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# Technical Cultural Heritage on the Elbe-Vltava Waterway

P Fošumpaur, T Kašpar and M Zukal

Department of Hydraulic Structure, Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic

zukal@fsv.cvut.cz

**Abstract.** The article presents the principal objectives and current results of the project “Documentation and Presentation of Technical Cultural Heritage on the Elbe-Vltava Waterway”, which is part of the National and Cultural Identity programme administered by the Ministry of Culture of the Czech Republic. The historical development of the modifications of navigable sections of the Elbe and the Vltava Rivers documents that its beginnings coincide with the beginnings of the settlement of the river valleys in the Middle Ages. These modifications were related to the human need to use rivers for navigation and hydropower generation and went through an interesting development throughout the Medieval Times. The lock structures situated on the Elbe-Vltava Waterway represent extensive and unique technical heritage which still serves its original purpose. The locks are typically composed of a weir structure, a lock and a hydroelectric power plant. The project’s objective is to document the existing technical heritage at the level of individual locks and their construction and technological elements. Furthermore, attention will be focused on the identification of endangered structures on the Elbe-Vltava waterway which no longer meet the present-day functional or capacity requirements and which will probably need to undergo sensitive modernisations in the future in the context of their cultural and historical value. The project intends to present and introduce these technical monuments to the general public. The presentation of the structures includes the historical development of their design, the description of the original technological elements and their present-day role in water transport, and the exploitation of their potential for recreation and tourism.

