

## Possibilities of inland waterway transport development on the Lower Vistula River from 2020–2030, considering River Basin Management Plans

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### Abstract

The Lower Vistula River is a Polish part of inland waterways E40 that has a comparatively low waterway class (Ib – III; excluding Włocławek Reservoir part – Va), and projects and works should be undertaken to improve the waterway class conditions. This also depends upon the ratification of the AGN agreement by Poland, which obliges the country to adapt the main waterways to at least the fourth class of navigability. A catalog of investment activities must contain environmental objectives due to the inclusion of Lower Vistula River in the Natura 2000 protected areas network. This research includes an analysis of the impact on the inland waterway transport of the investments included in the Vistula River Basin Management Plans (RBMP). These documents make it possible to rationally manage water resources (also in the waterway transport) and indicate actions aimed at maintaining them for future generations. Therefore, in line with the Water Framework Directive recommendations, all planned investments should have a minimal environmental impact. In the coming years, large-scale infrastructure investments are planned, which will allow the waterway transport conditions to be improved and the environmental goals of the Water Framework Directive (WFD) to be achieved.

### Introduction

Compared with other forms of transportation, inland waterway transport is one of the cheapest and most environmentally friendly types (Fremont & Franc, 2010) due to its relatively low energy consumption, low air pollutant emissions, relatively low water pollution, and lower external costs (Brons & Christidis, 2012). Inland waterways can be classified as a form of sustainable transport, when taking into account its economic, social, and environmental impacts (Steg & Gifford, 2005). However, in order to perform it effectively, the state of hydrotechnical infrastructure on rivers and canals, as well as fleets, should allow this method to be used over other forms of transport. Attention should also be paid to

environmental factors, including the size and seasonal variability of water resources, so the possibility of inland waterway transport can be determined.

In 2017, the President of Poland signed the act to ratify the European Agreement on Main Inland Waterways of International Importance (AGN) (European Agreement, 1996). According to the provisions of this document, Polish waterways will become international shipping routes by developing and modernizing them up to class IV navigability. This also follows from the provisions of the Assumptions of the Development Programmes for Inland Waterways in Poland for 2016–2020 with an outlook to the year 2030 (Ministry of Maritime Economy and Inland Navigation, 2016). The purpose of this agreement was to establish a legal framework necessary

to implement a development plan for the construction of an inland waterways network of international importance. Achievement of the intended goals will be possible only when systematic investments in waterways consider environmental conditions.

The Climate & Energy Package 2020 (European Commission, 2008) was established in 2008 by the European Parliament, and it requires that the implementation of tasks be aimed at reducing greenhouse gas emissions in EU countries. It is implemented in inland waterway transport not only due to an increase in the usage of renewable energy or improving the energy efficiency of transportation, but also in terms of the need to preserve biodiversity and the free migration of species when investments on waterways are made.

Established by the European Commission, “The White Paper” (White Paper, 2011) set out initiatives to unify the European transport area using inland waterways with a target date of 2050. They include e.g., creating favorable conditions for inland waterway operation. They note that by the end of 2050, at least 50% of transportation over a distance of 300 km must be transported by means other than road transport.

Poland has relatively few water resources, and the average annual surface water outflow in Poland is about 60 billion m<sup>3</sup> (Statistical yearbook, 2018). The lower part of the Vistula River holds about 65% of the water resources in its basin and about 30% of the hydroelectric potential of Poland (Achrem & Gierszewski, 2007). Hydrological conditions in the Vistula basin are characterized by high seasonal variations, with a tendency to experience extremely high water stages and long periods of low water levels. This results in poor navigation conditions, including due to the lack of required transit depth in the waterway as regulated by law. One of the main methods to increase the possible uses of water resources is their retention. The total capacity of all storage reservoirs in Poland amounts to about 3.0 billion m<sup>3</sup> (Statistical yearbook, 2018). However, the construction of a dam, despite its many positive aspects for the natural environment (including water stage equalization, increased flood safety, and the elevation of groundwater levels in adjacent areas, etc.) (Głazik, 1978; Dynowska, 1984; Babiński, 2013) is surrounded in controversy. Flood prevention on Polish rivers may cause a reduction in the potential costs due to flooding. The cost of the last floods in 1997 was about 12 billion PLN (Grela, Słota & Zieliński, 1999) and about 2.3 billion Euro in 2010 (Ostojski, Walczykiewicz & Maciejewski, 2011).

The possibility of developing inland waterway transport is also as a result of the existing forms of environmental protection in a Vistula catchment area. They are obliged to include restrictions resulting from maintaining high values of the natural environment in the planned investments. Depending on the law, the following were distinguished: (a) Natura 2000 areas – with a regional scale and (b) forms of nature protection resulting from the provisions of the Nature Conservation Act (Journal of Laws, 2004, no. 92, item 880) – on a national scale. The first of these includes: Special Protection Areas (SPA) (Directive 2009/147/WE, 2009) and Special Areas of Conservation (SAC) (Directive 92/43/EWG, 1992). The second includes, among others, national parks, landscape parks, nature reserves, etc.

