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River as a flow of commodities: The reasoning behind the third Danube regulation in Bratislava by Enea Grazioso Lanfranconi

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ABSTRACT:

The channel of most of the rivers is the result of long-term human endeavour to modify their shape. This paper focuses on the flow of commodities juxtaposed with the physical water flow of the river that has served over centuries as one of the main means of goods transport. The topic is closely observed on the example of the Danube regulation in Bratislava at the end of the nineteenth century and the transformation of the river into a canal. The reasons for the individual interventions in the natural riverbed differed. The third regulation (1886 - 1896) was meant to add the missing part of the canal on the route between the North and Black Seas, which would be fully adapted for freight transport by steamer. The 19th century has introduced a new paradigm to city planning. In the belief in technical innovation, the planning process was undertaken by engineers. The paper places in confrontation the oeuvre of two engineers, Charles-Joseph Minard and Enea Grazioso Lanfranconi. While the former, a French civil engineer, brought a unique way of visualizing the flow of goods between territories based on statistical data, the latter, a Hungarian hydraulic engineer, is the author of the third regulation of the Danube in the section between Devín *(Theben)* and Gönyű *(Gönyö)*. For the purpose of the paper, the original theoretical work of Enea Grazioso Lanfranconi was translated and analysed. Selected data from Lanfranconi's work was interpreted visually.

KEYWORDS:

Danube regulation, Enea Grazioso Lanfranconi, flow map, Charles-Joseph Minard, Bratislava

FLOW IN THE CITY OF ENGINEERS

The concept of *flow* is linked with several topics in current studies of cities, while the dominating one is its figurative meaning related to *global cities*—the flow of capital and labour **[1]**. This paper focuses on the flow of commodities juxtaposed with the physical water flow of the river that has served over centuries as one of the main means of goods transport.

The channel of most of the rivers is the result of long-term human endeavour to modify their shape. Once we look at the rivers as projects, we can analyse the process of their formation through specific interventions that have finally influenced not only the riverbeds but also the cities crossed by these rivers. To look at the history of urban development adopting the river-centric approach allows us to examine those stages of river change that have irreversibly affected the structure of the city. A similar approach to the study of urban history through key formative moments was applied in Real Urbanism: Decisive Interventions **[2]** research. The rather selective than complex approach was also applied by the group of researchers in the work City as a Project **[3]**.

In this paper, the topic is closely observed on the example of the Danube regulation in Bratislava at the end of the nineteenth century. The Danube embankments in Bratislava were recently analysed in Bratislava (Un)Planned City **[4]**. The team of researchers has looked at the formation of riverbanks as the urban complex of multiple flows following the definition of the term by Ignasi de Solà-Morales: *"the continuous movement of people, goods, services and data"* **[5].** This work elaborates on the matter by further focusing on the transformation of the river into a canal. (**Fig. 1**)

The reasons for the individual interventions in the natural riverbed differed. The first and second regulation of the Danube in Bratislava was related not only to the adaptation of the river for navigation purposes but also to the protection of the terrestrial Vienna Road, stabilization of the banks, flood protection and, finally, the personal building of the monarchy's image **[6]**. On the other hand, along with the issues of flood protection and free passage of ice in winters **[7]**, the third regulation was meant to add the missing part of the canal on the route between the North and Black Seas, which would be fully adapted for the transport of goods by steamer.