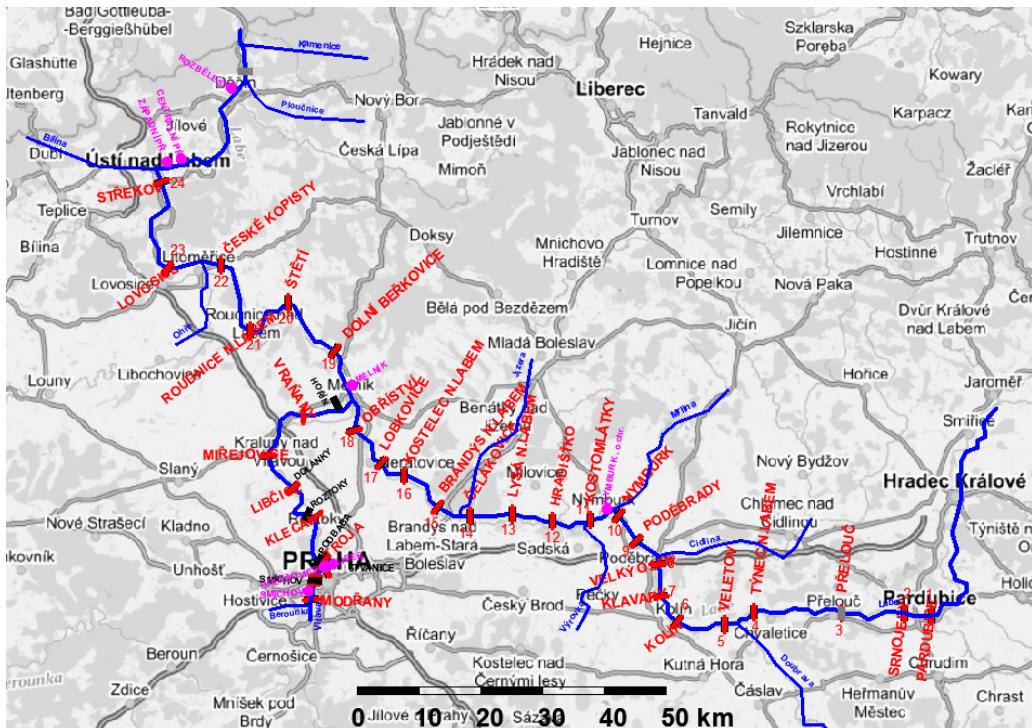
## 1. Introduction

The historical development of the modifications of the navigable sections of the Elbe and the Vltava Rivers documents that its beginnings coincide with the beginnings of the settlement of the river valleys in the Middle Ages. These modifications were related to the human need to use rivers for navigation and hydropower generation and went through an interesting development throughout the Medieval Times. During the 19<sup>th</sup> century and in the first half of the 20<sup>th</sup> century, an extensive water management infrastructure was gradually built on the Elbe-Vltava Waterway (EVW). Its construction was initially motivated mainly by the development of water transport, but, at the same time, it is a system of multifunctional structures fulfilling many other purposes (water intakes, hydropower generation, flood control, water sports and recreation). There are currently over 30 locks situated on EVW most of which belong by their nature to technical and industrial heritage, which, in general, represents one of the most endangered types of cultural heritage. The high degree of vulnerability of this cultural heritage stems from the fact that the original structures still serve their purpose and they need to be modernized and reconstructed. At the same time, these historic locks represent a unique



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collection of technical cultural heritage whose presentation and introduction to the general public will favourably support its both economic and non-economic use in society in the form of the development of tourism and the recreational potential of the waterways as well as the strengthening of national self-awareness. The EVW scheme is displayed in Fig.1.



**Figure 1.** Scheme of the Elbe-Vltava Waterway.

The regeneration and restoration methods used on British waterways were evaluated by Maeer and Millar [1], who conclude that the British waterways experienced a boom during the Industrial Revolution, but stagnation occurred after the end of World War II. At present, however, the state has taken care of the waterways. The result is, on the one hand, the restoration and conservation of cultural heritage and, at the same time, a non-negligible economic benefit in the form of tourism. A similar conclusion was reached by Harrison and Sutton [2], who positively evaluate the care of cultural heritage on the waterways in England and Wales in connection with indirect economic benefits to the regions and discuss possibilities for raising the necessary funding. An excellent example of the restoration and exploitation of technical heritage on waterways are also Scotland's canals, namely the Forth and Clyde Canal, which is connected with the Union Canal via a modern-time rotating boat lift in Falkirk [3].

In 2018–2022, the Faculty of Civil Engineering, CTU in Prague is involved in research on the grant project “Documentation and Presentation of Technical Cultural Heritage on the Elbe-Vltava Waterway”, which is part of the National and Cultural Identity programme administered by the Ministry of Culture of the Czech Republic. The co-researchers participating in the project are the staff of the Povodí Labe and Povodí Vltavy state enterprises. There are two main objectives of the project: (1) documentation of the technical cultural heritage on the Elbe-Vltava Waterway and (2) presentation of the technical cultural heritage on the Elbe-Vltava Waterway to the general public.

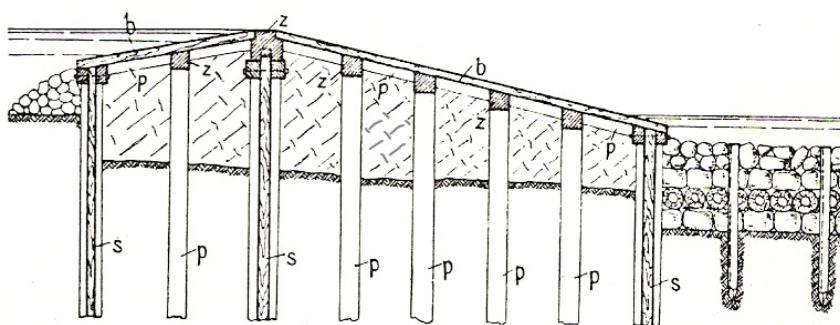
## 2. Development of the Elbe-Vltava Waterway

### 2.1. History of Elbe-Vltava Waterway modifications

The settlement of a territory usually started in the valleys of major rivers offering more favourable conditions for the development of agriculture and industry and for protection against enemy raids. From the 13<sup>th</sup> century, life along the Elbe River was centred mainly around the development of major royal towns situated near the river. In this way, the towns of Dvůr Králové, Jaroměř, Hradec Králové, Kolín, Nymburk, Poděbrady, Mělník, Litoměřice and Ústí nad Labem had originated. Alongside the benefits brought by the proximity to the river, people naturally also had to face the devastating consequences of floods. In dry periods, on the contrary, people had to face problems related to the shortage of water. From the beginnings of the settlement of Bohemia, the Elbe and the Vltava Rivers were used as preferred transportation routes encouraging the foundation of settlements, trade, and, later on, industry. The earliest preserved mentions related to the above go back to the 6<sup>th</sup> century and more numerous written documents date back to the 10<sup>th</sup> century.

