab2	200	40						
	Ab3			118	140				
northern pike *(Esox lucius)*	Š0	60,000							
	Š1			235	32				
In total			**570**		**2,322**		**100**		**485**

State in 2017

— "Zadní Pstruží" reservoir
Seven specimens of the ornamental form of carp *(Cyprinus carpio)* "koi" with a unit weight of 1–2 kg were registered in this reservoir.

— "Přední Pstruží" reservoir
Several specimens of the ornamental form of "koi" carp with a unit weight of 1–2 kg were registered in this reservoir.

— Ptáčnice reservoir
Very shallow water level. Without fish. Frog tadpoles (registered on 10 May 2017) were abundant here. On 2 August 2017 newt larvae were abundant and, during autumn sampling on 14 September 2017, adult newts were abundant.

State in 2018

— "Zadní Pstruží" reservoir
The presence of several specimens of the ornamental form of Prussian carp 1+ was registered in the reservoir.

— "Přední Pstruží" reservoir
The presence of several bigger specimens of the ornamental form of "koi" carp was registered in the reservoir. The reservoir became overgrown with submerged macrophytes (especially *Persicaria amphibia*) *(Fig. 3)*.

— Ptáčnice reservoir
Very shallow water level. Without fish.

Kroměříž Chateau – Podzámecká zahrada (Garden below the chateau)

State in 2017

— Dlouhý rybník (Long pond)
At the time of the research, the pond was fishery-managed as a breeding pond with supplemental feeding provided. Its stock was monitored during fish harvesting on 30 September 2017 *(Tab. 1)*. Apart from the added common carp *(Cyprinus carpio)*, grass carp *(Ctenopharyngodon idella)* and northern pike *(Esox lucius)*, an abundant occurrence of common bleak (*Alburnus alburnus*) and common perch (*Perca fluviatilis*) was found, as well as an abundance of common bream (*Abramis brama*), ruffe (*Gymnocephalus cernuus*), common rudd (*Scardinius erythrophthalmus*), common roach (*Rutilus rutilus*), and Amur bitterling (*Rhodeus sericeus*). All these species of fish come from

Tab. 2. Results of fish stock monitoring via the electrofishing (abundance of a and biomass of B in CPUE 1 hour) – Divoký rybník in the Podzámecká zahrada, Kroměříž

Species	**littoral zone**		**pelagic zone**	
	A [pc]	**B [g]**	**A [pc]**	**B [g]**
tench (*Tinca tinca*)	32	160		
gudgeon (*Gobio gobio*)	4	8		
chub *(Squalius cephalus)*	12	24		
common bleak *(Alburnus alburnus)*			4	80
stone moroko *(Pseudorasbora parva)*	96	240	24	120
common perch *(Perca fluviatilis)*	48	1,040	4	200
In total	**192**	**1,472**	**32**	**400**

Tab. 3. Fish stock (fish adding and harvesting) of Dlouhý rybník in 2018

Fish species	category	adding		harvesting		production
		[pc]	[kg]	[pc]	[kg]	[kg.ha^{-1}]
common carp *(Cyprinus carpio)*	K2	5,500	825			
	K3			2,185	1,876	
grass carp *(Ctenopharyngodon idella)*	Ab2	150	25.5			
	Ab3			133	121	
northern pike *(Esox lucius)*	Š0	60,000				
	Š1			180	51	
In total			**850.5**		**2,048**	**599**

the supply source (Morava river), to a lesser extent from incomplete harvest in the last breeding season. A valuable finding was that the invasive topmouth gudgeon *(Pseudorasbora parva)* was completely absent from the pond in 2017, probably as a result of being eaten by a relatively abundant population of perch, for which it is the preferred prey [14]. Specimens of "koi" carp and goldfish are also present in the pond stock and after the fish harvest their numbers return to the pond. Carp added here have an extremely high mortality rate of 82.5% while the normal rate is 15–25% [9]. This high mortality rate is a result of unfavourable environmental conditions (heavy siltation with anaerobic mud from fallen leaves, Aphanizomenon flos-aquae in summer). The average unit gain of 1.45 kg is very favourable, although the feeding coefficient of the grains provided could not be evaluated as the supplemental feeding records were not entirely accurate.

— Chotkův rybník (Chotek pond)
At the time of the research, the pond was fishery-managed as a breeding pond with supplemental feeding. In 2017 it was filled with water only in the middle of april. Part of the stock died out (according to the fish farmer statement and recorded presence of dead fish on 10 May 2017). This was caused mainly by unsatisfactory environmental conditions due to coverage of the entire water level with duckweeds. Its stock was monitored during fish harvest on 7 October 2017 *(Tab. 1)*. During the harvest, the presence of topmouth gudgeon was noted; it was present despite an abundant occurrence of perch originating from the Morava river. Sporadically and probably from the same source, there was also pike, zander (*Sander lucioperca*), and bream.

Fig. 4. Chotkův rybník after being emptied during the first vegetation season (2018)

— Divoký rybník (Wild pond)
In 2017, the pond was not fishery-managed due to difficult harvesting caused by the impossibility of emptying it completely. A large spill remains in the upper part of the pond above the island, which is very difficult to harvest due to the thick layer of mud. Stock monitoring was carried out on 7 October 2017 via electrofishing (*Tab.* 2) by wading in the littoral zone and from a boat in open water (both for 15 min). Apart from the fish stated in *Tab. 4*, there were also bigger specimens of carp registered that escaped from the narcotic electric field and therefore were not caught. Fish stocks are scarce and is mostly formed by juvenile specimens originating from the Morava river – gudgeon (*Gobio gobio*), common chub (*Leuciscus cephalus*),

Tab. 4. Results of fish stock monitoring via electrofishing (abundance A and biomass B in CPUE 1 hour) – Divoký rybník in Podzámecká zahrada, Kroměříž, 10 September 2018

Fish species	littoral zone		pelagic zone	
	A [pc]	B [g]	A [pc]	B [g]
tench *(Tinca tinca)*	28	680		
common roach *(Rutilus rutilus)*	56	128	4	88
common rudd *(Scardinius erythrophthalmus)*			4	4
common bleak *(Alburnus alburnus)*	4	64	12	272
Prussian carp *(Carassius gibelio)*			4	1,240
topmouth gudgeon *(Pseudorasbora parva)*	84	80		
common perch *(Perca fluviatilis)*	32	584	4	120
northern pike *(Esox lucius)*	4	160		
In total	**208**	**1,696**	**28**	**1,724**

Tab. 5. Results of fish stock monitoring via electrofishing (abundance A and biomass B in CPUE 1 hour) – pond in the Červené Poříčí Chateau park

Species	littoral zone		pelagic zone	
	A [pc]	B [g]	A [pc]	B [g]
gudgeon *(Gobio gobio)*	8	98		
common roach *(Rutilus rutilus)*	132	470	134	1,152
common bream *(Abramis brama)*	4	44	5	903
white bream *(Blicca bjoerkna)*	8	488	8	837
common bleak *(Alburnus alburnus)*			3	85
zander *(Sander lucioperca)*			14	15
common perch *(Perca fluviatilis)*	40	418		
In total	**192**	**1,518**	**164**	**2,992**

Tab. 6. Results of fish stock monitoring via electrofishing (abundance A and biomass B in CPUE 1 hour) – pond in the Červené Poříčí Chateau park

Species	littoral zone		pelagic zone	
	A [pc]	B [g]	A [pc]	B [g]
gudgeon *(Gobio gobio)*	28	80	4	10
common roach *(Rutilus rutilus)*	64	477	32	723
common bream *(Abramis brama)*			8	704
topmouth gudgeon *(Pseudorasbora parva)*	56	84		
common bleak *(Alburnus alburnus)*	8	16		
chub *(Squalius cephalus)*	4	74		
common dace *(Leuciscus leuciscus)*	4	14		
common perch *(Perca fluviatilis)*				
In total	**164**	**745**	**44**	**1,437**

bleak – and from natural spawn – topmouth gudgeon, common perch (*Perca fluviatilis*), tench (*Tinca tinca*). In this composition, the stock has only a very weak influence on the development of the quality of the pond environment.

State in 2018

— Dlouhý rybník (Long pond)
The pond was fishery-managed, as in previous years, as a breeding pond with supplemental feeding (40 q grains). Its stocks were monitored during fish harvest on 29 September 2018 *(Tab.3)*. In May, part of the common carp stock died in the pond due to oxygen deficiency associated with a massive growth of filamentous algae, which the common carp and grass carp stocks were unable to control. Apart from the added common carp, grass carp, and northern pike, there was also an abundance of common bream, which formed about 70% of the fish, and common roach with about 30%, both species originating from the Morava river. Other fish species – common bleak and common perch – were caught only sporadically. As in 2017, the invasive topmouth gudgeon *(Pseudorasbora parva)* was completely absent from the pond, probably as a result of being eaten by a relatively abundant population of perch, for which it is the preferred prey [14]. Specimens of "koi" carp and goldfish are also present in the pond stock and after the fish harvest these are returned into the pond. In 2018, carp stock also had an extremely high mortality rate of 60.3% here (it was 82.5% in 2017) while the normal rate in our country is 15–25% [9]. The persistently high mortality is undoubtedly a consequence of poorly favourable environmental conditions due to heavy fouling by anaerobic mud from fallen leaves coupled with a strong spring filamentous algal bloom and subsequent high transparency (135 cm in May 2018) and oxygen deficiencies. However, the average unit gain of 0.71 kg and even 1.45 kg in 2017 is good, or very favourable, although the feed conversion ratio (FCR) either cannot be evaluated, because feeding records were not completely accurate (2017), or is relatively high (2.94 in 2018). In September, the occurrence of red-eared slider (*Trachemys scripta elegans*) was registered in the pond.

— Chotkův rybník (Chotek pond)
The pond was emptied in 2018 and prepared for desludging. This seemed to be urgently necessary with regard to the current situation, as the rate of pond overgrowth by hydrophilous vegetation had reached a level that completely excluded the possibility of refilling the pond without fatal consequences for its ecosystem.

— Divoký rybník (Wild pond)
Even in 2018 the pond was not fishery-managed due to difficult harvesting caused by the impossibility of emptying it completely. Stock monitoring was carried out on 10 September 2018 via electrofishing (*Tab. 4*) by wading in the littoral zone and from a boat in open water (both for 15 min). Apart from the undoubted occurrence of bigger fish originating from the stock that could have not been harvested in previous years, the current stock of Divoký rybník was largely formed of juvenile fish originating from the Morava river (bleak) and from natural pond spawn (perch, topmouth gudgeon, tench – *Tinca tinca* and roach).

Červené Poříčí Chateau

This location was selected as a representative of national cultural monuments which are based on immovable cultural monuments (usually royal settlements) associated with subsequent adjacent parts of the landscape with performed park modifications which usually contain various water elements. In this case, they are informal water elements such as ponds.

Fig. 5. Osek II reservoir (left) completely overgrown with *Typha* and duckweed vegetation, grass carp (right) from Osek II reservoir with haemorrhages

State in 2017

The pond in the chateau park is not fishery-managed. Ichthyofauna monitoring was carried out on 19 September 2017 via electrofishing by wading in the bank zone (littoral zone) for 15 minutes and from a boat on open water (pelagic zone) for 22 minutes. The results are summed up in *Tab. 5.* Contrary to other locations, white bream (*Blicca bjoerkna)* was captured here. Apart from the fish caught, a few pikeperches (~ 70 cm) and two pikes (~ 60 cm) were also registered here.

State in 2018

During this year's investigations, traces of uncontrolled fishing were evident. It can be assumed that it aimed mainly at predatory fish. Ichthyofauna monitoring was carried out on 17 October 2018 via electrofishing by wading in the bank zone (littoral zone) and from a boat on open water (pelagic zone), both for 15 minutes. The results are summed up in *Tab. 6.* Most of the fish (especially gudgeon, common bream, common bleak, cub and common dace (*Leuciscus leuciscus*)) get into the pond through a tributary from the Úhlava river. In summer, a weak cyanobacterial bloom appeared on the pond and, in autumn, there was – as every year – an extremely strong silt from organic matter in the form of fallen leaves.

The complex of the former monastery in Osek in the Teplice region was selected and monitored as a representative of religious monument complexes which were, unlike the complex in Kroměříž, heavily devastated and at present are gradually being restored.

Monastery in Osek near Teplice

State in 2017

Reservoirs are not officially fishery-managed, and are stocked and harvested here by a private user according to a statement from the monastery fish administration. Fish stocks were monitored via electrofishing from a boat for 12 (reservoir I) and 22 minutes (reservoir IV) and via wading for 10 minutes (reservoirs II and III) on 20 September 2017.

— Reservoir I
An abundant stock of carp with an average unit weight of 1.4 kg was found in the reservoir, which caused strong turbidity on the bottom (transparency of only about 35 cm during the summer period). The occurrence of bigger grass carp was also registered here. The occurrence of tiny carp

Species	reservoir I		reservoir II		reservoir IV	
	A [pc]	B [g]	A [pc]	B [g]	A [pc]	B [g]
common carp *(Cyprinus carpio)*	20	28,150			3	2,672
common roach *(Rutilus rutilus)*	70	2,450			3	82
common rudd *(Scardinius erythrophthalmus)*	5	100	6	180		
common bream *(Abramis brama)*	25	2,200				
grass carp *(Ctenopharyngodon idella)*			6	24,420		
tench *(Tinca tinca)*			12	12,000		
Prussian carp *(Carassius gibelio)*					82	1,445
perch *(Perca fluviatilis)*					5	873
In total	**120**	**32,900**	**24**	**36,600**	**93**	**5,072**

Tab. 8. Results of fish stock monitoring via electrofishing (abundance A and biomass B in CPUE 1 hour) – reservoir IV

Species	**reservoir IV**	
	A [pc]	**B [g]**
common carp *(Cyprinus carpio)*	24	23,160
zander *(Sander lucioperca)*	4	12
common rudd *(Scardinius erythrophthalmus)*	+	
tench *(Tinca tinca)*	4	38
Prussian carp *(Carassius gibelio)*	38	760
In total	**70**	**23,970**

species – roach, rudd, and bream – was also abundant *(Tab. 7)*. The reservoir stock was supplementally fed. The reservoir environment was degraded by the occurrence of cyanobacterial bloom in the summer period. In fact, the reservoir is an artificial water structure with inappropriately regulated – or rather unregulated – fish breeding.