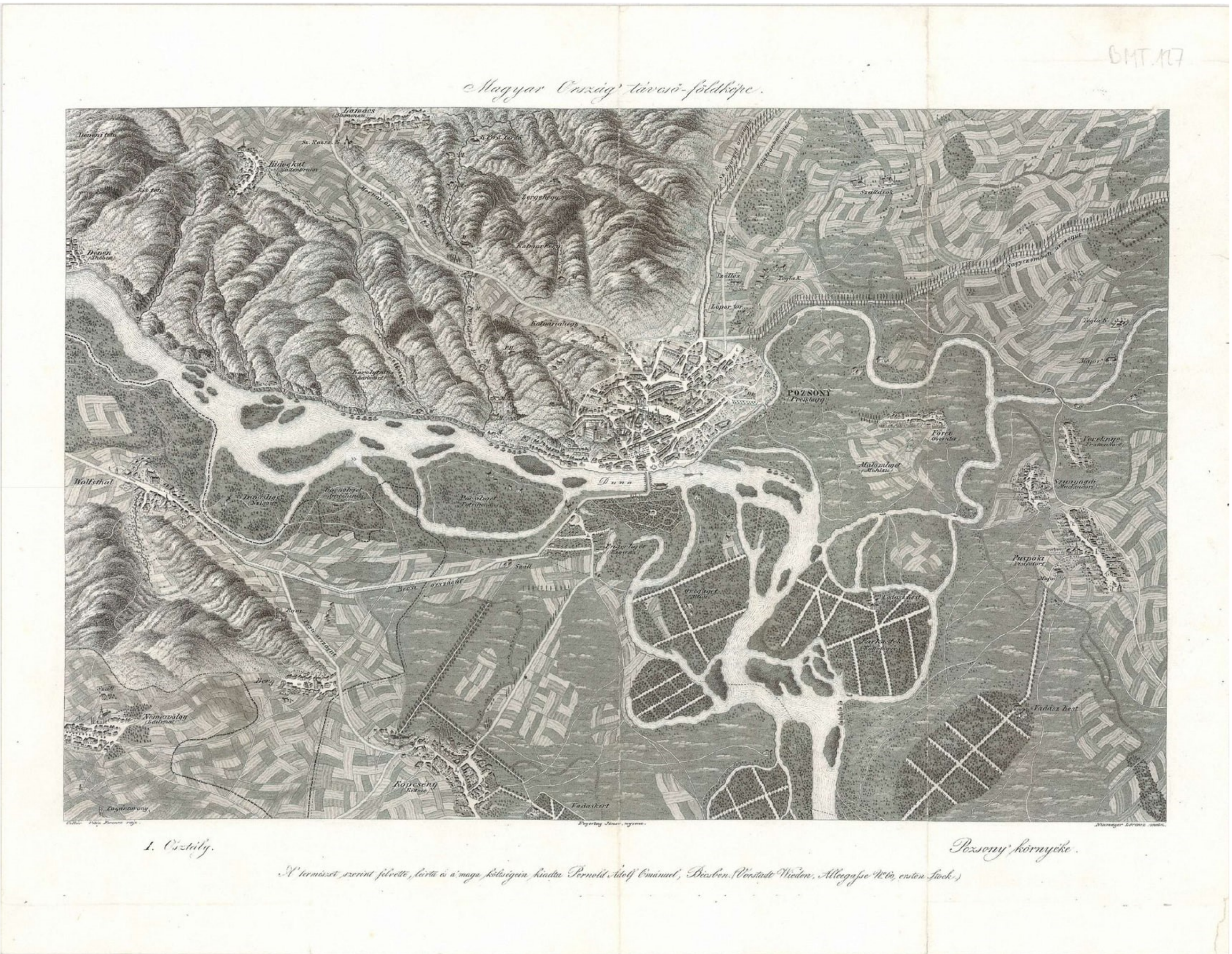

Figure 1: The Danube in Bratislava before the third regulation in
"The oblique aerial view of Bratislava and surrounding landscape" by Ferencz Collár Vitéz, 1840.
Source: Museum of Military History (Hadtorteneti Muzeum), Budapest, Hungary, available at hungaricana.hu

In order to understand the motivations of certain actions, it is necessary to adopt the thinking of the environment of nascent capitalism. At the fin-de-siècle, the fundamental objective was the facilitation of traffic flow and interchange between different networks. All possible aspects of the river were reduced to one single function—a means of transport necessary to ensure the prosperity in industry, imports and exports, trade in general. The period of emerging modernity is therefore often retrospectively regarded as the era of *the taming of nature* **[8]**. In the 19th century, a new paradigm was introduced in city planning. In the belief in technical innovation, the planning process was undertaken by engineers, which represented the opposite to the long-term effects of natural forces and uncoordinated human activities. As Slovak philosopher, Miroslav Marcelli, states: *"the engineering approach to problem solving does not meet any insurmountable boundaries: when they know how to design and build a house, they also design and build streets and the whole city from the streets; when they know how to design and build a road, a bridge, a canal and a dam, they will also design and build a whole system of roads and streams."* **[9]**

This paper therefore places in confrontation the oeuvre of two engineers, Charles-Joseph Minard and Enea Grazioso Lanfranconi. While the former, a French civil engineer, brought a unique way of visualizing the flow of goods between territories, the latter, a Hungarian hydraulic engineer of Italian origins, was the author of the third Danube regulation in the section between Devín *(Theben)* and Gönyű *(Gönyö)*. Although their specialisation had a different focus and during their lives, they were not related to one another, their work illustrates well the common idea of river as a flow. For the purpose of the paper, the original theoretical work of Enea Grazioso Lanfranconi was translated and analysed. Selected data from Lanfranconi's work were interpreted visually. The historical maps and depictions were studied mostly via the digitalised collection of the Hungarian cultural heritage portal and the on-line catalogue of works of art from the collections of Slovak galleries.

INNOVATIONS AND THE QUESTION OF TRANSPORT

The development of Western European cities in the nineteenth century was dominated by the new motive forces. The industrial revolution started the process of urbanization in the 18th century and resulted in a transition from a manufactory, based on manual labour, to a capitalist factory. The new market economy, freed from feudalism, caused cities to expand into suburbs. With the emergence of new private enterprises, new business relationships crossing the borders of nations (states) were also established. An American historian, Lewis Mumford, characterized this transformation as *"the replacement of the concrete marketplace of the medieval town by the abstract transnational market, which flourished wherever a profitable deal could be made."* **[10]**

The shipment and interchange of goods suddenly formed an increasingly large part of the activities of prosperous cities. Those were, naturally, especially port cities along rivers and seacoasts, such as Bristol, Liverpool, Havre, Lisbon, Naples, Frankfurt am Main or Amsterdam. The French urban planner, Marcel Roncayolo, states that the economic management of the city corresponded to economic liberalism: *"We will no longer understand the essence of the organization of the city in aesthetic terms; it is treated as a force field governed by the laws of attraction."* **[11]** Early capitalist states, in their own economic interest, cared for the rise of all industries. One of the preconditions of prosperity was the cheap transport of goods. In addition to the new method of production, the industrial revolution also introduced new means of transportation. Innovations such as steam locomotion and steamship accelerated the flow of commodities and people, but their efficiency depended on the degree of construction of the necessary infrastructure—railroads and water canals.

The use of railways represented certain advantages over waterways. The transport of goods by rail was faster even when compared to steamers. Most importantly, however, the railway was not exposed to natural events; the waterway could freeze in individual sections in the winter months, and the strength of its flow would fluctuate with the variable amount of water in the canal. On the other hand, the advantage of waterways was mainly low transport costs and tremendous efficiency. The countries that had the largest railway networks in the nineteenth century were therefore systematically building waterways alongside the railways, as they were aware of their advantages in transporting large cargo over long distances. It was estimated that the cost of canal transport was half the cost of rail transport, with the difference being even more significant for larger navigable rivers. Low transport costs could be achieved on waterways only if they were in good condition, while being navigable for larger ships. Therefore, the profitability of these roads depended not only on their length but also on their width and depth. Waterways proved also convenient in terms of land infrastructure. While in the case of railways, larger factories and plants could only be built at main stations, in the case of waterways, they could be located anywhere along the canal, which allowed the construction of factories outside the city, on cheaper sites. The battle between the two modes of freight transport was seen during the entire nineteenth century. As building the required networks was extremely costly, it was necessary to rely on relevant data and financing calculations for specific decisions.