The training of watercourses in the Czech Republic has a long history, and the most frequent reason for this was to protect against floods, ensure navigability, generate hydropower, enable water intakes (population, irrigation and industry), stabilize the riverbed against erosion by water, etc. The first training of the Vltava and the Elbe Rivers dates back to the reign of Charles IV, who tried to support the development of ship transport in Bohemia. The economic policy of Charles IV was based on the experience from Flanders, France and Italy, where he had seen how shipping helped to develop international trade. Further importance of the Elbe and the Vltava River training was in the exploitation of hydraulic energy through water mills, sawmills and trip hammers, which were established as early as the 13<sup>th</sup> and 14<sup>th</sup> centuries. For a more efficient use of hydropower, fixed weirs were built, which, however, formed an obstacle to navigation, and the eternal dispute of wood floaters over water law was the main problem of navigation until the 18<sup>th</sup> century. The disputes over water had to be solved by the municipal council, and Charles IV intervened in them by issuing a privilege in 1340 establishing the "Guild of Chartered Provincial Millers", whose jurisdiction was to judge disputes over water and the height of weirs. It was, in fact, the first water management institution in the history of the Czech state.

The first fixed weirs of the 13<sup>th</sup> century were wooden structures and a considerable number of them has been preserved to-date. They are historically valuable structures that are part of cultural heritage. The most durable ones are, in particular, wooden weirs with filling. They are basically composed of one or more wooden sheet-pile walls *s* and a row of piles *P* onto which horizontal beams *z* are pinned-jointed. The horizontal beams of the piles are connected by soldier beams *p* (see Fig. 2). The filling used was stone, rammed earth, clay, sand with loam, etc. The spillway structure consisted of the formwork *b* (formerly always made of larch planes) [4].



**Figure 2.** Wooden weir with filling [4].

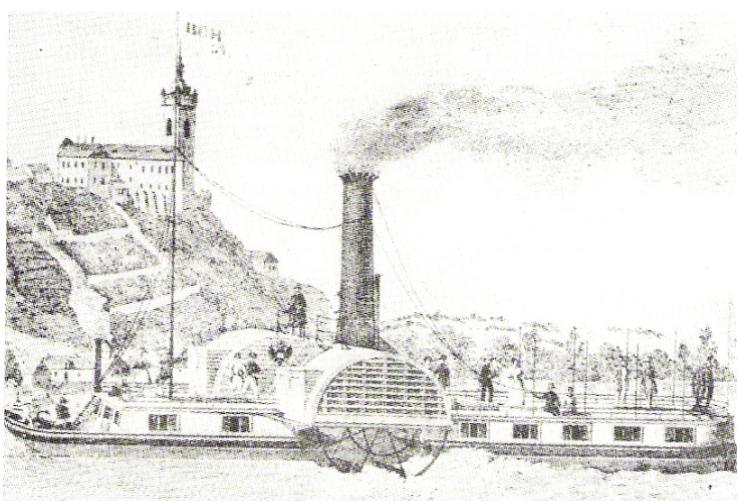
The above described weir construction most likely originated from the weir constructions on the Vltava River in Prague built as early as the 13<sup>th</sup> century. For this reason, they have been referred to as Prague weirs or Old Prague weirs to this day. The Old Town weir above Charles Bridge, whose longitudinal axis runs diagonally across the Vltava River, is fitted with a log sluice about halfway

across the river. Another weir from the 13<sup>th</sup> century that has been preserved on the Vltava River in Prague is the Štítkovský Weir, built in a similar way. The weir has a broken axis and is also divided by a log sluice [5]. The Middle Elbe River section from Hradec Králové to Mělník used to accommodate a total of 14 fixed mill weirs of the Old Prague type with heads from 0.97 m (Valy) to 2.97 m (Opatovice). In Opatovice, the first weir on the Elbe River had probably been built as early as the second half of the 14<sup>th</sup> century when the Benedictines of Opatovice founded a famous pond system in the Pardubice region.