— Reservoir II
From the ecological and aesthetic points of view, the reservoir was in a state of disrepair, and from the point of view of fisheries management, it was unused and practically worthless *(Fig. 5)*. More than 90% of its area was overgrown with hard emergent vegetation (*Typha*) and duckweeds (*Lemnaceae*). There was a thick layer of organic anaerobic sediments in the reservoir. During this year's investigations, an attempt made by the local government to destroy the hard vegetation via adding grass carp was discovered. Unfortunately, this attempt proved to be ill-conceived and useless. The fish stocked (grass carp and tench) developed haemorrhages to the skin and scales *(Fig. 5)* shortly after being added due to unsuitable environmental conditions and with high probability subsequently died. Apart from them, a sporadic occurrence of rudd was also registered there *(Tab. 7)*, which is able to survive such conditions but very probably not over the winter period of frozen weather.

— Reservoir III
From the ecological and aesthetic points of view, this reservoir was also in a state of disrepair and, from the point of view of fisheries management, it was unused. The reservoir environment was also degraded by thick layers of organic anaerobic sediments. Although there were several specimens of bigger fish (probably carps) clearly present in the reservoir which, when disturbed, whirled the sediments on the bottom, it was not possible to catch any of them via electrofishing. These kinds of fish probably will not be able to survive winter if the reservoir is frozen due to the shallow depth and thick layers of sediments.

— Reservoir IV
Abundant populations of Prussian carp were captured in the reservoir. Compared to the previous two reservoirs, this reservoir has favourable conditions for the survival of fish and for possible limited fishing use, targeted at the concept of the reservoir as part of the monastery complex (minimum sediment thickness, sufficient water level, relatively high quality aquatic environment without excessive phytoplankton, islands of wetland vegetation, flow rate). An overview of fish species caught is shown in *Tab. 7.*

State in 2018

In 2018, only Reservoir IV was monitored into which 6 pikes 2+ with a total weight of 5,700 g were added as a biomelioration measure on 6 April 2018. The objective of pike stocking was to reduce the overpopulation of Prussian carp. Fish stocks were monitored via electrofishing from a boat for 15 minutes on 17 October 2018 *(Tab. 8)*. As stated above, the reservoir provides very favourable conditions for sustainable fish farming, which would correspond to the overall concept of the complex. However, at the time of the investigations, it was complicated by uncoordinated management in the case of which it was impossible to predict the interventions (stocking, harvesting, feeding, water level manipulation) that would be applied. During spring monitoring on 6 April 2018 an inadequately treated and secured outlet structure (monk outlet) was found to be leaking, which led to a drop in water level by about 50 cm compared to normal. Apart from fish species caught, the presence of rudd was also observed. Carp was the dominant stock of the reservoir, undoubtedly originating from adding. The occurrence of this year's zander fry (0+) can be considered a valuable finding.

SUMMARY AND DISCUSSION

During field investigations and evaluation of the knowledge gained, four main factors have been identified which influence the determination of suitable fish, stocks and their long-term maintenance:

— input water quality supplying the given water elements and its eutrophication,
— temperature and oxygen conditions, changes in water pH,
— illegal fishing and uncontrolled hunting of fish, especially of predatory fish
— excessive siltation and organic matter supply (mainly fallen leaves) and its decomposition.

In order to design, implement, and maintain the target fish stock, it is necessary to investigate the aforementioned parameters and factors. Recommended procedures within routine care and maintenance, based on best practices, include measurements of transparency, pH, and water temperature, plus, for more detailed investigations, the use of field hydro-chemical devices to monitor seasonal fluctuations in water temperature, pH, and dissolved oxygen. The next step is the documentation of the current state of the fish stock using the aforementioned procedures.

Maintaining a fish stock in good condition, adequate quantity, and composition, including ornamental species, with regard to aesthetic impact and maintaining appropriate environmental quality, requires the reduction of undesirable (often also invasive) species (especially topmouth gudgeon, Prussian carp – natural form) by harvesting or adding predatory species (most often pike, zander, perch) which, however, require higher-quality conditions of the aquatic environment. Under optimal conditions, similar interventions have proven to have a favourable impact. For example, the combination of electrofishing and the addition of perch in the water area in Holašovice village heritage reserve led to a complete reduction in the population of Prussian carp, which were abundant here (in 2017 there were 64 Prussian carp and rudd confirmed, reproducing in an uncontrolled manner, and when 32 perch were added in 2018, there were 24 rudd and no Prussian carp specimens found). The reduction of undesirable species also occurred in Reservoir IV of the monastery in Osek near Teplice, where the use of pike fry was tested.

Even in the case of stocking only ornamental forms of Prussian carp, adding perch proved to have a beneficial effect on preventing uncontrolled reproduction associated with the appearance of a wild form, which no longer meets the aesthetic perception of the water element. It was demonstrated within the research project in the case of semi-operation of model ornamental reservoirs during their maintenance and monitoring. In 2018, without the presence of perch specimens, 20 added specimens of ornamental form reproduced with a resulting number of approximately 100 specimens with colouration ranging from ornamental to natural forms. In 2019, new Prussian carp fry were eliminated thanks to the presence of the perch. The amount of fish remained at the stocking level.

In the case of larger water areas with a production fishing function, it is necessary to choose such a composition and volume of fish stocking so that the recommended values stated in the heritage protection guideline are not exceeded. In contrast, it seems to be inappropriate to exclude farming use since the intended improvement in the quality of aquatic environment will not occur in the short term due to the eutrophication of our water bodies and spontaneous invasion by undesirable species. In contrast, the result is massive expansion of algal blooms (cyanobacteria) associated with health risks and reduced food supply for target fish and water birds.

The use of fish stocks to control the growth of aquatic vegetation, including algae, is, according to practical verification, possible, but it also requires the synergy of human labour, continuous removal of excessive biomass, supportive interventions (e.g. with gentle biological preparations, phosphorus precipitation), and ideally also limitation eutrophication of the input water. Early addition of suitable species (especially grass carp and common nase – *Chondrostoma nasus*) at the beginning of the season seems to be the most appropriate, but only after the biomass of the vegetation has been reduced to a level that can be controlled by the fish.

Fish breeding and the selection of suitable species for water elements is always closely linked to water quality, or the condition and quality of the entire water environment, including its interaction with the source basin of water elements, pools, ponds, and reservoirs. The environmental quality of water elements thus logically also has an impact on the condition and cultural value of monuments and historic heritage protected areas. The evolution of water quality and the qualitative (species composition) and quantitative (density and biomass) composition of fish stocks are closely connected. The effort to positively influence ecological processes and water quality in ponds and reservoirs through interventions in the fish community (stocking) is the subject of purposeful fisheries management. The purposeful management of fish stocking, whose main goal is to reduce the expansion of planktonic algae, is referred to as biomanipulation [15]. Biomanipulation therefore represents targeted influencing of lower links of the food chain by acting on fish as a hierarchically higher link of the food chain.

The fact that fish stock is able to control the species and size composition of zooplankton and phytoplankton communities and their abundance was first discovered by Hrbáček [16]. Subsequently, from the 1970s to 1990s, the manipulation of fish stocks and its impact on the structure and functioning of aquatic ecosystems became the subject of a number of scientific studies. The intensity of the research on this topic was motivated by the practical effort to reduce the effects of anthropogenic eutrophication (undesirable expansion of planktonic algae and cyanobacteria caused by excess nutrients in the environment as a result of human activities). At this time, the methodological guideline *"Účelové rybí obsádky v údolních nádržích" (Purposeful fish stocking in valley reservoirs)* [17] was also published, which provides an overview of the importance, creation, and use of regulated fish stocking in reservoirs. Later research has corrected some of the earlier views and, in particular, has better and more precisely defined the conditions under which biomanipulation is most effective. The up-to-date synthesis of the biomanipulation topic can be found, for example, in the works of Hansson et al. [18], Mehner et al. [19, 20], and Randák et al. [21].

Degradation of water elements is usually caused by:
- excessive fish stocks,
- unsuitable composition of a fish stock and fisheries management,
- uncontrolled development,
- inappropriate conditions – overgrowing, turbidity, pollution,

Some of the causes cannot be influenced by the location (water element) manager. In particular, these include aquatic environment quality:
- high temperatures of the environment connected with a rise in water temperature above a level that is bearable for fish (depending on the species, their limit level should not be exceeded) – drought periods are also a threat,
- insufficient water exchange, excessive evaporation – may be associated with an increase in salinity and electrical conductivity of water,
- poor water quality, polluted water, overabundance of nutrients in water (eutrophication), water especially rich in phosphorus,
- siltation caused by,
  - washout caused by soil erosion, brought by a supply watercourse in the basin,
  - biomass deposit from aquatic plants and fallen leaves,
  - introduction of other organic components and creation of mud (also from excessive feeding).

The consequence of poor water quality is the massive growth of algae and cyanobacteria, their dying and the disruption of the oxygen regime up to the oxygen in the water being depleted. The consequence of siltation is the reduction of the water column depth and water volume, overgrowth with aquatic plants up to the gradual clogging of the water element, decomposition of the organic component of the sediment/mud – also connected with the depletion of oxygen in the water – and the emission of harmful gases (up to the stage of hydrogen sulphide odour).

Causes connected with incorrect fisheries management:
- incorrect determination of the size and weight of the fish stock,
- inappropriate composition of fish stock,
- exclusion of the farming use of fish stock, which leads, according to experience, to the spread of inferior and invasive fish species,
- shortage of predatory fish species or their uncontrolled illegal fishing,
- excessive feeding and supplemental feeding,
- inappropriate interventions into the environment, e.g. completely undesirable or incorrectly determined application of chemical substances in an attempt to ensure water transparency and algae suppression,
- incorrect manipulation of water volume and depth,
- damaged inlet or outlet structures, draining an inappropriate water level from the reservoir,

These causes, designated as internal, can be influenced by modifying the way the water elements are maintained, adjusting the lease agreement with the management entity, increased checking of water elements, etc.

CONCLUSION

Fish stocking is a natural and integral part of aquatic ecosystems and, therefore, plays an important role in the functioning of food relations and thus in the development of environmental conditions. In general, in reservoirs with a high biomass of planktonophagous fish (mostly tiny carp species) the zooplankton is formed by small species and low biomass specimens and the phytoplankton is well expanded (low transparency). In contrast, when there is low biomass ichthyofauna in the reservoir, the zooplankton is dominated by large filter-feeding daphnia, the phytoplankton is very poor, and transparency is high.

In water elements that are part of heritage protected structures, their gardens, courtyards, etc., the role of fish is often underestimated and the water quality in them is often degraded by inappropriate fish breeding, often even illegal or uncontrolled. They are also often colonised by unwanted invasive (topmouth gudgeon, Prussian carp) or non-native fish species (grass carp) that have a negative impact on the environmental conditions in them. The inappropriate composition and quantity of fish stocking leads to unfavourable quality of the aquatic environment, and formation of turbidity connected with the emission of nutrients used by cyanobacteria and other algae.

The formation of fish stocking in cultural monument complexes should be aimed at creating such a state that the fish stocking will not have a significant negative impact on water quality. In practice, this means creating, with regard to specific conditions of individual structures, prerequisites for achieving the preferred state which may consist, for example, of ensuring good water transparency ("cleanness"), adequate development of submerged and emerged vegetation, or the presence of ornamental (colourful) forms of fish. It is very likely though that their combination will also be desired (reservoir with clean water, plants, and ornamental fish).

As a result of addressing the issues described within the project, a peer-reviewed heritage protection guideline *"Zásady udržitelnosti rybí obsádky vodních prvků kulturních památek a historických sídel" (Principles of sustainability of fish stocking in water elements of cultural monuments and historical settlements)* [22] was also approved by the Ministry of Culture for use in practice. The guidelines are available within the web presentation of the project under TGM WRI HEIS [11] and in the NUŠL (National Repository of Grey Literature) database at (*http://www.nusl.cz/ntk/nusl-411067*). The guidelines concerning the principles of design, maintenance, and sustainability of fish stocking are closely linked to evaluation of the extent and causes of environmental degradation of the reservoirs and ponds of heritage protected sites, since the degree of degradation and limiting conditions caused by external influences determines the potential for sustainability of both the environment and fish stocking.