THE MINARD SYSTEM AND THE FLOW MAP

Technological innovations were the fruit of the new approach to science and the way of thinking—the production of knowledge based on measurement, classification and comparison corresponding to empirical approach introduced by the Enlightenment. The accumulation of data enabled the rise of the new science of statistics in the early nineteenth century. Statistical findings were initially shown in the form of tables, but soon there were attempts to represent the data in a more comprehensible way.

A breakthrough in the field of what we today call *data visualization* was the use of *flow maps* by French civil engineer Charles-Joseph Minard. Minard's life spanned the final years of the French Revolution through the second half of the nineteenth century. Although Minard's oeuvre is today recognized mostly due to his complex diagram of the progress of the French troops **[12]**, his earlier flow maps were related to the topic of transport. Dedicating his career to engineering services such as inspecting, securing, and building waterways, port installations and bridges, he developed an understanding that complex infrastructural projects such as the ones he was working on must be considered not only in terms of technical feasibility but also regarding their financing, usage, and public utility. In order to support the analysis of statistical results, Minard was looking for compelling graphics and when visualising the space-related data, he soon switched from tables and diagrams to maps.

Among other topics, Minard also depicted the duel of means of transportation in an inventive manner in the nineteenth century. His series of flow maps showing the *"Circulation of Goods on French Railroads and Waterways"* provides a perfect illustration of their efficiency. (**Fig. 2, 3**) The series consists of ten maps that compare the fluctuating freight traffic on waterways and railroads in France from 1850 to 1862. While the green flows show the transportation volumes on waterways, the rose flows show traffic via railroads. On the first two maps, one millimetre of flow width on the map represents twenty thousand tonnes of goods. Comparison of the first two maps reveals that traffic on the railroad lines had, expectedly, increased substantially between 1850 and 1853. At the same time, the transportation on waterways had, less expectedly, not decreased but risen **[13]**. Minard was not part of any major scientific society or academy, nor did he publish in any scientific journal. He produced all his elaborated series of maps and diagrams when retired, mainly to satisfy his own interest. However, some of his notes indicate that he was regularly sending his prints to various acquaintances, such as fellow engineers, deputies, and local politicians **[14]**. A flow map has later become an established term for a specific type of thematic map indicating the movement of objects between areas.

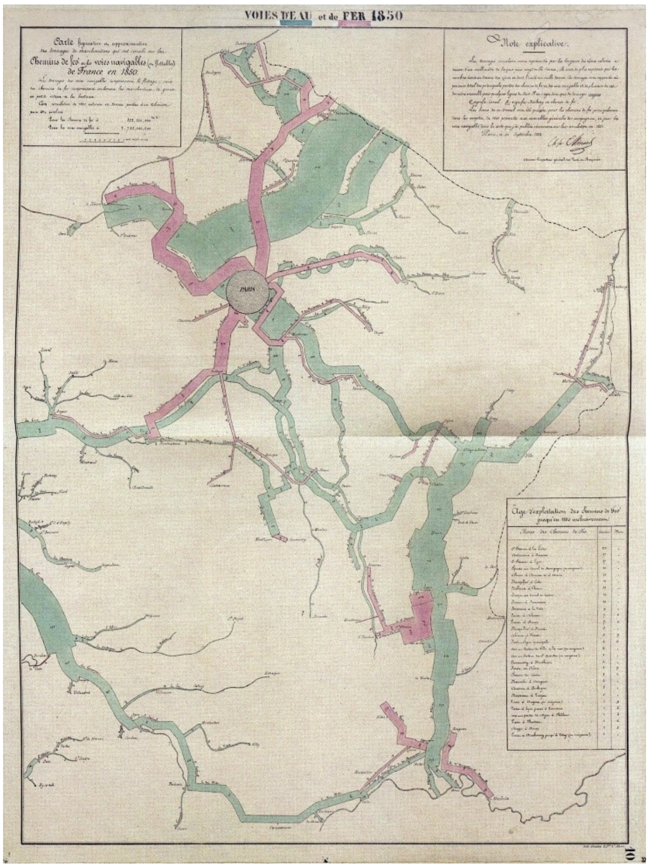

Figure 2: Circulation of Goods on French Railroads and Waterways in 1850 by Charles-Joseph Minard. Source: The collection of École nationale des ponts et chaussées

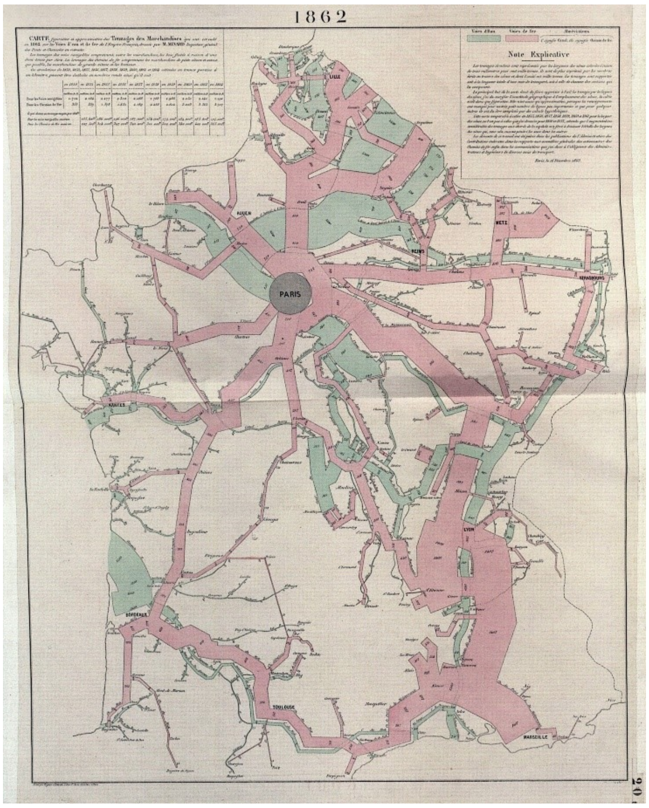

Figure 3: Circulation of Goods on French Railroads and Waterways in 1862 by Charles-Joseph Minard. Source: The collection of École nationale des ponts et chaussées