Basic planning documents required by the Water Framework Directive (WFD) (Directive 2000/60/EC, 2000) and the Water Law Act (Journal of Laws 2017, item 1566) include the National Water and Environmental Program (NWEP), as well as River Basin Management Plans (RBMP).

The records of the WFD (Directive 2000/60/WE, 2000) require the development of RBMP in the main river basins in Poland. In the first (2004–2009) and the second (2010–2015) planning cycles, the President of the National Water Management Board developed ten RBMPs for the river basin districts: Oder, Vistula, Dniester, Danube, Jarft, Elbe, Neman, Pregolya, Świeża, and Uecker. Currently, Poland is in its third planning cycle (2016–2021) for which the President of the National Water Management “Polish Waters”, is required to develop 9 plans – without the river basin Jarft and Uecker, and with the Banówka River basin area. Each RBMP includes a general description of the characteristics of the river basin district, a summary of the identification of significant anthropogenic impacts, and an assessment of their impact on the state of surface and ground waters, setting environmental objectives for surface water bodies and protected areas, a summary of the results of economic analysis related to the use of water, and activities included in the NWEP. The examined document also contains a list of other detailed programs and management plans for the basin district, the catchment area, economic sectors, problems or types of waters, including the content of these programs and plans, information on methods and procedures for obtaining information and source documentation used to draw up the plan, and information on the expected results of the plan (Głuchowska & Kasiorek-Godyń, 2010).



Figure 1. Study area of Lower Vistula River (Map..., 2007) on the background of protected areas (Geoportall, 2019), navigation class (Journal of Laws, 2002, no 77, item 695) and planned investments (Journal of Laws, 2016, item 1911)

## Study area

In terms of hydrography, the area of the Lower Vistula includes a section of the river from the mouth of the Narew River to the Gulf of Gdansk (approx. 350 km long). However, due to the construction of the Wloclawek Reservoir in 1963–1970 (Babiński, 2002), the division of river water bodies (RWB) in the administrative dimension (Map of the Polish Hydrographic Division, 2007) for this article was adopted for the lower section of the Vistula River segment from the Wloclawek Reservoir (km 675) to the estuary in the Gulf of Gdansk (km 941) (Figure 1). The total area this defined river catchment is 39.5 thous. km<sup>2</sup> (Map..., 2007).

The total length of navigable Polish inland waterways is 3655 km, of which less than 6% are inland waterways of international importance. In 2017, Polish inland waterway transport carried 5777.5 thousand tons of cargo, which represented less than 0.4% of its share in the transport services market (Statistical yearbook, 2018). The Vistula River, of which almost 88% of its length (920.3 km) is defined in the classification regulation as an inland waterway (Journal of Laws 2002, No. 77, item 695), constitutes a transport corridor linking the south of Poland with the Baltic Sea. The section of the Vistula River connecting the Baltic Sea with the mouth of the Narew River is included in the system of European International Waterways as E40. The Vistula River contains three classes of navigability: Ib (from km 674+850 to km 718+000), II (from km 718+000 to km 910+000), and III (from km 910+000 to estuary to the Baltic Sea) (Figure 1). These differentiations result from environmental factors and infrastructure (Szatten, Habel & Babiński, 2017).

The Vistula River was covered by various forms of nature protection, both at the European and national level (Figure 1). The studied river on the section from the Wloclawek Reservoir to the estuary, flows entirely to areas belonging to the European network – Natura 2000. The habitat protection areas included (Directive 92/43/EWG, 1992): Włocławska Dolina Wisły (km 675–704), Nieszawska Dolina Wisły (km 704–728), Dybowska Dolina Wisły (km 745–758), Solecka Dolina Wisły (km 764–813), Dolna Wisła (km 848–904), and Ostoja near the mouth of Vistula river (km 939–941), while bird protection areas included (Directive 2009/147/WE, 2009): Dolina Dolnej Wisły (km 675–939) and Ujście Wisły (km 939–941). However, due to national regulations, the lower Vistula is included in Landscape Parks “nad Dolną Wisłą” (from km 770 to km 861). In its

longitudinal profile, the protected landscape areas are also distinguished (in the direction from Wloclawek): Nizina Ciechocińska, Dolina Kwidzyńska, Nadwiślański, Biała Góra, Środkowożuławski, and Żuławy Gdańskie oraz Wyspa Sobieszewska. Establishment of the above forms of protection enforces the use of appropriate environmental regulations when carrying out investments, which also occur in the waterway (Journal of Laws 2004, No. 92, item 880).