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The construction of large hydraulic structures in the context of ideas and ideologies

SIXTUS BOLOM-KOTARI, MILENA FOREJTNÍKOVÁ

Keywords: hydraulic structures — dams — ideology — Czech lands

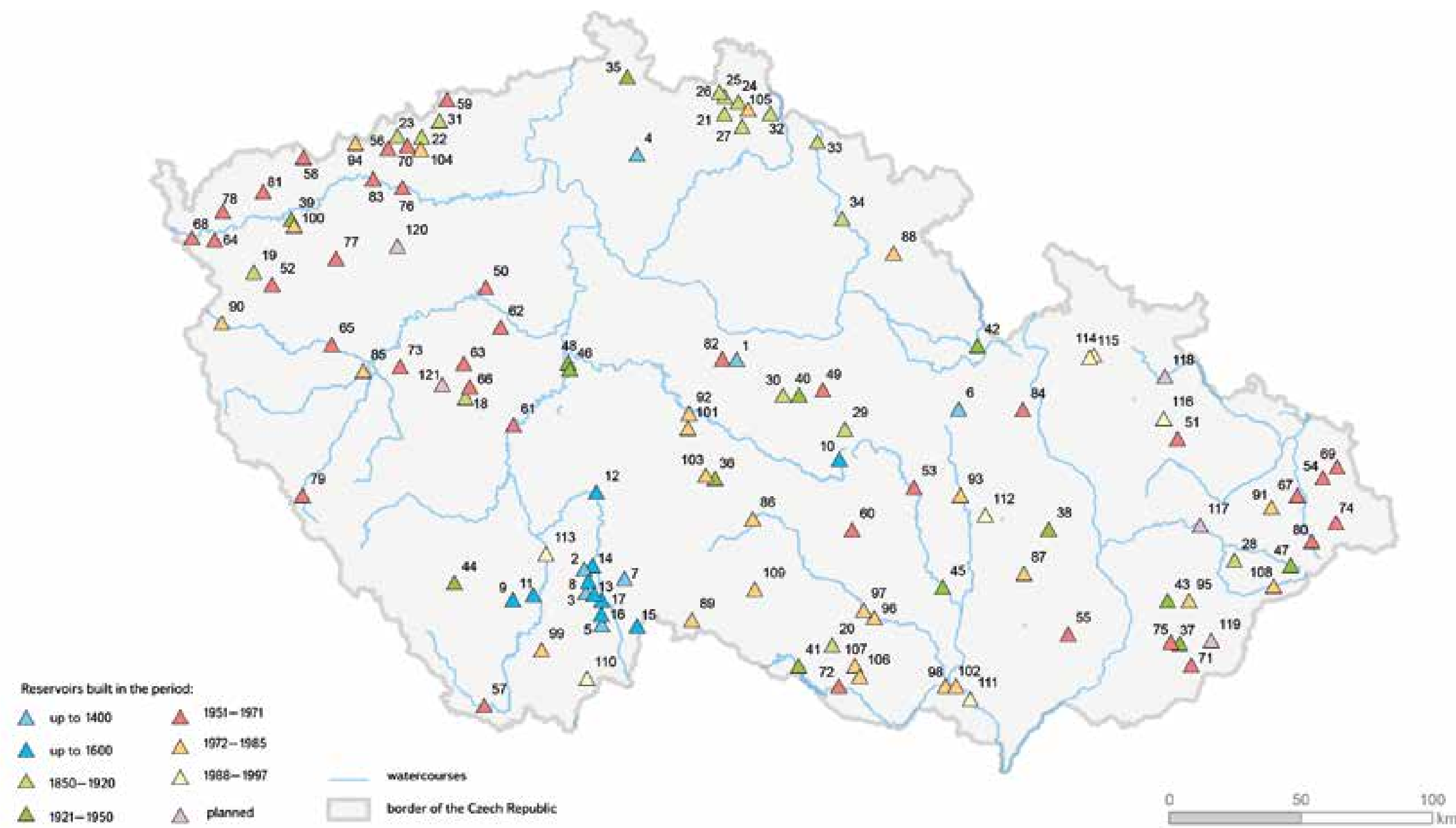

Fig. 1. Map of the Czech Republic, location of large hydraulic structures – differentiation according to the time of their origin

1 Velký rybník, 2 Bošilecký rybník, 3 Dvořiště, 4 Máchovo jezero, 5 Opatovický rybník, 6 Hvězda, 7 Velká Holná, 8 Záblatský, 9 Dehtář, 10 Velké Dářko, 11 Bezdrev, 12 Jordán, 13 Velký Tisý, 14 Horusický Pond, 15 Staňkovský rybník, 16 Svět, 17 Rožmberk, 18 Pilská, 19 Mariánské Lázně, 20 Jevišovice, 21 Harcov, 22 Jezeří, 23 Kamenička, 24 Bedřichov, 25 Fojtka, 26 Mlýnice, 27 Mšeno, 28 Bystřička, 29 Hamry, 30 Pařížov, 31 Janov, 32 Souš, 33 Labská, 34 Les Království, 35 Chřibská, 36 Sedlice, 37 Luhačovice, 38 Plumlov, 39 Březová, 40 Seč, 41 Vranov, 42 Pastviny, 43 Fryšták, 44 Husinec, 45 Brno (Kníničky), 46 Slapy, 47 Horní Bečva, 48 Štěchovice, 49 Křižanovice, 50 Klíčava, 51 Kružberk, 52 Podhora, 53 Vír, 54 Žermanice, 55 Koryčany, 56 Křímov, 57 Lipno, 58 Myslivny, 59 Fláje, 60 Mostiště, 61 Orlík, 62 Suchomasty, 63 Záskalská, 64 Jesenice, 65 Hracholusky, 66 Obecnice, 67 Olešná, 68 Skalka, 69 Těrlicko, 70 Jirkov, 71 Bojkovice, 72 Znojmo, 73 Klabava, 74 Morávka, 75 Ludkovice, 76 Nechranice, 77 Žlutice, 78 Horka, 79 Nýrsko, 80 Šance, 81 Tatrovice, 82 Vrchlice, 83 Kadaň, 84 Nemilka, 85 České Údolí, 86 Hubenov, 87 Opatovice, 88 Rozkoš, 89 Landštejn, 90 Lučina, 91 Větřkovice, 92 Želivka (Švihov), 93 Letovice, 94 Přísečnice, 95 Slušovice, 96 Mohelno, 97 Dalešice, 98 Nové Mlýny (upper), 99 Římov, 100 Stanovice, 101 Němčice, 102 Nové Mlýny (middle), 103 Trnávka, 104 Újezd, 105 Josefův Důl, 106 Těšetice, 107 Výrovice, 108 Karolinka, 109 Nová Říše, 110 Humenice, 111 Nové Mlýny (lower), 112 Boskovice, 113 Hněvkovice, 114 Dlouhé Stráně (lower reservoir), 115 Dlouhé Stráně (upper reservoir), 116 Slezská Harta, 117 Skalička, 118 Nové Heřminovy, 119 Vlachovice, 120 Kryry, 121 Amerika

ABSTRACT

This paper deals with some aspects of the relationship between man and water demonstrated via the example of large hydraulic structures constructed in the Czech lands. Based on this relationship, principles of the practical functioning of ideas and ideologies, including religion, can be presented. It is not just about "pagan" cults, aiming directly at worshipping water as a living being. Christianity also significantly influenced the framework in which water management operated across the centuries and, at the same time, new ideas associated with the Enlightenment and the Industrial Revolution during the 18th and 19th centuries. A key part of the paper is focused on the topic of the construction of large hydraulic structures in the 20th century, which was particularly intensive in its second half. It also mentions political, ideological, and natural changes which were, at the beginning of the 21st century, reflected in man's relationship with water resources and the possibilities of influencing them.

Motto: *"...Wayside shrines in the countryside, plant motifs of cathedral builders, Baroque unity between nature and structures show that until the 19th century nature was still sacred, albeit as God's mirror. Later, a significant distinction was made between the spirit and the material. Nature was gradually becoming an obstacle to progress. Only recently have we started to remember that consecrating the landscape is actually its humanisation."* [1].

INTRODUCTION

The Ministry of Culture and the National Heritage Institute focus their activities on the protection of technical monuments of many types. This paper discusses the cooperation between various fields as well as some difficulties which occurred during the project *"Historical water management objects, their value, function and significance for the present",* under the NAKI II programme (project code DG18P02OVV019) of the Ministry of Culture. This paper is approached as a dialogue between a historian and a preservationist, on the one hand, and a technical water manager on the other. We believe that mutual cognition and understanding of both approaches will contribute to the exchange of experience and a more varied depiction of the world and human society. It is an incentive for further discussion and reflection which tries to identify various aspects of broader relationships, whilst being aware of the impossibility of capturing the phenomenon in terms of its completeness or general validity. Possible conflict lines are connected, on the one hand, with the issue of the level of service of technology and technology manipulated by power and ideology, and, on the other hand, the usefulness, benefits, and embedded technical skills are pointed out.

The history of the relationship between man and water includes responses of various cultures and civilizations to sudden changes in natural conditions (e.g. dramatic floods), but also to long-term processes such as changes in rainfall or temperature. Water management and its development is not only a specific phenomenon, but it also reflects contemporary ideas and ideologies, to which religion also belongs. If we focus on the roots and consequences of a technocratic approach to water management connected with linear regulations of watercourses, construction of dams, and artificial waterways, its ideological inspiration can be anchored in the ideas of the Enlightenment which led to the deification of the reason. Since the second half of the 18th century, people gradually adopted rational criteria (to measure, weigh, and calculate, ideally by experts of the given specialisation), which previously had not been taken for granted, as decisive in relation to the surrounding world. This approach prevailed in the form of transformation of the "faith into science" and thus persists to the present day. But the limits of such thinking are more and more noticeable because human reason is only one of many possibilities for exploring reality, not the only one.

However, important water management structures were also built with man's belief in their own abilities and the support of gods. This belief has led to the search for ways to improve natural conditions so that the landscape or soil could nurture a larger population in a more comfortable and safer way of life, thus ensuring prosperity, whether in the local community or in a wider society.

The topic chosen for this paper, out of water management structures in terms of a symbolic socio-historical context, is the construction of large water areas which took place from the Middle Ages to the present. The aforementioned project elaborates on the topic of dams in most detail. When dealing with this type of hydraulic structure, we started to harmonise the cooperation of experts from different fields and clarify basic terminology during which we particularly realised that there are different attitudes and approaches to the assessment of the significance of individual structures.

Figure 1 shows selected hydraulic structures differentiated by colours according to the time of their origin. In the course of time, some of them ceased to exist, sometimes even entire pond systems, so the following overview and reflections involve those that exist to this day.

This map shows the concentration of a larger amount of reservoirs in some river basins in certain periods as well as the area-wide distribution of reservoirs in the second half of the 20th century.

Middle Ages and Early Modern Era

The Middle Ages and Early Modern Era accentuated the issue of religion in relation to the downfall of great ancient empires and the beginnings of new globalisation. Europe was the fundamental continent for the formation of medieval civilisation because it became, instead of the Mediterranean, the centre of political, economic, and cultural developments. Together with the transfer of social centres towards the north, it was Christianity, referring to outside of the material world, which formed more than a thousand-year period of the Middle Ages. Both circumstances were manifested in the overthrow of the ancient cult of the human body. It ceased to be admired as a source of beauty and joy, instead it was tabooed as a sinful enticement of hell. Religious asceticism significantly contributed to the change of the configuration of European culture after the fall of the Roman Empire [2]. This transition from Antiquity to the Christian medieval world was not rapid but a process lasting several centuries, as Jarmila Bednaříková described in her works, for example in [3]; in addition to this, Christianity even reached originally barbaric peoples via Rome, which is beneficial to observe in a global perspective [4].

Together with this approach to the human body, Christianity also changed the perception of water. Purifying water had a symbolically important but, in terms of its scope, minuscule role in the baptismal fonts of Christian churches, while Roman aqueducts and baths had been destroyed by the Goths, Lombards, and Vandals a long time ago. The majority of inhabitants were happy with wells, rivers, and brooks for their normal use of water instead of using imposing aqueducts. The "sinful" time spent at baths should have been dedicated to prayers and work. Although attempts to completely eliminate the collective bathing of naked men and women failed in medieval Europe, the importance of personal physical hygiene largely declined. And so when, from time to time, an epidemic of some disease appeared, it was considered *"God's punishment for sins"* in the Middle Ages. During plague epidemics, roughly one third of the population died under these circumstances [5], while the plague was also used to refer to other contagious diseases which had such a widespread impact. In the case of water-borne diseases it was, for example, cholera.

We often tend to underestimate the technical skills of people in medieval times, viewing from the perspective of current technological possibilities, with a resulting feeling of superiority over the past. Nevertheless, we can still admire as a small technical miracle the planning and localisation of several-kilometre long routes under a minimum slope without an optical levelling machine. At the same time, it was a necessary skill for the construction of supply channels

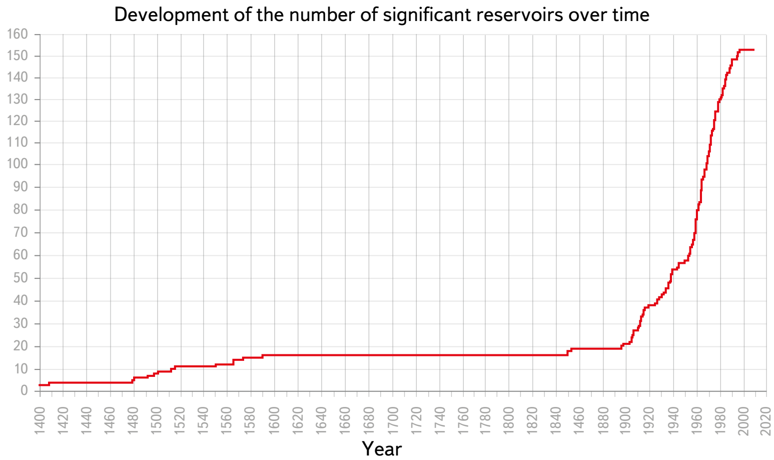

Fig. 2. Development of dam construction in the Czech lands (taken from: [21])

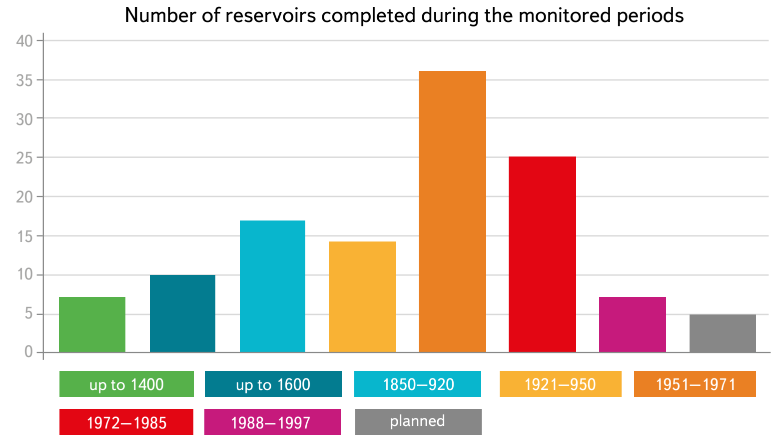

Fig. 3. Number of reservoirs built according to the monitored periods

of pond systems or for the transfer of water in mountainous landscapes from one river basin to another (Schwarzenberg navigation canal, Blatná water ditch, etc.). At the time, the contractor of the construction had only a rough idea of how the result would look and they were not interested in the technical details of how the goal would be achieved. This was also caused by the ideological approach in these antiquity times when in chronicles and other preserved materials it was not the intellectual competence of the builder himself but his connection with external circumstances or direct dependence on them which was emphasised. Perhaps it happened *"with God's help…"* or, in the contrary folk version *"he signed a contract with hell…"*. Christianity also limited the desire of man to *"become equal to God"* which was symbolised by the biblical story of the construction of the Tower of Babylon, built for the glory of man, and not of God. Only the Enlightenment, with all its consequences, denied the Christian fear of God's punishment if man exceeds their standards.