TRANSCONTINENTAL DANUBE

A similar fact-based practice eventually also prevailed in the local debate about the potential of the Danube as a waterway. The Danube, the second longest river in Europe after the Volga, flowed through what was then Austria-Hungary. Unlike other rivers that flow from north to south or vice versa, the Danube River runs from west to east. In 1846, the Ludwig Canal was completed between Bamberg and Kelheim, connecting the Rhine with the Danube. This merger created the possibility of a unique transcontinental axis, which would allow a continuous flow from the North Sea all the way to the Black Sea and together with the Danube's navigable tributaries, would constitute an extensive network of waterways. (**Fig. 4**)

Figure 4: Rhine–Danube canal at the top of the current map of Europe. Author: Monika Bočková

When compared to the western European rivers such as the Rhine, or the Elbe, traffic on the Danube mainstream was far behind and undeveloped. The difference became even more evident after the introduction of steamers, which, in addition to a regulated flow, also needed a greater depth of the riverbed and the Danube did not provide it in several sections. The Danube, which springs in the Black Forest in Baden and whose water level is 1,095 meters above sea level, was navigable only in Ulm at a width of 70 to 80 meters and a depth of 3 meters. Steamboats could only be sailed from Donauwörth.

Charles-Joseph Minard has also visually interpreted the traffic capacities of major European ports (shown as proportional circles) and rivers (represented as flows by proportional widths). The noticeably thin flow of the Danube indicates the low tonnage circulating through the river. Its thickest section between Vienna and Orsova corresponds to only 321,000 tonnes per year. The dominating width of the Elbe indicates 1,830,000 tonnes per year and the width of the Rhine—almost overshadowing the neighbouring Belgium—1,400,000 tonnes per year. (**Fig. 5**)