## Methods

The aim of this research was to determine the potential impact of investments included in the River Basin Management Plans (Journal of Laws, 2016, item 1911) on the section of the Lower Vistula for the development of inland waterway transport.

An analysis was performed on investments recorded in Annex 4 to the River Basin Management Plans (Journal of Laws, 2016, item 1911), implemented in the Lower Vistula basin. Only those investments that were located in water bodies of the study area – the Lower Vistula – were selected for detailed research. They were selected from the Map of the Polish Hydrographic Division (Map..., 2007) using Quantum GIS 3.4 software. It was indicated that, apart from the area in which the investment was located, areas were within the investment impact range. The possibility of non-compliance with environmental objectives resulting from the provisions of the WFD (Directive 2000/60/EC, 2000) has been determined. In addition, investments were referred to the forms of nature protection present in this area, indicating potential environmental conflicts. References to other strategic documents regulating the issues of inland waterway transport were also detailed, demonstrating the possibility of improving the currently defined navigability classes.

## Results and discussion

The hydrological and navigational conditions of the Lower Vistula depend on the dynamics of river sediment transport, which is determined by the geological structure and the hydrological regime of the river (Babiński, 2002). This situation is further modified by the operation of the Wloclawek Reservoir, which minimizes the size of floods and limits low-water stages. However, due to climate change (Syvitski & Kettner, 2011), the periods of low-water stages / discharge are an increasing problem. According to the research of M. Habel et al. (Habel, Szatten

& Nadolny, 2017), the lowest water stages on the Lower Vistula occur between August and October, the second part of the navigation season. The annual average water level (AWL) of the Vistula in the Fordon gauging profile for 1984–2015 was 319 cm. From 1985–2015, water stages below AWL were observed for fewer than 50 days over fourteen navigational seasons. Also within the same period, water stages below AWL were observed for more than 120 days only in two years, and there was only an average of 59 days favorable for navigation during the navigational season. Therefore, it is advisable to carry out infrastructural investments within the Lower Vistula, which are aimed at improving the navigational conditions.

Planned investments in water management include activities which aim to directly improve the quality of waters and other activities e.g., social or economic, requiring interference in the water environment. These investments may include: (a) activities that may adversely affect the condition of RWB (for example, artificial reservoirs); (b) activities that are neutral from the point of view of the impact on the state of the RWB (e.g., dry flood reservoirs); and (c) activities conducive to the improvement of the state of the RWB (e.g., the reconstruction of flood areas). The investments included in the River Basin Management Plans on the section of the Lower Vistula River included (Journal of Laws, 2016, item 1911) (Figure 1):

- Macro-leveling of riverbanks in the Wloclawek Reservoir (A–B);
- Protection against flood waters in the Lower Vistula River section from Wloclawek to its estuary to the Gdansk Gulf – water stage below Wloclawek (C);
- Protection against flood waters of the Lower Vistula River section from Wloclawek to its estuary to the Gdansk Gulf – maintenance works in the area of the great water channel of the Lower Vistula (D–F);
- Protection against flood waters of the Lower Vistula River section from Wloclawek to its estuary to the Gdansk Gulf – reconstruction of groynes on the Vistula River at km 933–847 (D–E);
- Protection against flood waters of the Lower Vistula River section from Wloclawek to its estuary to the Gdansk Gulf – reconstruction of groynes on the Vistula River at km 847–718 (E–F).

The first investment involves building a new water barrage below the Wloclawek Reservoir (Siarzewo location, km 706–707), mainly to ensure flood safety. The benefit of inland waterway transport will be the

creation of a class Va waterway along the length of the new reservoir and a significant improvement of navigational conditions below the Wloclawek reservoir. The second investment concerns the riverbanks of the Wloclawek Reservoir on the section from km 620+500 to km 637+500. This is also connected with flood protection of the river valley. As a result of dredging sediments accumulated in the Vistula channel, the depth conditions will be improved. The next investments involve the reconstruction of damaged groynes in the Vistula River channel. The immediate goal of this work is to prevent the formation of ice jam floods by creating conditions for free outflow of water and ice, providing the depth for icebreakers, and protecting embankments against disruption. This solution will enable improving the depth conditions in the waterway.

The aforementioned investments have a specific spatial impact on the River Basins Management Plans, which may result in the failure to achieve a good state / potential of RWB. The threat of not meeting environmental goals may occur along entire sections of the Lower Vistula. However, in RBMPs, it is assumed that specified investments will have potentially low ecological impacts on river water bodies below them.