Other larger modifications of the Vltava and the Elbe Rivers date back to the 16<sup>th</sup> and 17<sup>th</sup> centuries after the Habsburgs had entered the Czech throne. The Habsburg rulers, who owned the salt mines in Salzburg, tried to improve the navigation conditions on the Vltava and the Elbe Rivers to enable salt and timber water transport to Bohemia and Germany. Numerous fixed weirs that raised the water level and created hydraulic gradients for mills became a major obstacle to navigation and a source of disputes. That is why Emperor Ferdinand negotiated this issue with the representatives of the principality and the estates as early as 1549. In 1570, a Commission was set up to regulate the Elbe and the Vltava Rivers from Prague to Litoměřice. In 1627, Emperor Ferdinand II sent the Commission to check all weirs on the Vltava and the Elbe Rivers. After that, the navigation potential of the Elbe River began to increase rapidly, and, in 1651, Saxon ships could sail all the way from Hamburg to Prague.

In 1764, the Navigation Commission was established headed by its director, Prof. Ferdinand Schor. It started systematic geometric measurements, and thus the first maps of the Elbe-Vltava Waterway came into existence. The first navigation locks in Bohemia were built on the Vltava River near Županice below Kamýk and near Modřany as early as 1726 to 1729. Numerous weirs began to be dismantled to facilitate navigation, shallow waters were deepened, rocky shoals blasted away and towpaths for towing boats by horses built. All of this, of course, was not accomplished without difficulty and it was, above all, the millers who put up strong resistance as the demolition of weirs posed a threat to their existence.

In 1770, the Directorate for Water Structures in Bohemia (later known as the Directorate of Waterways) was founded. It replaced the Chartered Provincial Millers with trained military engineers. In 1777, Maria Theresa issued a so-called navigational patent to promote navigation, which prioritized navigation over all the other uses of the river and declared navigable streams as state property. A technological breakthrough in the field of navigation was the invention of the steam engine. The first steamboat manufactured in Bohemia was ceremonially launched at the Karlín shipyard on Rohan Island on May 1, 1841. It was named Bohemia and its design was developed by the Englishmen Andrews and Ruston, together with Vojtěch Lanna, an imperial boatswain and entrepreneur from České Budějovice. The steamer was 38 m long and 5 m wide, with a 0.42 m draught designed to carry 140 passengers.



**Figure 3.** Steamer Bohemia.

## 2.2. Modern-time modifications of navigable sections of the Elbe and Vltava Rivers of 19<sup>th</sup> and 20<sup>th</sup> centuries

In the 19<sup>th</sup> century, a navigation boom on the Vltava and the Elbe Rivers was triggered thanks to systematic modifications of the riverbed, regular maintenance and the construction of shipyards. The company in charge of the predominant part of the training works was owned by the industrialist and boatswain Vojtěch Lanna from České Budějovice. The company gradually acquired a large fleet of bucket wheel excavators, towing steamers and boats and other technical vessels with which it could handle most of the training and channelling modifications on Czech rivers. Between 1833 and 1862, it performed regulation works on the Vltava River where longitudinal concentration structures were built to narrow the river channel. This increased the navigation depth and prevented the formation of shallow waters. The start of steamboat navigation on the Elbe River and the signing of the Navigation Acts in 1844 obliged the Austrian Empire to excavate the international section of the Elbe River to a prescribed depth and maintain it. It was necessary to remove river islands, dismantle old weirs and deepen and straighten the navigation channel [6].

The legal framework of the modern EVW was laid out by the Imperial Water Act No. 93 of 1869, followed up by provincial water laws issued by individual land assemblies from 1870. The Czech Land Assembly set up a survey commission, which supported the implementation of large-scale regulatory work on the Lower Vltava River and on the Elbe River in 1875-1887, which greatly contributed to further development of navigation. In 1895, the Technical Department of the Vice-Regent's Office in Prague concluded studies on the project of the Vltava and the Elbe River channelling from Prague to the state border, and the Ministry of the Interior finally approved it. The implementation of this major project was commissioned to the Commission for Channelling the Vltava and the Elbe Rivers in Bohemia. The Commission first built barrages on the Lower Vltava River below Prague: Klecany (1898), Libčice (1900), Trója (1902), Miřejovice (1903) and Vraňany-Hořín (1905). The channelling of the Vltava River in Prague for navigation was carried out between 1907 and 1913 by the construction of a new Helmovský Weir and the navigation locks near Štvanice, Židovský Island and Žofín Island. The improvements included repairs of old fixed weirs, the banks of the Vltava River and the fairway. The missing sections of the embankment walls within the city were also built starting from 1840 [7].