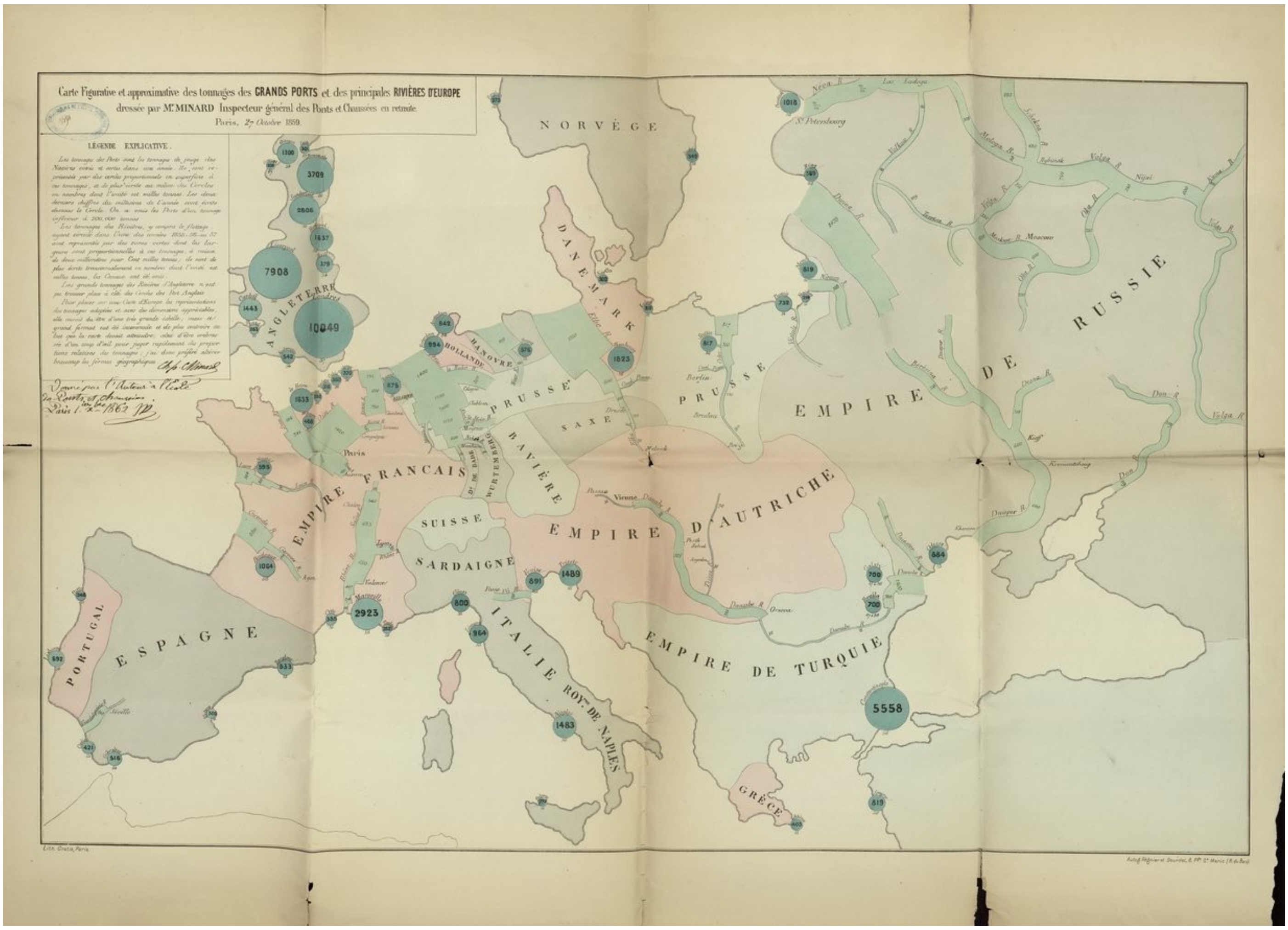

Figure 5: Cargo Tonnage of the Major Ports and Rivers of Europe in the 1850s by Charles-Joseph Minard.
Source: The collection of École nationale des ponts et chaussées

In 1876, Austria-Hungary had only a modest number of navigable waterways developed—3,287 kilometres. When adding the foreign parts of the Danube, the 154-kilometer-long section between Passau and Regensburg and the 955-kilometer-long estuary between the towns of Orsova and Sulina, the resulting sum of navigable waterways was 4,498 kilometres **[15]**. For river-rich Central Europe, this represented only a very poor network of waterways. In addition, the existing waterways were in a much-neglected condition as the result of insufficient regulation, inappropriate human interventions and peaking instability and erosion-depositional activity of the river in this period **[16]**.

A Hungarian hydraulic engineer, Enea Grazioso Lanfranconi commented: *"This situation, in a country that is rich in raw materials and whose prosperity comes from them, and where, especially in Hungary, the industry is still underdeveloped, we must call it wrong. The advantageous location of the numerous large rivers of the Austro-Hungarian monarchy, as well as their size, gives the opportunity to develop and transform the waterways in a way that even France cannot."* **[15]** Provided by the relatively precise measuring methods, Lanfranconi constructed various maps of the Hungarian rivers, charting also their characteristics such as width or depth. In his *Profile of the Danube in Hungary* he decided to include Tisza River as well, probably to show the comparison with the regulated flow. Lanfranconi also undoubtedly admired and respected the regulatory work of István Széchenyi on the Tisza in Hungary that was performed between 1846 and 1880. **(Fig. 6)**

The condition of the Danube waterway differed in individual sections. The river was relatively well regulated for 186 kilometres between Kelheim and the Bavarian-Austrian border at Passau. The Austrian section from Passau to the Hungarian border in Devín was not completely regulated in its length of 348 kilometres, but it was in a condition that was sufficient for navigation. The Hungarian part of the river, between Devín and the border with Romania, 968 kilometres long, was the most problematic section. While the first hundred kilometres between Devín *(Theben)* and Gönyű *(Gönyö)* passing through Bratislava *(Pressburg)*, was only slightly adapted to navigation with its width, depth and sinuosity of the stream, the last hundred kilometres were complicated by the difficult passage over the rocks of the Iron Gates. The remaining 955 kilometres to the mouth of the river in Sulina were in a navigable condition.