With the Renaissance and overseas discoveries, the pendulum of history turned into a path of globalisation and a return to ancient heritage. Czech fish farming, whose golden era in the 16th century coincided with the boom of the Czech Renaissance, remains an example of the turnaround from local medieval measures to broader ambitions. The most famous Czech founder of fish ponds, Jakub Krčín of Jelčany and Sedlčany (1535–1604), worked in the service of the Renaissance nobleman Vilém of Rožmberk and also the legendary emperor Rudolf II. Fish pond founders strived to create an entire system of water management within the landscape. In contrast to the situation in the Middle Ages, they were not obstructed by the fragmented ownership of land when one village was divided among several owners. At the beginning of the Early Modern Era, the class of the richest noblemen had stable extensive property of the territorially integrated manor where there was space for the realisation of ambitious plans in the form of large hydraulic structures. It is therefore unsurprising that fish farming in ponds was almost exclusively a form of economic activity pursued by the aristocracy in the Czech lands during the 16th century [6].

Enlightenment and its heritage in the 20th century

The impression of dominance over nature, in which people believed in the basis of the transformation of the world during the Industrial Revolution, was manifested by faith in the future, endless growth, and progress. This can be evidenced by the construction plans of many large hydraulic structures. Later confidence in rational solutions to all mankind's problems followed the tradition whose roots reside in the Enlightenment. In the 20th century, these traditions were part of the mainstays of modern technocratic thinking in the East and the West. This was inseparably linked to both the efforts to rationally overcome myths and binding hierarchies, including religion, and the radical, rationalistic, spatial reformatting of the environment in which orderly citizens were supposed to live. What was typical was the belief in such kinds of value that can be exactly calculated and whose trajectories toward the future can be approached similarly as physicists work with the laws of gravity or conservation of mass. But the theory on the liberating power of human rationality already holds in its foundations the potential of new totalitarianism – the identification of the image of a scientific, mathematically-based world (which can be to a maximum extent a mere part of reality) with the reality of the present moment. This belief in science, like other ideologies, does not admit an alternative, so it is virtually condemned to irrational and, therefore "non-scientific" categories.

The regimes of state socialism implemented the Enlightenment version of modernity in the second half of the 20th century. The legacy of Enlightenment absolutism of the late 18th century (central European experience with the reign of Emperor Joseph II and his "revolution from above" was essential in this respect) transformed into a "caring dictatorship" – a comprehensive and highly authoritative care for citizens, from which it is not possible to escape in any legal form [7].

Social engineering, with efforts to improve living conditions of all inhabitants without distinction, regardless of whether the inhabitants concerned are interested in such improvement or not, was reflected, among other things, in the massive construction of dams. This activity had been preceded by a half-century construction of modern dams in the Czech lands, inspired by an intensification of industrial production at the turn of the 20th century. Until the mid-20th century, water management structures and water management infrastructure were built on a "bottom-up" basis, in response to the needs of municipalities, local agriculture, upon the initiation of industry, or as flood protection activities of a specific region. Local and trans-regional water cooperatives were founded (the first one in the Čáslav Region in 1882), which played a key role in improving water conditions between 1890–1939 [8].

In the first decades (end of the 19th and beginning of the 20th century), construction of dams was influenced by efforts to integrate this distinctive element into the landscape, composed by man for centuries according to human standards. The buildings are naturally segmented (ornamental) using traditional materials (stone, fired roof tiles). Les Království reservoir (1910–1920) is typical in this respect; it is described as a fairy-tale structure but its purpose is purely practical. Similar efforts to integrate these hydraulic structures were made at the level of human relations. The inhabitants of individual localities usually had some time to get used to the idea of their environment being changed, or they actively demanded the construction of hydraulic structures with their advantages, even though the situation was usually more ambiguous than as it was described by left-wing writers. Marie Majerová, in her novel *Přehrada (Reservoir)* [9], spoke ironically about the old slow bureaucratic system and its struggle for the deification of the described hydraulic structure, in contrast to the ideal of the "revolution from above", the dictatorship of civilization associated with scientific-technical progress:

"For sure, everything suggests that this is going to happen. But Božena still does not believe. How many plans have failed and how many promises have been made in vain! In the times which were historical for her, during her grandfather's rule over Cholín, the municipality of Prague in Vienna demanded permission from the competent authorities of the Austrian monarchy to build a weir in the locality where a huge dam now stands. And in fact, her whole life and the life of their family coincided with the struggle for a dam. They were constantly talking about it at home, both longingly and hatefully. […] Representatives of political parties secured people's favour with attractive slogans, thick cigars and sweets. […] And for many years, nothing happened again. Unless the mayors of the Central Vltava basin wrote a memorandum, or agricultural representatives from the region complained to their senator. […] After some years, a road was finally built along the river, after a long pause a railway line and then, when no one believed any longer that such a construction would take place, the water-way fund was enacted."

In the scope of massive economic recovery after the end of the Second World War, it is possible to talk about the golden age of the construction of dams on both sides of the Iron Curtain, as well as outside of the so-called developed world. In the case of Czechoslovakia, the largest number of dams were built in the second half of the 20th century, though these were often constructed at locations that had already been identified and recommended around 1900. The copied graph shown in *Fig 2.* illustrates this. *Fig 3.* shows the number of dams built according to the same periods as in the map in *Fig 1.*

Political changes in Czechoslovakia after 1948 initiated an era of planned but, suddenly, rather forced improvised construction of large water-management structures. The authoritarian nature of the regime allowed the entire implementation system, material, machinery, and labour to be put into operation relatively easily and without any hesitation, compared to the previous period of complex discussions, prevarication, and private ownership considerations. Authors like Zdeněk Pluhař, who was one of the builders of Vír reservoir, accommodated the need to change patterns of thinking in people's minds similarly radically. Pluhař's novel *Modré údolí (Blue Valley)* [10] does not mention the magical valley of Svratka nor the story of a specific building.

Fig. 4. Mušov church was to be demolished with the flooded village. It was saved at the last minute thanks to a group of students from the Department of art History of the Faculty of arts of Charles University who discovered frescoes on the oldest Romanesque wall of the church under layers of newer plaster. The condition of the church at the time of the first filling of the reservoir. (Photo: personal archive of I. Přibylová)

Fig. 5. Bystřička hydraulic structure completed in 1912, safety spillway

Fig. 6. Orlík hydraulic structure, concrete gravity dam completed in 1960 (Photo: V. Macha, 2021)

Fig. 7. Letovice hydraulic structure, an earth-filled dam completed in 1976. Its condition at the time of repairs of the safety spillway in 2022 (Photo: M. Forejtníková)

The schematic descriptions of characters and environment, as well as the development of events leading to the victory of builders over nature, are fully subordinated to this ideological assignment:

"Comrades, now we no longer work for somebody else's profit, now we build for ourselves. The dam is ours, like everything in this state…" the inhabitants of a flooded village will not even remember the destruction of their houses because the dam – and trust in the ruling system – will free them from fear of the future. *"After all, you will get rid of this eternal fear. You know very well what floods are in our valley, how awful it is when ice mass starts moving. Ask the dad, Julka, how many times people lost their shelter, their entire property, how many people died here during the floods. […] the first star already lit up in the purple sky a long time ago, and it was large and radiant."*

Little depended on the attitude of local residents, nature, landscape harmony, or even on the wider economic logic of such construction. Obstacles to new construction in the form of ownership relations, local social ties, public opinion and, in fact, anything could have been quite easily overcome by pointing out that a particular constructive activity is an indispensable part of "socialist care for citizens" and has no alternative. During the 20th century, over 100 villages disappeared due to the construction of water reservoirs [11, 12]. The legacy of one-sided conception and conviction of the clear contribution of the construction of large hydraulic structures left a lot of problems in the landscape and society, which remain unresolved to this day [13–15].

However, from the point of view of a water manager, this period seems somewhat different. In post-war Czechoslovakia, it was necessary to renew and complete the construction of basic infrastructure and industry.

The state water management plan of the Republic (in Czech known as SVP – Státní vodohospodářský plán) [16], was also elaborated on the basis of the knowledge and experience of pre-war Czechoslovakia during 1949–1953, and became the first systematic overview of the possibilities of using the state's rich water resources. It was a directive-led plan for water management measures in all sectors of the national economy, as well as for spatial planning, enabling the use of water resources during individual floods on the basis of a detailed local survey. The plan initiated systematic monitoring and evaluation of data on natural conditions affecting water resources and water management, leading to its continuous update and completion. It elaborated the issue of drinking water supply, promoted complex and multi-purpose use of water resources, transition from local water supply system to group or regional water supply networks. It dealt with anti-flood treatment and drainage conditions of entire areas. It was a binding document which, among other things, enabled the emergence of a huge number of dams in a notably short time.

One of the current documents pertaining to the SVP regarding dam construction is the General Scheme on the Accumulation of Surface Water (in Czech known as Generel LAPV) [17], which, in terms of spatial planning, protects sites that could be used for the construction of dams in the event of continued climate changes in the future.

Period after 1990

As in earlier times, changes in ideas and their practical impacts do not happen overnight. Even before the revolution in November 1989, views on environmental issues were used for political and ideological battles; changes in circumstances still reverberated in subsequent years. Construction of some large hydraulic structures were suspended for some time in these crucial years and there were discussions about their purpose. In other cases, construction had already been suspended before 1989 for primarily economic reasons, although the authorities proclaimed acceding to discussions with environmental NGOs. Eventually, however, they were mostly completed and today they are beneficial to both energy and other water management purposes – for example, Dlouhé stráně pumped storage hydropower station, Silesian Harta hydraulic structure and, thirdly, Novomlýnské nádrže (Nové Mlýny reservoir). Political and ideological changes after 1990 also led to the rejection of economic instruments of socialism, such as the planned national economy and, at the same time, long-term planning in water management was also abandoned. Natural phenomena such as floods (e.g. 1997, 2002), torrential rains (continuously), or long-term drought (e.g. 2015–2017) showed that planning in water management was necessary so that the negative effects on the social environment, aimed at an immediate commercial or political profit, were at least partially counterbalanced. The requirements of European Union directives [18] and anticipated climate change have also brought water management planning back to the fore. Unlike the times of the SVP, these documents are now required to be discussed with the public and at the local government level [19].

From a historian's point of view: The question is what practical long-term impact these plans will have on the future form of water management in the Czech Republic.

A cascade of three dam reservoirs in the Dyje river, under the Pavlov hills in southern Moravia, is a revealing example of this imposed technocratic solution. The government decision from May 1971 on the construction of Novomlýnské nádrže was the last step to be taken in any discussion about the issue of their construction, as evidenced by the following sentence in the chronicle of the flooded village of Mušov: *"There won't be any discussion about this. It's a done deal."* Citizens were put in the position of mere "pawns" on an imaginary chessboard [21, 22]. The reservoirs were built to prevent annual flooding and to increase the intensity of agricultural production. Construction was justified by the socialist economy's plans for extensive systems of irrigation of agricultural land, which were partially abandoned after 1989. From environmental activists' point of view, it is just a lousily done water-management imitation which destroyed "*the most valuable and most beautiful riparian forests in our country and perhaps in the whole of Central Europe*" [23]. The church of St. Linhart (*Fig. 4*) rises above the water level of the middle reservoir as a memento.

The construction of large hydraulic structures was always conditioned by the interplay of several influences: technical skills and natural conditions, intentions of the contractor and the investor, ideological background, and general awareness. All these influences are subject to change over time. The construction of every major hydraulic structure is time-consuming and, even during the construction itself, these conditions can change individually or in different combinations.

The construction of Bystřička masonry dam (*Fig. 5*) falls into the period before the First World War and it is an example of how the purpose and use of a hydraulic structure can change over time. The selection of the location and the size of the hydraulic structure were associated with the primary purpose of the water source for the planned controversial Danube-Odra canal. Although the idea of this canal has not come to pass so far, the hydraulic structure has, over the time of its existence, helped many times in coping with floods [24]. The reservoir is used continuously, mainly for recreational purposes; operatively it was used to rapidly increase the flow rates in the Bečva river and thus to dilute the concentrations of toxic substances at the time of a recent accident.

The planned Skalička hydraulic structure has also changed its main purpose and related suggested technical solution many times, without yet being fully built. The original intention was similar to that of Bystřička, i.e. in the period of socialism the reservoir was meant as a source of cooling water for a planned nuclear power plant, but after 1997, the flood control function prevailed (designed as a dry reservoir). Nowadays, in the period of longer-term drought, from a water management perspective, a solution in the form of a permanent water surface is coming to the fore.

After the Second World War, a newly introduced ideology coincided with majority awareness of the need for rapid post-war renewal of industry, energy development, and creation of a new society. Most of the dams built in the 1950s and 1960s were presented as large structures of socialism and their construction was usually not disputed. Later, in the period of normalisation of the 1970s and 1980s, hardly anybody believed the officially promoted ideology and, in the general awareness, there was an increasing shift toward environmental issues. The intention to build further dams was increasingly coming into conflict with the ideas of state conservation of nature. The integration of hydraulic structures into the landscape in different periods can be compared in *Fig. 6* and *7*.

CONCLUSION

Despite all the differences in approaches of different fields towards the issue of dams and water management as a whole, it can be stated that some conclusions can be agreed on.

In the Middle Ages, water management was understood as jura regalia. In modern times, water is also considered a public possession and is a subject of public interest. The fragmentation of society at the beginning of the 21st century does not match the former techno-optimism, belief in progress or in the hierarchical management of society from above grounded in the expert opinions of the authorities. Nevertheless, solutions for the construction of large hydraulic structures which were tried and tested in the 20th century continue to be used where there is no other alternative for the provision of water needs for the future. The promotion of sustainable use of water resources with the preferences of subtler interventions brings harmonisation changes to the landscape, and an effort to return to natural water conditions is thus demonstrated. This trend is also reflected in new solutions by water management designers. Only time will tell to what extent a similar turn is also taking place in human minds – a turn towards restoring balance within ourselves.