**Figure 4.** Needle weir in Klecany (1900).



**Figure 5.** Hořín lock (1935).

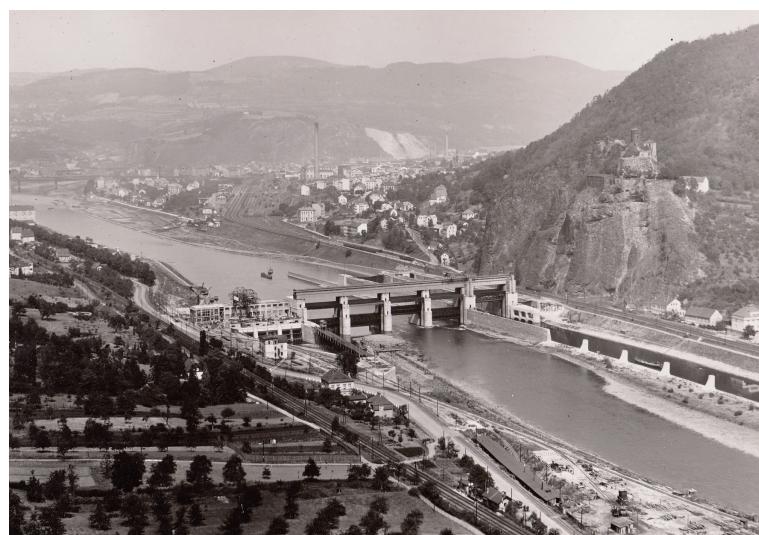
The project was focused not only on reaching the necessary navigation depth, but also on a number of other functions, including the protection of towns, settlements and agricultural crops from floods,

hydropower generation in run-of-river hydroelectric plants, water supply and meeting public health and aesthetic requirements at low flow rates.

The Commission activity was greatly supported by the issue of the Imperial Waterway Act No. 66 of 11 June 1901 (on the construction of waterways and training of rivers), which was pushed through in the Imperial Assembly mainly by the Czech deputies as a compensation for the construction of Alpine railways, to which the most developed Czech Lands had contributed the most. The act allowed the Commission to build two locks in Prague, complete the channelling of the Elbe River from Mělník to Střekov and make the Middle Elbe River section navigable. To this end, locks were built on the Lower Elbe River at Dolní Beřkovice (1907), Štětí (1909), Roudnice nad Labem (1912), České Kopisty (1914) and Lovosice (1919). The Střekov Lock was constructed in 1935.



**Figure 6.** Weir in Roudnice nad Labem (1918).



**Figure 7.** Střekov barrage (1935).

The works on the Middle Elbe River proceeded in five phases starting in 1901. According to the original work schedule resulting from Act No. 66/1901, the Middle Elbe River was supposed to be trained according to previously prepared projects systematically from the mouth of the Vltava River by Mělník further upstream. However, it turned out that due to the current speed of the work progress, it was not possible to leave the most endangered river sections without intervention and so the modifications started to be carried out in the places where a delay would result in the most severe damage during floods. The absolute majority of the locks on the Middle Elbe River were built during the first three phases until the end of World War II [8].

### 3. Project focus and outputs

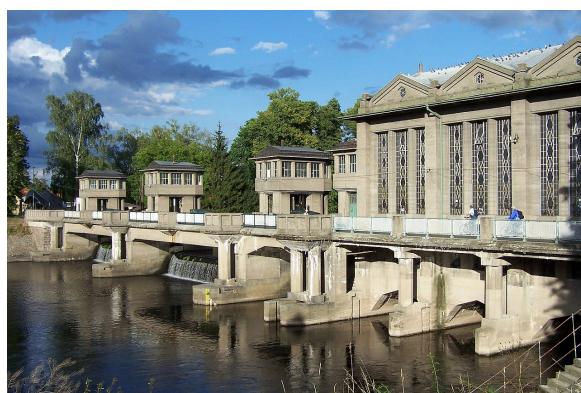
#### 3.1. Documentation of technical heritage on the Elbe-Vltava Waterway