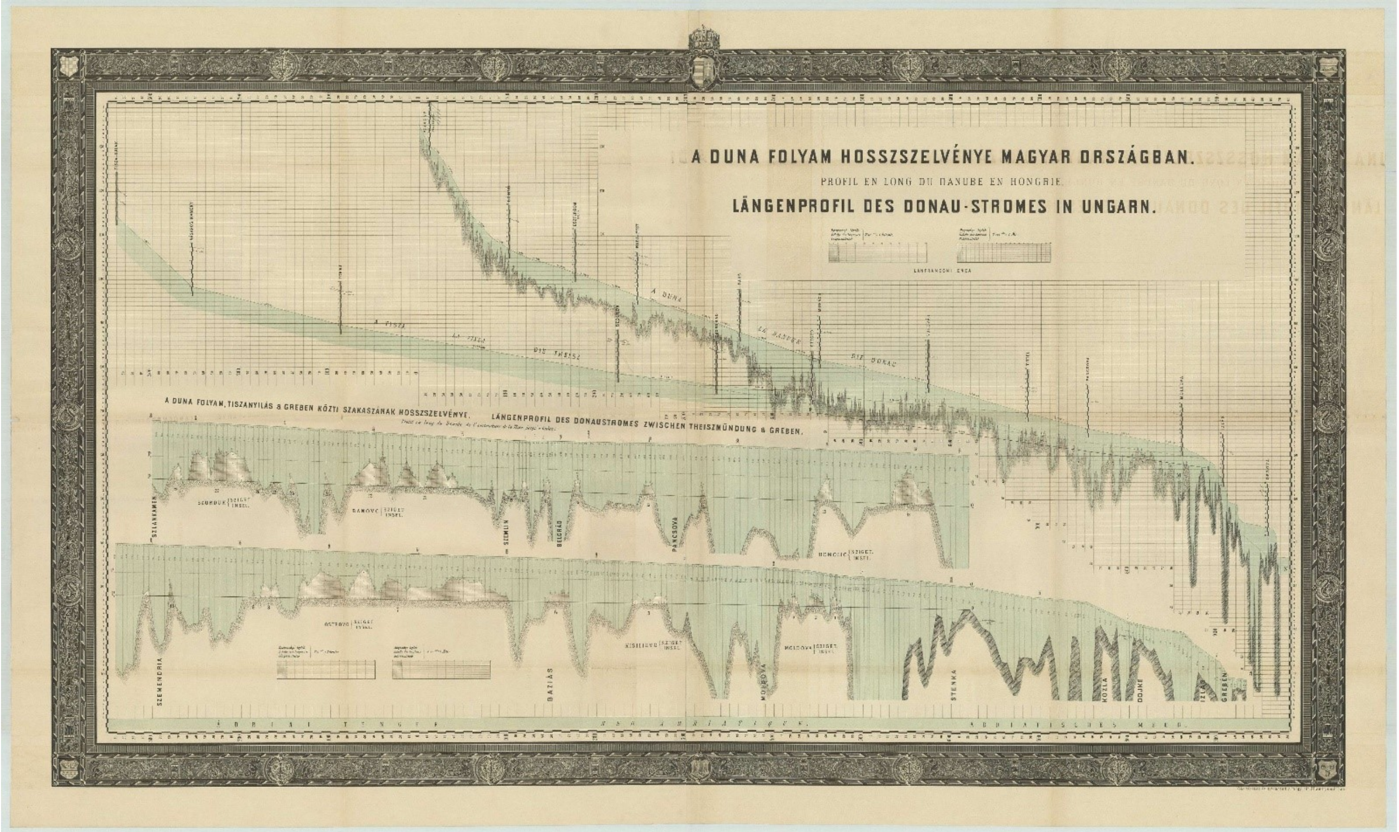

Figure 6: Profile of the Danube in Hungary by Enea Grazioso Lanfranconi, 1870. Source: National Archives of Hungary, available at hungaricana.hu

GRAND PROJECT OF ENEA GRAZIOSO LANFRANCONI

On 16 January 1878, a representative of the Reichstag, Professor Eduard Suess, spoke in the Austrian Chamber of Deputies for the regulation of the Danube. However, the proposal submitted by him was not elaborated in sufficient detail and it was therefore difficult to quantify the estimated costs of its implementation. The head of the regulation work on the Danube along Vienna, Gustav von Wex, later calculated the cost of the necessary regulatory work between Bratislava and Gönyű of about 20 million Austrian guldens. **[17]** Lanfranconi considered this amount exaggerated and believed the cost estimate was only an unjustified brake for the domestic development of trade. Finally, Lanfranconi decided to elaborate a detailed project to regulate the Danube section between Devín and Gönyű to prove the regulation was feasible for less than expected. He described his proposal in the work *"Über die Wasserstraßen Mittel Europas und die Wichtigkeit der Regulierung des Donaustromes mit besonderer Berücksichtigung der Strecke zwischen Theben-Gönyö"* **[15]** in 1880 and addressed it directly to Francis Joseph I.

In the theoretical part of the proposal, Lanfranconi did not avoid criticism of previous regulations and embankments construction. In the years 1832 to 1850, 33 spurs in total were built between Devín *(Theben)* and Hamuliakovo *(Gutor)*. (**Fig. 7**) *"The spurs system has proved not only insufficient, but in most spurs even very unsuitable for the current flow. From the 33 spurs built, only two have been preserved, while the remaining ruins of six are visible."* **[15]** After 1850, without a regulation plan for this route, bank protection structures were built wherever the large breaks and erosions occurred. For the proposed regulation, Lanfranconi suggested to maintain only the existing stone embankments for the new regulation of the river, although their length was insufficient, and maintenance difficult. (**Fig. 8**) The project that Lanfranconi presented had a clear goal—to definitively fix the main flow. In the proposal, he planned to achieve the fixation in three steps: 1. stabilization of the banks with stone embankments, 2. blocking of all side arms and 3. caving of several artificial punctures. (**Fig. 9**)

Figure 7: Transversal spurs on the right bank of the Danube visible on "Pressburg Abendseite" by Johann Gabriel Friedrich Poppel and Ludwig Rohbock, 1857. Source: Bratislava City Gallery, Slovakia, available at webumenia.sk

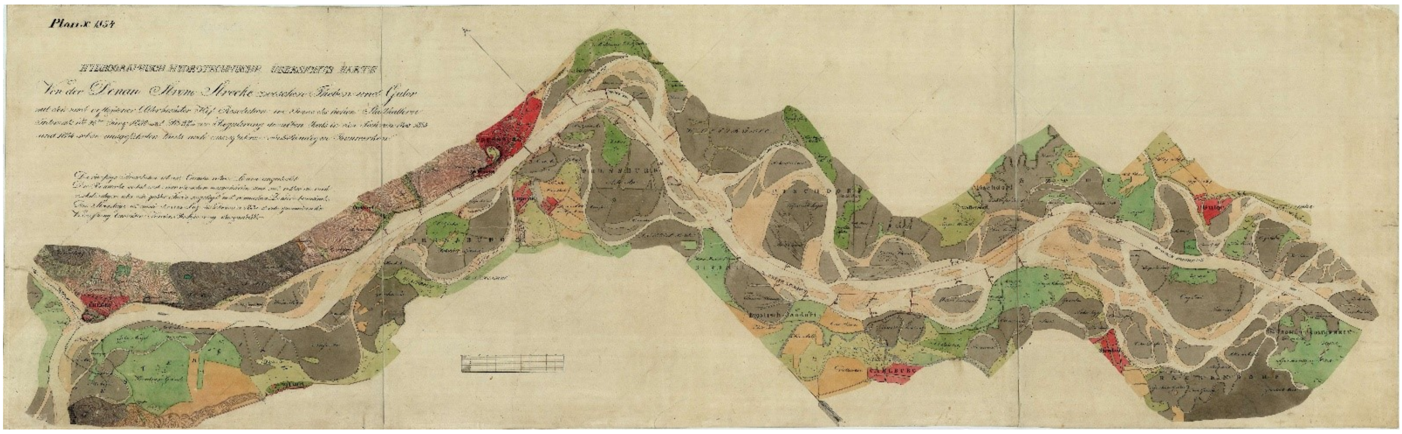

Figure 8: Planned transversal spurs marked in red colour on Hydrotechnical overview map of the Danube between Devín and Hamuliakovo, 1835. Source: National Archives of Hungary, available at hungaricana.hu

Figure 9: Section of the river between Devín and Gutor from Lanfranconi's proposal of the Danube regulation between Devín and Gönyű, 1878. Source: National Archives of Hungary, available at hungaricana.hu

Severing several side arms was a radical intervention. This step seemed necessary not only to fix the main flow but also to achieve the required depth. The arms divided the course of the river, which lowered its level. *"... each of them usually lacks the strength to create a deep riverbed, which is why the combination of these different forces is proving to be the most necessary."* **[15]** The depth of the riverbed could also be achieved by dredging, but Lanfranconi argued the process would be costly and inefficient. After all, as he pointed out, the erosive force of a river is the best and cheapest excavator. Concentrated mainstream would eventually remove all obstacles in the channel.