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Photo: 123RF.com

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Interview with Ing. arch. Eva Dvořáková and Ing. arch. Tereza Bartošíková, Ph.D., about protection of technical and industrial cultural heritage in the Czech and Slovak Republik

As part of the December issue of VTEI, which is entirely devoted to the topic of technical and industrial cultural heritage and the "Programme of applied research and development of national and cultural identity (NAKI II)" of the Ministry of Culture, we asked for an interview with two specialists in this field, Ing. arch. Eva Dvořáková from the National Heritage Institute (Národní památkový ústav, NPÚ) and Ing. arch. Tereza Bartošíková, Ph.D., from the Monuments Board of the Slovak Republic (Pamiatkový úrad Slovenskej republiky, PÚ SR).

Ladies, how did you come to deal professionally with the subject of technical and industrial heritage?

Dvořáková: Shortly after graduating from CTU, I joined the then State Institute for Monument Preservation and Nature Conservation in the Department of Folk Architecture and Technical Monuments. At first, my work focused only on folk architecture, which was already close to me because I graduated from the Department of Reconstruction under the architect Svatopluk Voděra. His publications on folk architecture and its adaptations were an example for us at the time of how beautiful folk buildings are and how to approach their adaptation sensitively. Dr. Jiří Vondra was in charge of technical monuments in the Department at that time, and he gradually handed over part of his agenda to me. It is necessary to realize that at the time I am talking about, i.e. at the beginning of the 1980s, "technical monument" meant at most a mill, a forge, or a bridge. Apart from some significant architectural buildings, such as Kotěra's elevated water tank in Pankrác, industrial heritage was not considered to be of historical value at all. After the retirement of Dr. Vondra, no one cared much about the agenda of technical monuments at the then State Institute for Monument Preservation. At that time, technical monuments were not perceived in art-historical circles as an adequate part of cultural heritage, so it automatically became "my agenda".

Bartošíková: When I was choosing a university in my school graduation year, I said that I wanted to repair castles or build bridges. The talent exams secured me a place at the Faculty of architecture. I had the opportunity to specialize in history of architecture and restoration of monuments. Nevertheless, I was drawn to technical constructions, so I focused mainly on the renovation of industrial facilities. I wrote my diploma thesis and later also my dissertation thesis on this topic. After my studies, I took up the position of methodologist for technical monuments at the Monuments Board of the Slovak Republic. So I can say that I have a job that I wanted, and I have combined history and technical constructions in my work.

Can you explain to the readers what a technical monument is, what industrial heritage is, and how their protection is anchored in legislation in the Czech and Slovak Republics?

Dvořáková: The following general definition is most often used for technical monument: *"A technical monument is unique or typical material remains that demonstrate the development of technology and its level in certain historical conditions. It is a document of the historical development of human society."* However, it should be pointed out that technical monument is a general designation and it is not anchored, nor was it, in the two laws issued so far aimed at protecting monuments. The law recognizes only the term 'cultural monument'

Act No. 22 of 1958 on cultural monuments defined the category of monuments, including technical monuments, as *"... a cultural asset that is evidence of the historical development of society, its art, technology, science, and other fields of human work and life, or is a preserved historical environment of housing estates and architectural ensembles or a thing related to prominent persons and events of history and culture."*

On 1 January 1988, Act No. 20/87 Coll., on State Monument Preservation, came into effect, replacing Act No. 22/58. It does not leave out science and technology either. It considers cultural monuments to be those that are important documents of the historical development, way of life, and environment of society from the earliest times to the present, as manifestations of the creative abilities and work of man from various fields of human activity for their revolutionary, historical, artistic, scientific, and technical values.

When it comes to the term 'industrial heritage', the interpretation in the Czech language is somewhat complicated. The term *industria*, given by some dictionaries, is translated from Latin as diligence, industriousness, while other professional publications use the term industry for *industria*. So the border is a bit blurred in this case. I would like to also point out that the State Monument Preservation Act does not recognize the term. The concept of industrial heritage is probably best explained in the *Methodology for Evaluation and Protection of the Industrial Heritage from the Perspective of Heritage Management* by Miloš Matěj and Michaela Ryšková, published by the National Heritage Institute in 2018.

Bartošíková: The biggest difference between the Czech and Slovak understanding of monuments is based on differences in legislation. In Slovakia, we have a relatively new law on monuments, which has added many competencies and obligations to preservationists. We are an authority and we directly decide on the restoration and declaration of new monuments. The law also changed the nomenclature of the monument fund, where we no longer have the categories of national cultural monument and cultural monument as in the Czech Republic. All our legally protected buildings are national cultural monuments.

The Act on the Protection of Monument Fund does not recognize a special type of monument – technical monuments. The current Slovak law only generally defines the protection of national cultural monuments and heritage sites. According to our law, heritage value is the sum of significant historical, social, landscape, urban, architectural, scientific, technical, artistic or artistic-craft values. Every monument must therefore have a documented historical value.

In practice, we talk about industrial monuments as a subset of technical monuments. Technical monuments also include wells, bridges, and dams that were not used for production. We understand industrial monuments as monuments of industrialization – they are mostly industrial sites built in the 19th and 20th centuries. Technical monuments have been in the monument fund for a long time, and we are gradually starting to focus on the protection of industrial monuments of a larger scale and from more recent times.

How is the area of industrial heritage covered in your institution (NPÚ/PÚ SR) and who else do you cooperate with in matters of its rescue, protection, restoration, or eventual conversions?

Dvořáková: When I joined the then State Institute for Monument Preservation and Nature Conservation, there were five employees working in the Department of Folk Architecture and Technical Monuments, only one of whom was in charge of the agenda then called monuments of science, production, and technology. Since the establishment of the Institute in 1958, only thanks to the efforts of the then director Ing. arch. Jiří Gwuzd was it possible, in the 1980s, to establish a separate department of technical monuments at the Regional Centre for State Monument Preservation and Nature Conservation in Ostrava. Other regional workplaces only rarely had an expert who would deal with this agenda.

Since then, much has changed for the better. There is one position for an industrial heritage specialist in each regional workplace of the National Monuments Institute. The establishment of the Methodological Centre of Industrial Heritage in Ostrava also contributed to the qualified assessment of technical heritage, which arose out of the need to improve the knowledge, documentation, and protection of technical and industrial monuments and under whose leadership it is gradually becoming possible to start research within individual manufacturing sectors.

Collaboration with the National Technical Museum dates back to the establishment of the Institution as it follows the idea that technical museums will take over exceptional technologies in their collections. At the end of the 1960s, cooperation with the newly established Technical Museum in Brno increased, where it was possible to establish the first workplace of industrial archaeology in our country. With it, this professional institution responded to the initiatives of the newly established International Committee for the Conservation of the Industrial Heritage TICCIH (1975).

Since the 1990s, when the Ministry of Culture announced the first science and research programme projects, in which not only monument preservation institutions but also universities or individual scientific institutions participated from the beginning, we have started cooperation mainly with the Czech Technical University. Cooperation with the Czech Chamber of authorized Engineers and Construction Technicians (Česká komora autorizovaných inženýrů a techniků činných ve výstavbě), and the Czech Association of Civil Engineers (Český svaz stavebních inženýrů), with whom the National Heritage Institute has concluded a long-term cooperation agreement through the Board for Technical Monuments (Kolegium pro technické památky), can be considered significant in the field of technical heritage.

Currently, a Memorandum of Cooperation with the Railway Administration has been signed; both institutions hope to improve the situation during the restoration of the railway fund.

Within science and research, the Methodological Centre of Industrial Heritage cooperates with a number of institutions. One of the examples is the cooperation on the methodology of classifying and evaluating water management objects, which was established in collaboration with T. G. Masaryk Water Research Institute, the Historical Institute of the Academy of Sciences of the Czech Republic, Palacky University in Olomouc, the National Heritage Institute, and a number of experts and consultants outside these institutions.

Bartošíková: Currently, the Office operates a section of technical monuments, which is an advisory body to the General Director composed of employees of the PÚ SR and regional monument offices. In Slovakia, I am the only one solely in charge of technical monuments, that is, the report on technical monuments of the PÚ SR. There are several colleagues at the regional monuments offices who, as part of their work, deal with technical monuments, but not exclusively.

We have established cooperation with the Slovak Technical Museum and its branches and with the Slovak Mining Museum. From an institutional point of view, cooperation with the Mining Archive in Banská Štiavnica as well as with local technical museums is important for us.

Cooperation with universities has deteriorated because long-time teachers dedicated to technical monuments have retired. However, we are open to cooperation.

A separate category consists of cooperation with civic associations and enthusiasts. Often in interaction with passionate owners of monuments, such collaboration brings the best results for both the monument and learning about the history of the given type of object.

For many monuments, there is a clash of different points of view and interests. For example, nature conservation, safety of water works, economic interests. Do you think that monument preservation is currently able to balance the individual aspects? And where do you see potential for improvement?

Dvořáková: Compared to the earlier, sometimes extreme doctrinalism, monument preservation today is pluralistic in its approaches and methods. It is always looking for and finding solutions individually, case by case, taking into account the value and character of the monument in question, the degree of its preservation, and the nature of the contemporary needs that the restoration is supposed to fulfil. It is necessary to continuously communicate with society, whose public interest is primarily intended to be protected by monument preservation. Methods of monument preservation have also changed significantly, which reflect the development of architecture as well as the results of current science and research. In the field of technical and industrial heritage, one of the guidelines for informed decision-making is the above-mentioned *Methodology for Evaluation and Protection of the Industrial Heritage from the Perspective of Heritage Management*, which will be followed up by specialized production sector methodologies in the future. A prerequisite for improving contentious issues of conflicts will be the application in practice of subsequent methodologies of individual production sectors, in the creation of which monument preservation closely cooperates with a number of professional institutions, including TGM WRI.

Bartošíková: As preservationists, practically every time a monument is restored we try to find an adequate compromise between the requirements of monument preservation and other interests that enter into it. The economic point of view is present across the entire monument fund because the owner of a cultural monument has their own, mostly limited financial possibilities. The economic aspect is already included in the proceedings for declaration of an object as a cultural monument; the owner is afraid of an increased level of financial and administrative burden in the preservation and handling of their property if they have to meet the demands of monument preservation. Above all, it would be necessary to find appropriate motivational tools so that the owner of a cultural monument does not take it primarily as a burden, but receives a helping hand and appropriate compensation from the state.

We often come across nature conservation when there is a need to maintain some monuments visible from a distance or in cases where trees disturb the structure with their root system. We are starting to encounter questions about the construction of fish channels at larger scale water works. Energy efficiency becomes a serious issue in the operation of technical monuments. As an example, industrial plate windows were replaced with plastic windows at a hydroelectric power station with the justification that they had to prevent the turbines from freezing in winter. Originally, the building had year-round 24/7 service and room temperature control; it is currently fully automated without heating.

Another issue is barrier-free accessibility of monuments, which is not always possible to ensure in the case of technical monuments. We try to deal with security aspects individually for each monument in order to ensure both the safety and the original appearance of the object. We prefer the use of original material and construction solutions, but when it is necessary to replace the water tanks discharge devices, for example, we allow the use of current technical solutions. We managed to harmonize the solutions of the water and air sides of the dam with the water managers in the case of the mining water reservoir (tajchy).

What are the specifics of monument preservation for objects of a technical nature? Is there any difference in assessing their historical importance from, say, "classic" cultural monuments? Are there methodological guidelines, or specific criteria, for evaluating their historical importance?

Dvořáková: Compared to the classic heritage fund, technical heritage is a very diverse fund made up of specific representatives of many manufacturing sectors, and therefore it is necessary to apply special approaches to the determination of their heritage values. What principles govern the declaration of technical monuments and their inclusion in the *Central List of Cultural Monuments* and what values are prioritized for industrial heritage is given by the above-mentioned *Methodology for evaluating and protecting industrial heritage from the point of view of monument preservation*, which will be followed up in the future by methodologies reflecting the specifics of selected industrial sectors, key for the development of industry and for Czech sites in the Czech Republic.

Bartošíková: By law, the preservation of technical monuments is the same as for other types of monuments. With technical monuments, we come across specific situations, especially if the object still serves its original purpose. In that case, the preservation of the original function is often tied to standards and regulations related to their safe operation. In such cases, it is self-evident to preserve the functionality of technology or process automation at the expense of the authenticity of some small parts.

In Slovakia, we do not have general methodological instructions for assessing the significance and values of monuments. Technical monuments have some specific aspects that are different from other types of monuments, for example the technological flow of the original production. From the point of view of monument preservation, the fact that the preserved object or technology is unique, the first of its kind, or the most efficient in terms of the given industry in Slovakia is also important. However, we also protect typical examples of technical monuments or equipment.

Most technical monuments have a technical value in connection with other monument values, for example, architectural, historical, or artistic-craft value. Preservation of technological equipment is not a condition for registration of the monument as a national cultural monument.

Classic monuments – chateaus, churches – are easier for the public to understand as they are "visually pleasant", have more decorative elements, and artistic decoration. Gradually, however, industrial aesthetics also begins to penetrate the consciousness of the lay public.

Is there any closer form of cooperation – for example a professional platform – in this area between your two institutions?

Dvořáková: Cooperation between the two organizations, albeit modest, dates back to the 1970s, when the first contacts appeared, more so between technical museums, but in which representatives of monument preservation also took part. Here I would like to recall the activities of the late Dr. Laco Mlynka in the field of water mills and participation in various excursions and lectures at conferences. Reciprocal meetings between the staff of both our institutions also contribute to bilateral cooperation at the moment.

Bartošíková: On behalf of the PÚ SR, I cooperate on various technical topics with the Methodological Centre of Industrial Heritage in Ostrava, with individual employees of the NPÚ, with the Research Centre for Industrial Heritage under the Faculty of architecture of the Czech Technical University, but also with the mill experts behind the vodnimlyny.cz portal, for example.

Do you see something mutually inspiring in the approach to the issue of industrial heritage on the Czech and Slovak sides?