The lock structures on EVW represent extensive and unique technical cultural heritage which still serves its purpose. The locks are typically composed of a weir structure, a lock and a hydroelectric power plant. The systematic documentation and records of these structures and technological elements for the needs of their conservation and planning their reconstructions and modernizations with respect to their cultural historical nature are not available at present. Hence, there is an urgent need to collect the relevant data in the form of original technical documentation sheets, development of technological elements, old maps and plans using a specialized public database. The data are currently available in a highly fragmented way in the archives of the Povodí Labe and Povodí Vltavy state enterprises, in the National Technical Museum, municipal archives, original publications, etc. The history and functional

descriptions of individual locks are only found in special publications issued in the past mostly thanks to the initiative of the administrators of these structures (Povodí Labe, state enterprise or Povodí Vltavy, state enterprise). They include, e.g., the publications Middle Elbe River [8], Lower Elbe River [7], History of the Lower Elbe Waterway [9]. In the first project year (2018), complete historical data and background materials to the structures situated on the Lower Vltava River between the Štěchovice Dam and Mělník and on the Lower Elbe River between Mělník and Ústí nad Labem were collected. These archival materials coming from all archives and museums available were digitized for the needs of filling a specialized database. At the same time, the structure of this database was designed enabling entering text and numeral data, photographs, maps and plans. The created database allows fast information searches based on many different criteria. The database is compiled on the basis of an expert system with an option of sharing information via a web interface with different user and administrator levels (rights to insert, edit, view data).

The project also includes the identification of endangered technical cultural heritage on EVW. The research is focused on listing the elements with functional and capacity deficiencies requiring the modernization and reconstruction of historic locks for various reasons including the following:

- ensuring safety of people pursuant to standards in force,
- increasing lock capacity – requirements for construction and technological elements of locks,
- solving nautical and hydraulic problems (original locks sometimes do not meet current demands for safe navigation conditions),
- structural and geotechnical problems,
- material analysis of historical elements.



**Figure 8.** Poděbrady barrage.



**Figure 9.** Poděbrady hydropower plant.

Another planned output of the project is a map with a detailed content illustrating the historical development of the technical modifications implemented on EVW. It will also include a set of technical drawings of selected locks of special cultural historical value (e.g. Střekov, Miřejovice, Poděbrady Locks, Vraňany-Hořín navigation canal and others).

### *3.2. Presentation of technical heritage on the Elbe-Vltava Waterway*

The second main objective of the project is the presentation of the acquired data on the EVW development to the general public. Here, the basic means is the linking of the compiled specialized public database with a web interface with an option of viewing data or searching them according to entered criteria. The presentation of the structures includes the historical development of their design and the description of the function of the original technological elements. The presentation of the technical heritage on EVW is presently a topical issue also in connection with the dynamic development of sports and recreational sailing (major contribution to tourism with socioeconomic

benefits). In cooperation with the Waterway administrators, information boards and promotional leaflets for visitors will be prepared in information centres in individual localities within the project. Part of the presentation will also be the preparation of an audio-visual DVD and the incorporation of the research achievements into the educational programmes of secondary schools and universities and into the curricula of the University of the Third Age.

The final output of the project in 2022 will be an exhibition presenting the technical cultural heritage on EVW and the results of the original research within the whole project to the general public. The exhibition will be conceived as a travelling exhibition including a critical catalogue.

#### 4. Conclusion

The article presents the principal objectives, research methods and outputs of the project “Documentation and Presentation of Technical Cultural Heritage on the Elbe-Vltava Waterway”. The project mission is to create conditions for the documentation and presentation of the technical cultural heritage on the Elbe-Vltava Waterway and prerequisites for its effective conservation. It involves industrial heritage, which belongs to the most vulnerable types of cultural heritage. The basic conservation means is its documentation and identification of endangered elements during its modernization, reconstruction and maintenance. Technical heritage care on waterways also has a significant economic potential in terms of the development of the tourism industry.

#### Acknowledgement

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