Lanfranconi stated that the specific section of the Danube, once separated from the side arms, would provide the most favourable conditions for navigation, even at the lower levels of water, if it was narrowed to a width of 300 meters along its entire length. However, a constant-width corridor would mean a widening in the city of Bratislava. From Linz to the Iron Gates, the Danube was nowhere as narrow as in Bratislava, where the entire amount of water flowing from Austria was passing through the river channel no wider than 272 meters. In terms of width, but also the average depth and inundation area, the part of the Danube in Bratislava was highly problematic. (**Fig. 10**)

Lanfranconi estimated the cost of definitively consolidating the Danube between Devín and Gönyű at 10 million Austrian guldens, which was half of the original estimate. The unit price of each proposed intervention was determined based on experience from already implemented works. He proposed to divide this amount over a period of 6 to 7 years. Lanfranconi concluded that flow regulation should be a common goal of the government, not only to protect the country from frequently recurring catastrophic floods, but also to give its people *"the most powerful lever for progress."*

REGULATION IMPACT

Lanfranconi's arguments finally led to the implementation of the regulation according to his proposal between the years 1886 and 1896. The fixation of the river corridor was performed through the elevation of the banks and the creation of bank-protecting structures. The stabilizing stone, provided by Lanfranconi's own quarry near Devín, has remained in major parts of the embankment until present day. The fixation of the mainstream has determined further development of the city of Bratislava in many ways. The severance of the side arms allowed the city to expand on both the left and the right bank. The growing industrial district was later supported by the two basins of the winter port built between 1897 and 1904. The idea of increasing the transport efficiency culminated in the plans of the industrial canal that would connect factories on the eastern outskirt. This ambitious plan was never implemented. (**Fig. 11**) Although Lanfranconi's regulation has improved the freight transport and significantly lowered the risk of floods, it is retrospectively evaluated in terms of negative impacts on the environment and the overall image of the city. The act of the taming of nature has in this case caused a disruption in the city–river relation and only recent projects and visions for the city aim to renew the lost connection.