Dvořáková: There is a lot of inspiration on both sides, and the obvious effort of the professional staff of both institutions is to preserve the most outstanding representatives of industrial heritage, including assistance in their restoration and the search for new uses. What distinguishes the two institutions is their legislative status within the state. While in the Czech Republic the National Heritage Institute is a professional organization ensuring the protection of cultural heritage without executive powers, the Monuments Board of the Slovak Republic combines both components, i.e. both professional and executive. Which is better, it is hard to judge.

Bartošíková: Our Czech colleagues inspire us in particular with their extremely broad publishing activity and the creation of methodological materials. The educational activities and popularization of technical monuments by the NPÚ is more extensive and worth following. In general, in the Czech Republic, the financing of research, publishing activities, and restoration of monuments is handled better and more diversely from the sources of the Ministry of Culture, but also of regional units, municipalities, and the European Union. There are many areas where we could be inspired.

Can you give an approximate representation of technical and industrial heritage among listed buildings in the Czech and Slovak Republics? And what is the representation of water management objects within the technical and industrial heritage?

Dvořáková: If the first inventories of cultural monuments taken during the 1960s registered a little over 1,000 monuments of science, production, and technology, today's *Central List of Cultural Monuments* includes around 3,000 of them. Even the current completion of high-quality representatives of industrial heritage based on professional research is still not finished. Nevertheless, it can be stated that, of the approximately 3,000 declared technical representatives, industrial constructions make up less than 10 per cent. This data comes from the *Industrial Topography* database of the Industrial Heritage Research Centre of CTU.

As for the numbers of water management structures listed in the *Central List of Cultural Monuments*, it is difficult to find them, since it is not clear whether water mills that no longer have a water wheel can be considered as water management structures or as folk architecture. In addition, searching in the current *Monument Catalogue* is somewhat difficult in this regard.

Bartošíková: In Slovakia, we have a monument registration system which divides national cultural monuments (sites) into individual monument objects. Technical monuments have a representation in the monument fund of less than four per cent. However, water management structures are represented relatively abundantly among technical monuments. Of the 680 technical monuments, 170 are directly related to water management – water reservoirs, dams, levees, waterworks, water tanks, pumping stations, and the corresponding technologies. Another 85 are monuments that were powered by water – power stations, mills, sawmills, hammer mills, and technologies for their propulsion. This means that 37 per cent of technical monuments in Slovakia are directly connected to water.

The high rate of occurrence of water management objects in the monument fund is due, on the one hand, to the geographical characteristics of Slovakia, where water power is present throughout the whole country and was the impetus for the beginning of production. It is also due to the historical practice of preservation, when important mining monuments were declared as monuments in the first place, which also included mining water reservoirs (tajchy) and, subsequently, the interest in the protection of monuments shifted to craft production buildings, especially water mills, sawmills, and hammer mills. The representation of preserved technological equipment is also significant since hydroelectric power stations are mostly still functioning, mill turbines were not removed from mills, and water reservoirs must also be kept in operation.

From your point of view, which listed historical water management buildings are unique and iconic within the Czech and Slovak Republics? And which water management facilities, on the other hand, are not protected, but from your point of view would deserve preservation?

Dvořáková: Every water work deserves recognition. The idea of how the first millers probably built the shafts or how they built the dams must necessarily arouse our admiration. The medieval pond systems built on the Pernštejn or Rožmberk estates can certainly be considered iconic in our country. After all, the Třeboň ponds are still listed under the name Třeboň Pond Heritage as a cultural asset of the Czech Republic proposed for inclusion in the *List of World Cultural and Natural Heritage*. A number of specific water management structures, including artificial linear constructions, have not yet been sufficiently explored. Similarly, modern landscapes of water works are not appreciated, especially the Vltava Cascade, which certainly deserves protection. The convolute of elevated water tanks from the First Republic also deserves special attention, for example a unique elevated water tank in Kladno-Rozdělov with the first ever metal structure made of carbon steel and a non-load-bearing brick casing, which is now non-functional, but is among the good examples of new use in the form of a hi-tech water control centre and a cyber security centre.

Bartošíková: Of the protected buildings, an interesting system of monuments in Kremnické vrchy, the so-called Turček aqueduct from the 15th century – underground power station – 11 kilometres long hereditary adit of Emperor Ferdinand. It is a work that is significant for historical reasons, but also because of its technical values. The hydroelectric power station was started in 1922; it is located 245 metres underground and has three horizontal Pelton turbines installed. It is the deepest underground power station in Europe. A well-known UNESCO water management monument is the system of mining water reservoirs (tajchy) in Banská Štiavnica, which were used to drive mining and metallurgical equipment.

We are currently trying to register the system of water works on Starohorský potok. These are two water reservoirs with Ambursen-type dams, two derivation power stations, and technological accessories. They are significant not only because of the unique type of dams and overflow device, but also because it was the first attempt to operate a pumped storage Hydropower plant in our country.

What is your role as an institution in conversions of historical industrial buildings? Is there a methodical procedure, a guide to achieve a successful conversion? And what exactly is a successful conversion?

Dvořáková: A successful conversion, or a new use, can be considered such a modification where the main attributes of the original production building are preserved to the greatest extent possible. New interventions should not erase the original operational, technological, and typological features and should not cover the overall character of the building and the atmosphere of the environment with a new expression. The basis for understanding the production structure and its subsequent new use is perfect knowledge of the construction as well as knowledge of the production process. Within the field research of the National Heritage Institute, one of the new methodologies is specifically focused on conversions. In the field of water management constructions, I would probably mention the very refined conversion of the water tower at Letná, for which the architectural team received an award from the General Director of the National Heritage Institute.

Bartošíková: According to the Monuments Act, the decision on the intention to restore a national cultural monument is issued by the regional monument authorities which, from a methodological point of view, guide the restoration of all monuments and buildings in conservation areas. Unfortunately, the protection of technical monuments cannot be given priority, and that is why conversions of factories are often methodologically guided by the same people as castles and churches. We would like to enable higher specialization of fellow methodologists in the future. Personally, I consider a good conversion to be one that not only ensures continued functioning of the object, but is also appropriately sensitive to it. Choosing the right function is the most important step in a good conversion. It often happens that the object loses a lot of period details and technologies through conversion, which unfortunately give way to the demands of new use.

In what ways is your institution educating or popularizing this topic towards the public? And as part of this education, do you also cooperate with institutions and entities supporting tourism?

Dvořáková: of course, one of the aims of monument preservation is to popularize industrial heritage. This is done through organizing exhibitions, lectures, and cooperation, especially with the local municipalities and associations. At the same time, since 2014, the National Heritage Institute has been awarding the Patrimonium pro futuro awards every year with the subtitle Social appreciation of examples of good practice, in an effort to evaluate and highlight what has been achieved in the field of monument preservation and to recognize those who have contributed to successful work. In recent years, technical monuments have also received this award, whether it was the Jizera Mountains Technical Museum (Jizerskohorské technické muzeum) in Bílý Potok, or the renovation of railway roundhouse in Kořenov.

Bartošíková: We organize lectures, conferences, and educational events for families with children on the topic of technical monuments. Unfortunately, there are not very many of them. I also publish on the topic of technical monuments, but these are mainly more professional articles; popularization would need more mass media and a simpler approach. I regularly try to prepare events for the public connected with technical monuments during European Heritage Month.

In terms of media, we have the best collaboration with Slovak Radio, which has been broadcasting the series "Heritage of mills" this year and the series "Around technical monuments with a backpack " last year. This year, in cooperation with the Slovak Technical Museum, we are preparing an exhibition and conference dedicated to ironworks. We should also publish a digital almanac dedicated to mill research.

What do you think are the biggest challenges in protecting this type of cultural heritage at the moment? Can an approach of some other European countries be inspiring in this regard and why?

Dvořáková: The biggest challenge for us is to continuously complete field research, on the basis of which it is possible to add monuments to the *Central List of Cultural Monuments,* and at the same time follow international trends in their preservation. A great contribution in recent years has been the establishment of cooperation with a partner monument institution in Oslo, because Norway repeatedly contributes to the restoration of cultural monuments in our country. Although some types of monuments are very different, for example Norwegian whaling heritage, the principles of protection remain the same. Another very inspiring country is the Federal Republic of Germany, where a good example is Emscher Park, the restoration of a depressed industrial area in the Ruhr, which can be a guide for the restoration of the former industrial areas of Kladno and Ostrava.

Bartošíková: The main challenges of the protection of technical monuments include more sensitive conversions, better protection of technologies, appreciation of the importance of archaeological technical heritage, as well as protection of mining and industrial cultural landscape. I think the protection of monuments of the second half of the 20th century is a phenomenon that goes beyond the field of technical monuments. Specifically, the protection of industrial sites is not properly understood in our country either – mostly we only manage to ensure the protection of solitary buildings.

Among European countries, Spain's approach to the protection of chimneys is interesting, where even when the factory is demolished, they leave the chimney standing as a reminder of history. In our country, the entire factory is often demolished only for preventive reasons, or because it is possible to draw subsidies for it.

To conclude, we would like to ask a slightly more personal question – which monument from the field of water management do you like the most or have a closer relationship to and why?

Dvořáková: Mostly it is the technical monument where I am currently the guarantor of restoration. From the area of water management constructions, I would probably mention the lock in Hořín and, from my point of view, its successful technical modification. The essence of the lock modifications was to increase the passability of the navigation channel for taller cabin ships and cargo traffic, so that the original reinforced concrete arch of the larger lock chamber was replaced by a steel structure that is hydraulically lifted on pistons. When the upper arch is extended during the passage of ships, it represents a perfect water work, which remains a legitimate cultural monument supplemented by a new technical solution that is in line with the objective of the lock. In the case of technical heritage, it is necessary to accept the idea of other possibilities of innovation of technical devices and technologies while preserving their main function, and that these innovations are permissible from the point of view of monument preservation, because they allow the functionality of the technical work to be preserved.

Bartošíková: From an aesthetic point of view, I like water tanks. In the monument fund, especially the elevated water tanks – in Trnava, Bernolákovo, and Palárikovo – are interesting. The system of two artistically decorated ground reservoirs with preserved technology, but also with the torso of the original orchad treatment with sculptural decoration, which is located in Bratislava, I described in detail in a professional proposal for declaration as a monument.

I was also pleasantly surprised by the system of monuments – a well – a pumping station – a technological facility on the island of Sihoť in Bratislava. Normally, this object is not accessible as it is a still functional source of drinking water. However, it is characterized by a picturesque aesthetic set in a natural environment, which you do not expect in Bratislava.

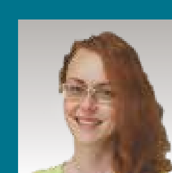
Thank you both for the interview.

Ing. Miriam Dzuráková
and Ing. Robert Kořínek, Ph.D.

Ing. arch. Eva Dvořáková

Ing. arch. Eva Dvořáková is a graduate of the Faculty of Civil Engineering, majoring in architecture, at the Czech Technical University (CTU) in Prague. Since 1974, she has been working in the field of monument preservation. In the National Heritage Institute, within a specialized department, she deals with technical and industrial heritage and also researches industrial and technical facilities and objects. She is one of the initiators of the establishment of the Industrial Heritage Protection Section at the National Technical Museum in Prague (1987) and is a member of the Scientific Council of the Industrial Heritage Research Centre at the Faculty of architecture of CTU. She is also the co-author of a number of publications, including Industriální skanzen Čechy a Morava (Prague 1992), Technické památky v Čechách, na Moravě a ve Slezsku (Prague 2000), Industriál – paměť – východiska (Prague 2007), and Industriální cesty českým středozápadem (Kladno 2009).

Ing. arch. Tereza Bartošíková, Ph.D.



Ing. arch. Tereza Bartošíková, Ph.D., has been an employee of the Monuments Board of the Slovak Republic since 2015. She graduated from the Faculty of architecture of Slovak University of Technology (STU) in Bratislava, and defended her Ph.D. thesis at the same Faculty. During her studies, she completed an internship at the Industrial Heritage Research Centre at CTU. She deals with technical monuments in the entire area of Slovakia from the earliest times to the second half of the 20th century. She combines research and mapping of technical monuments with publishing and educational activities. On the basis of her proposals, several valuable and interesting technical objects have already been declared cultural monuments, including water management ones.

Use and popularisation of historical and current water management sources of information for the development of an environmentally friendly society

Since time immemorial, research in all scientific fields has brought countless new information and broadened the spectrum of current knowledge. In the past, research was made more difficult by the then possibilities of disseminating newly acquired knowledge. Many scientists in the world have asked the same questions, proposed and tested similar hypotheses, obtained similar scientific results, and reached their own unique conclusions. The problem was the very limited possibility of sharing this new information, thus the possibility of their mutual use and very often their preservation and availability to future generations. It is safe to say that in the history of science, a huge amount of knowledge and information was discovered that was not used enough, was discovered repeatedly, or was completely lost.

The present time brings countless possibilities and tools for collecting preserved historical data and using them in the context of today's findings. The collaboration of experts from various scientific fields with historians proves to be very beneficial; they can find their way around archives, search them, and make historical documents from various fields of science available for new processing and use. Another great benefit is the possibility of digitization and advanced technical processing of historical findings, and thus preserving it for future generations.

These activities are supported by the projects of the Programme for the Support of applied Research and Experimental Development of National and Cultural Identity (NAKI and NAKI II), announced by the Ministry of Culture. Since 2012, the TGM WRI employees have been intensively using this project programme to make available and re-use historical water management information and to compare it with current knowledge.

In the *Long-term conceptual development of a research organisation* ("LCDRO") for 2018-2022, which is based on *the Methodology for Evaluating Research Organizations and Research, Development and Innovation Purpose-tied Aid Programmes* (*Methodology 17+*), approved by *Resolution of the Government of the Czech Republic No. 107/2017*, on the *Methodology for Evaluating Research Organizations and Research, Development and Innovation Purpose-tied Aid Programmes*, since 2018, the research task RT11 *"Use and popularisation of historical and current water management sources of information for the development of an environmentally friendly society"* has been included.