The potential impacts on the water environment of typical hydrotechnical projects include: (a) in the case of constructing an artificial reservoir, e.g., creating a barrier for fish migration: destruction of habitats as a result of flooding or exacerbated erosion; (b) in the case of maintenance works along the riverbanks: silting of habitats or disturbance of aquatic organism migration. However, RBMP includes an action program that aims to achieve environmental goals, and also activities that may disrupt this process which are necessary to implement due to sustainable water management. For example, the construction of a water reservoir below the Wloclawek fish pass is predicted, and partial loss of flooded habitat is expected as an environmental compensation. Also, the creation of the reservoir will stop the deep erosion process below the already-existing water reservoir. The silting of the water during the works is short-term, and therefore will have no impact on the achieving the desired ecological status / potential of the waters. Additionally, it is recommended that the work be conducted outside the breeding period of fish.

The main goals of the RBMP consistent with WFD are: (a) reaching or maintaining at least good status of waters and ecosystems which depend on them, (b) improving the status of water resources,

(c) improving the capability of using the waters, (d) decreasing anthropogenic pressures and their impact on the status of waters, and (e) improving flood protection. In connection with the above goals, it seems reasonable to carry out planned investments that only potentially affect the quality of the water environments and bring relative benefits to the waterway transport sector.

It should also be noted that the investments planned in the RBMP are consistent with the plans for waterways adjacent to the Lower Vistula. Also planned are: revitalization of the Bydgoszcz Canal and the canalized part of Noteć River waterways to achieve class II navigability, revitalization of the Elbląg Canal, and the construction of a waterway connecting the Vistula Lagoon with the Gdansk Bay, along with the reconstruction of the entry to the Elbląg port. These are only selected investments designed to improve the condition of the entire waterway network in Poland.

One of the main priorities of the AGN agreement are a significant improvement of the navigation conditions of the Vistula River Waterway. The specific scope of investment tasks on the Vistula River Waterway include – in the short term: (a) construction of another dam downstream of Włocławek, which is urgent due to the instability of the existing dam, (b) selection of the concept of canalization of the Vistula River Waterway, and (c) preparation of the documentation necessary to start the Lower Vistula Cascade investment project. In the long term: (a) construction of subsequent dams of the cascade and (b) construction of at least two major logistics centers (e.g., in Bydgoszcz, Warsaw) (Ministry..., 2016).

Multimodal ports serve the development of not only waterways but also land corridors (road and rail), providing better transport access to seaports from the land. The operations of the Multimodal Port Bydgoszcz-Solec Kujawski will allow shifting part of the goods transported from seaports to the Vistula waterway, and will therefore relieve the most overloaded transport routes in inland transport. Therefore, in case of the Lower Vistula, it will be a key element to enable the development of seaports in the Port of Gdańsk and Baltic Container Terminal in Gdynia in the long-term (Location study, 2018).

The direction of investment is indicated by forecasts of demand for transport using inland waterways. An expected increase in the demand for transport by Polish waterways fluctuates from 30% for local operators, up to 60% for foreign operators (SRT, 2013). It is worth noting that there is a very

low share of this type of transport in the overall share of transport – 0.5% in 2030 (at the baseline level of 0.23% in 2010). However, to activate this form of transport, system investments should be carried out, including those in the RBMP. In order to adapt them to the navigability parameters for routes of international importance (AGN requirements), the estimated costs of construction and upgrading selected Polish inland waterways vary depending on the adopted concept and variant. These amounts are about 31.5 billion PLN for only the central and lower section of the Vistula River from Warsaw to Gdańsk.

## Conclusions

Based on the research carried out on the characteristics of the investments included in River Basin Management Plans in the Lower Vistula River region (Journal of Laws, 2016, item 1911), with a comparison of the environmental status and actual navigation conditions, the following conclusions can be made:

1. Inland navigation is the most environmentally friendly form of transport, which increases economic activation of areas located along navigation routes. However, infrastructural investments in waterways require high amounts of capital, with additional environmental costs.
2. Investments specified in the RBMP were determined to have a low potential ecological impact on the river water bodies below them.
3. Ratification of the European Agreement on Main Inland Waterways of International Importance (AGN) established that Polish waterways will become international shipping routes with class IV navigability. Recommendations resulting from the AGN for Polish waterways specify the elimination of the main bottlenecks (i.e., the Vistula River from Warsaw to Płock and from Włocławek to Gdańsk – Lower Vistula).
4. Supporting the development of environmentally friendly technologies and modes of transport, including inland waterway transport and combined transport, is consistent with the idea of sustainable development and preventing climate change.
5. Investments, financed by the national budget, can also be co-financed from the EU funds under the 2014–2020 financial perspective. It helps to prepare more environmentally-friendly investments at a higher technological level.
6. Funds invested in a waterway benefit not only the navigation area, but may also fulfill other functions, such as flood prevention, industrial

and municipal water intake, agricultural and forest management, and energy production, among others.

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