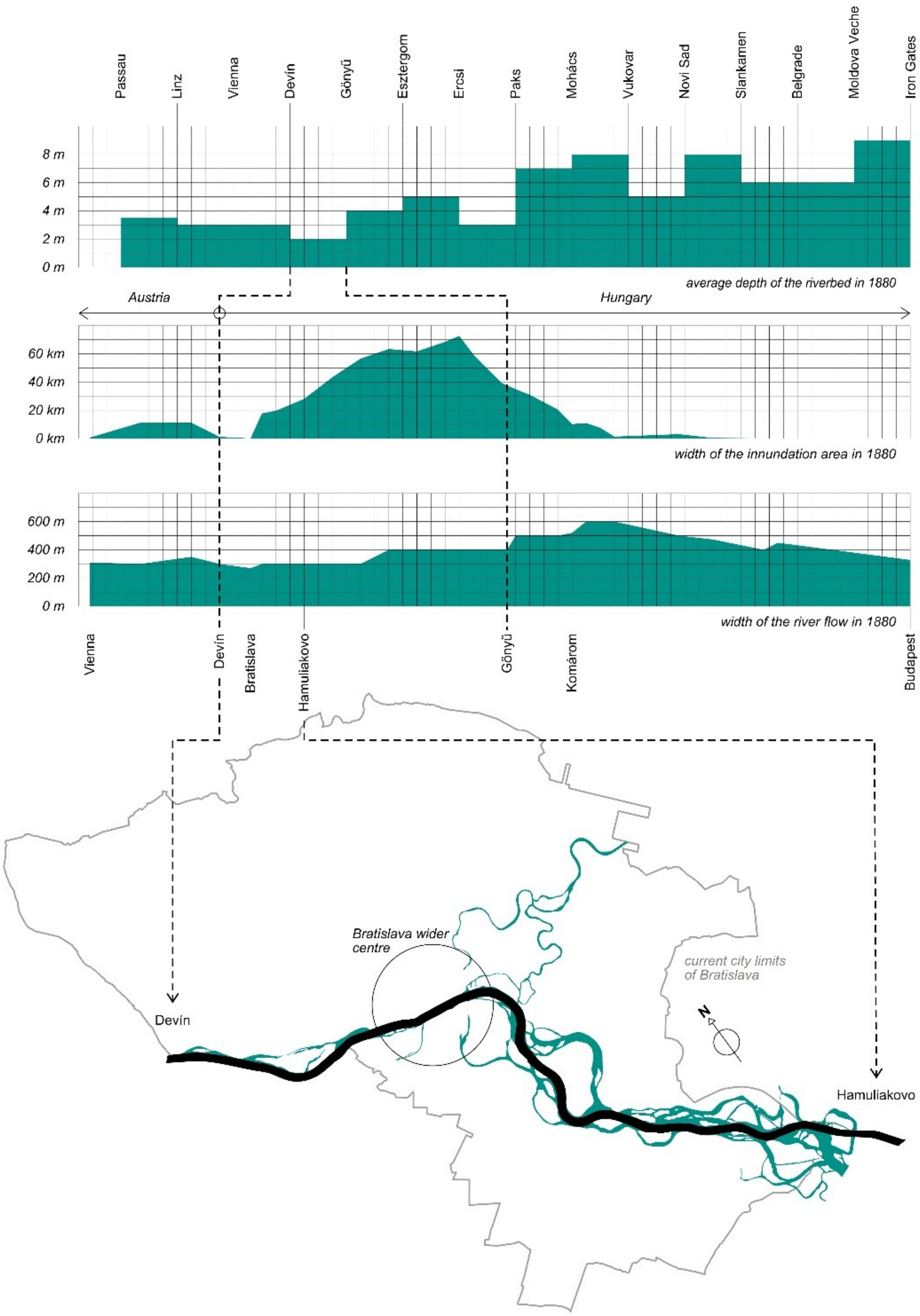

Figure 10: Visual interpretation of the selected historical data provided by Lanfranconi together with the unregulated and regulated flow of the Danube in Bratislava. Author: Monika Bočková

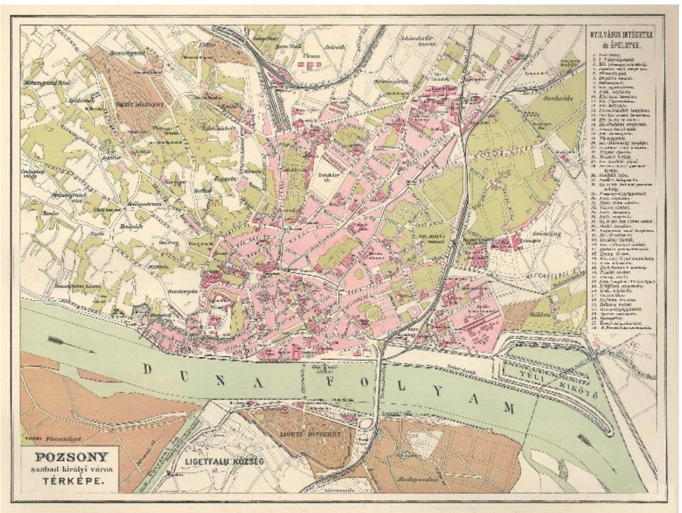

Figure 11: The Danube in Bratislava after the third regulation on the Map of the free royal city of Pressburg, 1910. Source: Museum of Military History (Hadtorteneti Muzeum), Budapest, Hungary, available at hungaricana.hu

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REFERENCES:

[1] Sassen, S. (1991) “The Global City: New York, London, Tokyo” Princeton University Press. Princeton, United States. ISBN 0-691-07063-6
[2] Shaap, T. ed. (2019) “Real Urbanism: Decisive Interventions”, Architectura & Natura, Amsterdam, Netherlands
[3] Aureli, P. V. eds. (2013) “City as a Project”, Ruby Press, Berlin, Germany
[4] Moravčíková, H., Szalay, P., Haberlandová, K., Krišteková, L., Bočková, M. (2020) “Bratislava (Un)Planned City”, Slovart, Bratislava, Slovakia. ISBN 978-80-556-4696-1
[5] de Solà-Morales, I. (1996) “Present and Futures. Architecture in Cities”, In: Present and Futures. Architecture in Cities. Exhibition catalogue. Actar, Barcelona, Spain, p. 15.
[6] Bočková, M. (2021) “Bratislava and the Planned River: Mapping the Impact of the Danube Regulations between 1772 and 1896 on Urban Development”, In: Architektúra & urbanizmus, Vol. 55, No. 1–2, pp. 105–111. DOI: https://doi.org/10.31577/archandurb.2021.55.1-2.9
[7] Füry, J., Décsi, L., Stanovský, J. (1986) “Povodie Dunaja včera a dnes“, In: Povodie Dunaja, Informačný spravodaj, No. 1, pp. 15–35.
[8] Oliver, S. (2000) “The Thames Embankment and the Disciplining of Nature in Modernity”, The Geographical Journal 166, No. 3, pp. 227–38. Available at: http://www.jstor.org/stable/823074 [Accessed: 20 Aug 2021]
[9] Marcelli, M. (2011) “Mesto vo filozofii”, Kalligram, Bratislava, Slovakia, p. 106.
[10] Mumford, L. (1961) “The City in History”, Harcourt, Brace & World, New York, United States, p. 410.
[11] Roncayolo, M. (1992) “Des utopies sociales à l’urbanisme technique”, In: Villes et civilisation urbaine, XVIII–XX siècle. Larousse, Paris, France, p. 163.
[12] “Carte figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812–1813”
[13] The description text from “Carte figurative et approximative de l'importance des ports maritimes de L’empire français”.
[14] One of them was the French statesman Eugène Rouher, the secretary of agriculture, commerce, and public work at the time, later the head of the government. Rouher valued applied statistics, as a tool to comprehend some effects of the accelerating industrialisation, and he considered statistical maps such as Minard’s highly expedient tools for administration.
[15] Lanfranconi, E. G. (1880) “Über die Wasserstraßen Mittel-Europas und die Wichtigkeit der Regulierung des Donaustromes, mit besonderer Berücksichtigung der Strecke zwischen Theben und Gönyö”, Angermayer, Pressburg, Austria-Hungary.
[16] Jungwirth, M., Haidvogl, G., Hohensinner, S., Waidbacher, H., Zauner, G. (2014) “Österreichs Donau. Landschaft – Fisch – Geschichte“, Institut für Hydrobiologie und Gewässermanagement, BOKU Wien, Vienna, Austria. “Die Schifffahrtshindernisse der Donau”, In: Pressburger Zeitung, 17 Jan 1878.