This part of LCDRO, with the contribution of purpose-tied institutional funds, supports research and the dissemination of knowledge, which in the area of RT11 represents the use of historical resources and experience in accordance with the theme of area 5 (Environmentally friendly society) of the Research and Development Concept of the Ministry of the Environment for 2016–2025.

The research task is mainly linked to projects implemented under the NAKI programme, focused on water management topics from a historical perspective and activities within their implementation after their completion (*Tab. 1*).

The projects are oriented towards research and processing of historical sources of information with the aim of assessing the state and effect of changes on environmental components, natural resources, landscape, and people. The most valuable contribution of these projects is the search, registration, and inventory of available documents related to the topic. In addition to books and other written materials, other sources of information include historical maps, photographs, archival materials, works of art, and personal experience from contemporary witness. Information from historical sources is processed and presented in classic and modern forms of output so that they are accessible for further use and presentation to interested professionals and the lay public. In addition to professional outputs, project results are made available in the form of popular science books, interactive maps, web applications, educational programmes, and public databases. The results of the projects are presented to the public through websites, exhibitions, workshops, seminars, conferences, media reports, etc.

RESEARCH TASK RT11 IS CURRENTLY DIVIDED INTO THREE SUB-OBJECTIVES:

DC11-1 Research and processing of historical sources of information in the field of water supply and management

Within sub-objective DC11-1, research and processing of historical sources of information is carried out in the areas of water supply and management, water treatment for the needs of settlements and industry, water supply, water purification, and historical development of water management.

This part is supported by the ongoing project *"Water towers – identification, documentation, presentation, new utilization"* within the NAKI II programme and the implementation of the project *"Possibilities of water recreation within the capital city of Prague (from history to the present)"*, the completed project*" Recreational potential of water in Prague – status and perspectives"* within the Operational Programme Prague – Growth Pole of the Czech Republic, and *"Documentation, pasportization, archiving and proposal of chimney reservoir converting as an endangered group of heritage of industrial monuments in the Czech Republic"*, implemented in 2013–2015 within the NAKI programme.

DC11-2 Research and processing of historical sources of information in the field of water management in the landscape

Within sub-objective DC11-2, research and processing of historical sources of information in the areas of water management in the landscape, the impacts of significant water management changes on further development (construction of water works, water management treatment of watercourses, extreme climatic phenomena, sources of pollution, etc.), and historical development of water treatment.

The sub-objective is supported by the ongoing projects *"Historical water management objects, their value, function and significance for the p resent"* and *"Irrigations – rediscovered heritage, their documentation and popularization"*, implemented within the NAKI II programme, and the implementation of the completed projects *"Non-invasive and economical techniques of water elements* *environment quality and maintenance solution in the frame of historical monuments care"* (NAKI) and *"Assesment of agricultural land in the areas of extinct fishpond systems with the aim of supporting sustainable management of water and soil resources in the Czech Republic"* (KUS Programme of the Ministry of agriculture).

In the years 2012–2016, the combination of historical water management topics was addressed in the projects of the NAKI programme *"Identification of significant areas with cultural and historical values threatened by natural and anthropogenic stresses"* and *"Submerged villages – the lost cultural and natural heritage of the South Moravia" (Tab. 1).*

DC11-3 Environmental education and promotion of water management issues with the aim of creating an environmentally friendly society

Sub-objective DC11-3 is focused on current trends in the transmission of information to the public, awareness of professional activities in the field of water management, inclusion of the professional and lay public in environmental education, training and awareness (environmentální vzdělávání, výchova a osvěta, EVVO) and environmental consultancy (environmentální poradenství, EP), streamlining the presentation of environmental protection in the media, and expansion of the portfolio of contacts and presentation possibilities. Activities are carried out in cooperation with the TGM WRI PR department by publishing popularization articles and promoting project results in the VTEI journal, on web and Facebook pages, and in the media.

As part of the activities of LCDRO *"Use and popularisation of historical and current water management sources of information for the development of an environmentally friendly society"*, a number of professional outputs were created which were presented to the professional public in the form of professional articles and presentations at scientific conferences and seminars and processed into methodologies. These outputs contribute to better results of TGM WRI in the evaluation of research organizations and the related allocation of purpose-tied research support.

Other activities are aimed at popularizing interesting historical and contemporary water management topics. For this purpose, both within the projects and other activities of TGM WRI, popular-scientific types of outputs are created. Below is a selection of them:

Popular scientific and professional books

- PAVELKOVÁ, R., FRAJER, J., NETOPIL, P. et al. *Historické rybníky České republiky: srovnání současnosti se stavem v 2. polovině 19. století.* Prague 2014, 167 p.
- ROZKOŠNÝ, M. et al. *Zaniklé rybníky v České republice – případové studie potenciálního využití území.* Prague 2015, 170 p.
- MLEJNKOVÁ, H. et al. *Zatopené kulturní a přírodní dědictví jižní Moravy.* Brno 2016, 263 p. Available at: https://heis.vuv.cz/projekty/zatopene-dedictvi?s=pdf/kniha_zatopene_dedictvi.pdf
- *Zatopené kulturní a přírodní dědictví jižní Moravy exhibition catalogue.* Prague 2016, 210 p. Available at: https://heis.vuv.cz/projekty/zatopene-dedictvi?s=pdf/katalog_vystavy.pdf
- ROZKOŠNÝ, M. et al. *Kvalita prostředí vodních prvků kulturních památek a historických sídel. Posouzení stavu a možnosti řízení kvality v rámci památkové péče.* Prague 2019, 120 p. Available at: https://heis.vuv.cz/projekty/vodniprvky
- KULT A. et al. *1919–2019. Sto let činnosti Výzkumného ústavu vodohospodářského od jeho založení v roce 1919: Historie v datech.* Prague 2020, 405 p;
- *1919–2019. 100 let činnosti Výzkumného ústavu vodohospodářského: Historie ve fotografiích.* Prague 2020, 110 p.
- VONKA, M., KOŘÍNEK, R., HOŘICKÁ, J., PUSTĚJOVSKÝ, J. *Komínové vodojemy: situace, hodnoty, možnosti.* Prague 2015, 127 p.
- VONKA, M., KOŘÍNEK, R. *Komínové vodojemy. Funkce, konstrukce, architektura.* Prague 2015, 103 p.

Specialized maps and map files

- *Současný stav historických rybníků na území České republiky, 2013.* Available at: https://heis.vuv.cz/projekty/historickerybniky
- *Současné půdní poměry na plochách zaniklých rybníků v okresech Pardubice a Jindřichův Hradec*, 2015.
- *Změny využití krajiny v zázemí vodní nádrže Vranov*, 2016. Available from: https:/ https://heis.vuv.cz/projekty/zatopene-dedictvi?s=mapy/Vranov_mapa%20vyuziti%20krajiny.pdf
- *Změny využití krajiny v zázemí vodní nádrže Brno*, 2016. Available at: https://heis.vuv.cz/projekty/zatopene-dedictvi?s=mapy/Brno_mapa%20vyuziti%20krajiny.pdf
- *Změny využití krajiny v zázemí vodního díla Nové Mlýny*, 2016. Available at: https://heis.vuv.cz/projekty/zatopene-dedictvi?s=mapy/Nove_Mlyny_mapa%20vyuziti%20krajiny.pdf
- *Vliv změny využití krajiny na ohroženost půdy vodní erozí v zázemí vodního díla Nové Mlýny*, 2016. Available at: https://heis.vuv.cz/projekty/zatopene-dedictvi?s=mapy/Mapa_vliv_krajiny_na_erozi.pdf
- *Archeologické lokality pod hladinou Vodního díla Nové Mlýny*, 2016. Available at: https://heis.vuv.cz/data/webmap/datovesady/projekty/zatopenededictvi/mapy/mapa_archeo.pdf
- *Historické vodohospodářské objekty v povodí Svitavy*, 2020, Available at: https://heis.vuv.cz/projekty/vh-objekty?t=vystupy&t2=svitava
- *Možnosti vodní rekreace na území hlavního města Prahy (od historie po současnost)*, 2020. Available at: https://heis.vuv.cz/projekty/praha-rekreace?t=aktivita2&t2=vysledky
- *Historické vodohospodářské objekty v povodí horní Moravy*, 2021. Available at: https://heis.vuv.cz/projekty/vh-objekty?t=vystupy&t2=horni_morava
- *Historické vodohospodářské objekty v povodí Moravice*, 2021. Available at: https://heis.vuv.cz/projekty/vh-objekty?t=vystupy&t2=moravice
- *Historické vodohospodářské objekty v povodí Ploučnice*, 2022. Available at: https://heis.vuv.cz/projekty/vh-objekty?t=vystupy&t2=ploucnice
- *Historické vodohospodářské objekty v povodí Doubravy a horní Klejnárky (Čáslavsko)*, 2022. Available at: https://heis.vuv.cz/projekty/vh-objekty?t=vystupy&t2=caslavsko

Workshops, conferences, and exhibitions

- *Zatopené kulturní a přírodní dědictví jižní Moravy*, 2016 – mobile exhibition.
- *Povodně a sucho v zatopených obcích jižní Moravy, jak je zachytily dobové kroniky, fotografie a vyprávění*, 2016 – educational event.
- *Památky ohrožené přírodními a antropogenními vlivy*, 2018 – Brno, professional seminar.
- *Rybníky 2018* – Prague, cooperation with organizing the conference.
- *Věžové vodojemy v pozadí*, 2018 – workshop.
- *Historie plavebního kanálu Dunaj-Odra-Labe,* 2019 – Brno, workshop.
- Věžové vodojemy, 2019 – Prague, conference.
- *Národní dialog o vodě*, 2019 – Nové Město na Moravě, meeting of the water management public and representatives of the state administration and local government.
- *Praktické poznatky a doporučení k péči a údržbě vodních prvků památkově chráněných lokalit*, 2019 – Kroměříž, professional seminar.
- *Extrémní hydrologické jevy ve vztahu k ochraně památek*, 2018 – educational seminar.

Tab. 1. Projects focused on the processing of historical water management sources of information

Time period	Principal investigator	Project identifier	Programme	Project title	Project aims
2012–2015	FOREJTNÍKOVÁ, Milena	DF12P01OVV035	NAKI 2011 till 2017 (MK)	*"Identification of significant areas with cultural and historical values threatened by natural and anthropogenic stresses"*	As part of the project, the degree of potential threat to selected categories of monuments (national cultural monuments and world cultural heritage monuments) and protected areas (urban heritage reserves, village heritage reserves, archaeological heritage reserves, and other heritage reserves) by significant natural, industrial, and agricultural risks was evaluated with a uniform procedure for the entire Czech Republic.
2012–2015	ROZKOŠNÝ, Miloš	QJ1220233	KUS 2012 till 2018 (MZE)	*"Assesment of agricultural land in the areas of extinct fishpond systems with the aim of supporting sustainable management of water and soil resources in the Czech Republic"*	As part of the project, an inventory of the areas of former pond systems (water bodies), and an assessment of the current landscape in these areas was carried out, and changes to strengthen the sustainable management of water and soil resources were proposed.
2013–2015	KOŘÍNEK, Robert	DF13P01OVV021	NAKI 2011 till 2017 (MK)	*"Documentation, pasportization, archiving and proposal of chimney reservoir converting as an endangered group of heritage of industrial monuments in the Czech Republic"*	As part of the project, the location of existing chimney water towers in the Czech Republic and their construction historical survey was carried out, construction documentation/passporting of the objects was created, original and current image documentation was collected, and proposals for the reconstruction and conversion of existing chimney water towers were created both from the point of view of the original purpose and a completely new use.
2013–2016	MLEJNKOVÁ, Hana	DF13P01OVV012	NAKI 2011 till 2017 (MK)	*"Submerged villages – the lost cultural and natural heritage of the South Moravia"*	The project evaluated the historical, socio-cultural, and ecological continuity of the area, which was completely changed by water management adjustments, and compared the state of society, culture, landscape, watercourses, water bodies, and their use, habitats, and other components shaping the cultural and natural heritage of South Moravia, before and after the flooding of large areas during the construction of water reservoirs – Nové Mlýny, Vranov Reservoir, and Brno Reservoir.
2016–2019	ROZKOŠNÝ, Miloš	DG16P02M032	NAKI II 2016 till 2022 (MK)	*"Non-invasive and economical techniques of water elements environment quality and maintenance solution in the frame of historical monuments care"*	The project was aimed at verifying environmentally friendly and non-invasive technologies for maintaining or improving the quality of the aquatic environment and reducing the amount and dangerous properties of the bottom sediment of reservoirs in the area of cultural monuments and historical settlements.
2018–2020	MLEJNKOVÁ, Hana	UH0382	Operační program Praha – pól růstu ČR	*"Recreational potential of water in Prague – status and perspectives"*	The project aim was to evaluate the development of water recreation in Prague from the end of the 19th century to the present day and to map the recreational potential of current and future bathing locations in Prague. The subject of the research was the evaluation of current possibilities (including advantages and limitations) for water recreation and the mapping of other, so far unused water bodies with the aim of determining the potential of their use and assessing the current water quality and the possibilities of improving their condition.

Time period	Principal investigator	Project identifier	Program	Project title	Project aims
2018–2022	KOŘÍNEK, Robert	DG18P02OVV010	NAKI II 2016 till 2022 (MK)	*"Water towers – identification, documentation, presentation, new utilization"*	The project aim is the identification and registration of water towers, their documentation, determination of their value and comprehensive processing of the historical, structural, technological, and architectural development of these buildings in our country. Furthermore, the project deals with proposals for new uses for them, especially in the form of conversions.
2018–2022	DZURÁKOVÁ, Miriam	DG18P02OVV019	NAKI II 2016 till 2022 (MK)	*"Historical water management objects, their value, function and significance for the present"*	The project aim is to contribute to the knowledge, systematic documentation, and setting of objective evaluation criteria for a specific group of technical monuments from the category "historical water management structures". As part of the project, a methodology for unambiguous identification, classification, evaluation in terms of monument preservation, protection, and restoration of historical water management objects is created through criteria established on the basis of an interdisciplinary approach.
2020–2022	ROZKOŠNÝ, Miloš	DG20P02OVV015	NAKI II 2016 till 2022 (MK)	*"Irrigations – rediscovered heritage, their documentation and popularization"*	The project aims to document comprehensively and in detail and popularize the history of irrigation and part of the industry associated with its implementation and production of soil irrigation equipment as specific sectors of water management and industrial heritage.

— *Danube Day*, 2018–2022 – regular educational event.
— *TGM WRI Open Day* 2018–2022 –regular educational event.
— *Mobile exhibition on the occasion of the 100th anniversary of the founding of the TGM WRI*, 2019.
— *Konverze věžových vodojemů*, 2021 – Prague, exhibition.

Web and Facebook pages

— *Flooded cultural and natural heritage of South Moravia:* https://heis.vuv.cz/projekty/zatopene-dedictvi https://www.facebook.com/zatopenededictvi
— *Possibilities for water recreation within the capital city of Prague (from history to the present):* https://heis.vuv.cz/projekty/vezovevodojemy https://www.facebook.com/plovarnypraha
— *Water towers*: https://heis.vuv.cz/projekty/vezovevodojemy, www.vezovevodojemy.cz, https://www.facebook.com/VezoveVodojemy

Web applications

— *Evaluation of areas on former pond systems (water bodies) with the aim of strengthening sustainable management of water and soil resources in the Czech Republic. Interactive application.* Available at: https://heis.vuv.cz/projekty/historickerybniky
— *Non-invasive and environmentally friendly procedures for solving the environmental quality and maintenance of water features within monument preservation. Web presentation of the project*. Available at: https://heis.vuv.cz/projekty/zavlahy
— *Interaction of extreme hydrological phenomena with listed objects. Web application.*
— *Possibilities of water recreation within the capital city of Prague (from history to the present). Web map application*. Available at: http://www.dibavod.cz/vodni-rekreace-praha
— *Irrigation – rediscovered heritage, its documentation, and popularization. Web application of the project, database of selected locations of irrigation systems and buildings.* Available at: https://heis.vuv.cz/projekty/zavlahy
— *Historical water management objects, their value, function, and significance for the present time. Project web application.* Available at: https://heis.vuv.cz/data/webmap/datovesady/projekty/vhobjekty/
— *Threats to listed buildings from external influences. Web map presentation.* Available at: https://heis.vuv.cz/data/webmap/datovesady/projekty/ohrozenepamatky/default.asp

Databases

— *Database of water towers*. Available at: http://www.vezovevodojemy.cz/?action=diesel.list&table=vodojemy
— *Flooded Cultural and Natural Heritage of South Moravia* Database. Available at: https://heis.vuv.cz/projekty/zatopene-dedictvi?t=dtb

- *Possibilities for water recreation within the capital city of Prague (from history to the present) database.* Available at: https://heis.vuv.cz/data/webmap/datovesady/projekty/polrustu2rekreace/default.asp?lang=&tab=4&tab2=6&wmap=
- *Database of selected irrigation systems and objects.* Available at: https://meliorace.vumop.cz/zavlahy/popularizace/databazi.html
- *Database of mapped historical water management objects of the Czech Republic.* Available at: https://heis.vuv.cz/data/webmap/datovesady/projekty/vhobjekty/default.asp?lang=&tab=2&tab2=7&wmap=
- *Database of historical water management objects in selected river basins of the Czech Republic*. Available at: https://heis.vuv.cz/projekty/vh-objekty?t=vystupy&t2=databazepp

Educational material

- *"Jak se žilo v Bítově a Kníničkách, než zmizely pod hladinami přehradních nádrží?" (How was life in Bítov and Kníničky before they disappeared under the dam reservoirs?)* Available at: https://heis.vuv.cz/projekty/zatopene-dedictvi?s=eduk/zivot_v_obcich_pred_zatopenim.pdf
- *"Procházka starým Bítovem". (A walk through old Bítov).* Available at: https://heis.vuv.cz/projekty/zatopene-dedictvi?s=eduk/prochazka_starym_bitovem.mp4
- *Virtual tour of Cornštejn under Bítov.* Available at: https://www.youtube.com/watch?v=VflxM7j8ZjM
- *Atlas of biothreats* (created to support the methodology of *Identification of important areas with cultural-historical values threatened by natural and anthropogenic influences*).

The research projects and other activities focused on historical topics showed the importance of historical data which are often neglected, especially due to their poor availability. The study of this type of information sources often requires the cooperation of historians and archive workers, and also mutual helpfulness and cooperation between professional institutions or state enterprises and private companies that have their own professional archives. Equally important is the benefit of working with contemporary witness and preserving their memories, as well as private documents and archives, including photographic ones. A specific feature of a number of water management systems, works, and objects is their continuous modernization and reconstruction with the aim of ensuring the fulfilment of current social needs and requirements. For these reasons as well, it is important to be able to preserve, or at least document, their condition and equipment – including instrumentation – during different periods of their operation. It is therefore very worthwhile to dedicate oneself to such research, and thus save a lot of useful and often irreplaceable information for future generations.

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Banská Štiavnica water management system – an important UNESCO technical monument

From the 16th to the 19th century, a unique water management system was created in Banská Štiavnica and its vicinity, which served the local mines. The water management system consisted of water channels – collecting ditches, which concentrated surface water from Štiavnické vrchy (Štiavnica mountains) and brought it to the mining water reservoirs (tajchy). Tajchy are water reservoirs that were built to accumulate surface water from the collecting ditches. Water from the tajchy was discharged into water canals – transporting ditches that brought water to the shafts. Here, the water was piped into the depths of the mine, where the obtained water energy powered pumping machines that pumped groundwater out of the flooded mines. Once the groundwater was drained, the miners could continue extracting gold and silver. Water-powered processing facilities also operated in Banská Štiavnica and its vicinity, which processed the extracted ore from the mines. For centuries, the Banská Štiavnica water management system set in motion more than a hundred water-powered devices. The system consisted of about 60 tajchy, 170 km of ditches, and 15 water tunnels.

Tajchy – dams and reservoirs

Tajchy are earthfill dams. The dams were filled with the earth from the nearby area. From the point of view of the construction of dams, we can divide tajchy into homogeneous and heterogeneous. Homogeneous tajchy are older, lower, and more massive. The body of such a dam consists of one or more types of soil with similar properties. These dams are the oldest and were mostly built before the arrival of Samuel Mikovíni. The second type is heterogeneous dams, which consist of stabilizing parts and a central sealing core. These are slimmer, higher dams with better stability. In the stabilization parts, there are mostly construction debris and in the sealing core, clay or loam. The height of the tajchy varies from 3.3 m to the highest Velká Richňava (31.9 m). Usually, tajchy have only one dam – a dam over the valley. However, there are also tajchy with two or more dams. For example, Počúvadliansky tajch has six dams.

Collecting and transporting ditches and water tunnels

Collecting and transporting ditches were open channels that were laid out along contours with a minimum slope. The slope of the collecting ditches was around 0.66% (4 feet per 100 fathoms). The transporting ditches had a gentler slope than the collecting ditches – about 0.16% (12 inches per 100 fathoms). The width of the ditches was from 0.6 m to 1.0 m, while their depth varied from 0.5 m to 1.5 m. The ditches consisted of a trough and a dyke. In order to avoid major losses and to speed up the transfer of water, some long arched parts of the ditches were replaced by water tunnels. Water tunnels were also dug along the ditch routes which transferred water from basin to basin. Building ditches and water tunnels was certainly not cheap.

Current state of the water management system – UNESCO technical monument

In 1993, Banská Štiavnica – and the technical monuments in its vicinity – was inscribed on the UNESCO World Cultural Heritage List, the first ever Slovak town to achieve this. The first and fifth conditions for registering the city and its vicinity on the UNESCO list include a unique water management system built since the 16th century, which saw its greatest growth in the 18th century, made maximum use of the hydro-energy potential of the surrounding hills, and remained the most advanced water management system until the 19th century – criterion I. With exhaustible mineral resources, the city became vulnerable with its historic urban structure in disintegration, and the handling of a unique water management system that needed to be protected was threatened – Criterion V.

In a few months, it will be exactly 30 years since the inscription of the Historical Town of Banská Štiavnica and the Technical Monuments of its Vicinity on the UNESCO list. In this part of the article, we present a brief recapitulation of what could and could not be saved in those 30 years. We will focus only on the first – the most important criterion for registration in UNESCO, namely a unique water management system and a description of its current state.

Fig. 1. Štiavnické Mines – Veľká Windšachta, Evička (Photo: S. Červeň)

Fig. 2. Beliansky tajch – summit reservoir of Belianska water management system (Photo: S. Červeň)

Fig. 3. Water tunnel (Photo: S. Červeň)

Fig. 4. The main Richňava collecting ditch (Photo: S. Červeň)

Fig. 5. Veľká Richňava after reconstruction (Photo: S. Červeň)

Fig. 6. Collecting ditch during restoration by CA (Photo: S. Červeň)

Fig. 7. Collecting ditch after restoration by CA (Photo: S. Červeň)

Fig. 8. One of the collecting ditches destroyed by logging (Photo: S. Červeň)

Fig. 9. Inappropriate reconstruction of one of the collecting ditches (Photo: S. Červeň)

Fig. 10. One of the collecting ditches destroyed by logging (Photo: S. Červeň)

In total, there are currently 26 registered Banská Štiavnica tajchy in Štiavnické vrchy, divided into 8 water management systems. Of them, 22 tajchy were transferred from the management of Rudné bane, state enterprise, or from the ownership of the city of Banská Štiavnica to the administration of Slovenský vodohospodársky podnik (Slovak Water Management Company, hereinafter SVP). The other three tajchy are privately owned, and the last tajch is in the administration of Lesy SR, state enterprise (Forests of the Slovak Republic); 23 tajchy reach the maximum operating level. Of the remaining three tajchy, one has been at a minimum water level since its construction. The functional objects were removed from the second tajch, and thus water accumulation is not possible in the reservoir. The dam on the third tajch was damaged during the 20th century, so it can no longer hold water. There are three other smaller tajchy at risk, whose reservoirs are on the verge of being filled with sediments. A total of 18 tajchy were declared national cultural monuments in 1955 and 1979 (10.46555/VTEI.2022.09.001 NKP). In the period from UNESCO inscription (1993) until now, in addition to some listed tajchy, selected objects such as a dam, a safety spillway, bottom outlets etc., have also been declared as monuments. A total of 13 tajchy have been renovated since 1993, either by the administrator, the owner, or another institution.

Štiavnický tajch Civic Association

If in the previous part of the article we talked only about tajchy, in the following one we will evaluate the state of the water management system and its parts – collecting and transporting ditches. In 2011, the Štiavnický tajch Civic Association (hereinafter CA) was founded, thanks to which 73 collecting and transporting ditches and 15 water tunnels were identified in the field over the course of 10 years, with the help of historical maps from the 18th to 20th centuries.

We have divided the current state of collecting and transporting ditches into six groups (in km):

- functional: 2.5 ditches
- preserved: 7.5 ditches
- visible: 13 ditches
- deformed: 11.5 ditches
- not preserved: 20.5 ditches
- non-existent: 18 ditches

Of the total number of ditches, only 2.5 km are functional and maintained. Currently, only 7 ditches have the status of a national cultural monument and are under the protection of the Monuments Act. The other ditches, as UNESCO technical monuments, are protected in accordance with Act no. 100/2002 of 30 January 2001 on the protection and development of the territory of Banská Štiavnica and its vicinity. The declaration of other collecting ditches, transporting ditches, and water tunnels as national cultural monuments is constantly being delayed, which leads to their constant damage. The most frequent causes of the damage of collecting and transporting ditches lie in the ignorance of the owner, manager, or lessee of the land about their occurrence, which is almost incomprehensible in a UNESCO site. Ditches are often removed during forest management – logging, processing, extracting wood, and transporting the harvested wood along the dyke of the ditch. Most of the ditches were damaged in this way. Another reason for the damage of the UNESCO technical monument is the private owners, especially in the cottage areas around the tajchy, who often have access roads to the properties built through ditch channels. In this case, the ditches are damaged by motor vehicles, and even by backfilling the ditches, creating crossings, or building parking areas in the ditches. Incomprehensible are some reconstructions of ditches, where earthen trapezoidal troughs are replaced by concrete ones. This kind of damage of UNESCO's technical monuments has nothing to do with the protection of world heritage and is an indication that something is wrong. Of the total 170 km of ditches that were built around Banská Štiavnica, only 2.5 km are currently functional. However, it is still possible to save and restore another approximately 53 km. The goal of the Štiavnický tajch CA is to protect, save, and educate the public about the unique water management system in the vicinity of Banská Štiavnica. For the protection of UNESCO technical monuments in Banská Štiavnica and its vicinity, a working group was established at the initiative of Štiavnický tajch CA, which is convened by the town of Banská Štiavnica and where proposals for the protection of ditches are presented to the relevant stakeholders. In the field, CA organizes volunteer restoration work, where selected sections of collecting ditches are saved and restored with the help of volunteers. In total, 1.5 km of one of the collecting ditches was saved and maintained within 18 months. As part of public education, CA published two publications about the Banská Štiavnica water management system; the topic is presented on social networks and the website (https://bstajchy.sk/), and there are guided tours around parts of the system and tajchy. The ultimate goal of Štiavnický tajch CA is to restore the last renewable 53 km of ditches and provide them with an administrator who will care about this extremely important UNESCO world technical monument.

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UNDERGROUND HYDROELECTRIC POWER STATION IN KREMNICA

The underground hydroelectric power station is part of the heritage-protected water management system in the Kremnické vrchy (hills) in Slovakia, which consists of the so-called Turčekovský vodovody (water supply system) from the 15th century, a system of three hydroelectric power stations with retention reservoirs and the eleven-kilometre-long tunnel of Emperor Ferdinand. The hydroelectric power station was put into operation in 1922 and it has been functional ever since; it has three original horizontal Pelton turbines from 1920. The main space of the power station has a vaulted ceiling with architectural details. It is located 245 metres underground, under the object of the shaft with a headframe. It is the first and also the deepest underground power station in Europe. In 2023, the information about the underground hydroelectric power station in Kremnica will be followed up by a series of short articles about historical water management buildings, where technically or architecturally valuable objects of this type of industrial heritage will be presented.

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