

The selected hydrotechnical conditions of the Dnieper – Bug Channel and the Pripjat River in the development of the International Waterway E40

Wybrane warunki hydrotechniczne kanału Dniepr – Bug i rzeki Prypeć w rozwoju Międzynarodowej Drogi Wodnej E40

Marcin Kalinowski¹, Rafał Koba¹, Patrycja Jerzyło²

¹Institut Morski w Gdańsku. Zakład Ekonomiki i Prawa

²Politechnika Gdańska. Wydział Inżynierii Lądowej i Środowiska

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Abstract: International waterway E40 (MDW E40) is included in the network of inland waterways of transnational importance. It is a link between two areas: the Baltic Sea and the Black Sea. The E40 route runs through three countries: Poland, Belarus, and Ukraine.

The article presents the results of the study on the analysis of two very important sections of the MDW E40 on the Belarusian section, namely: the Dnieper – Bug Channel and the Pripjat River. Both elements, from the point of view of navigability, are the most important links throughout the Belarusian section of the waterway.

This article will be useful for the development of plans for revitalization of the international waterway E40 not only on the Belarus part, but also in Poland and Ukraine. Due to the accession and signature by Poland of the AGN Convention in January 2017, the article can constitute a material to supporting state policy in the context of the inland waterway system's development in Poland and Europe.

Keywords: Dnieper – Bug channel, AGN convention, E40 Inland Waterway, revitalization, inland navigation

Streszczenie: Międzynarodowa droga wodna E40 (MDW E40) wpisana jest w sieć dróg wodnych śródlądowych o znaczeniu ponadnarodowym. Stanowi swoisty łącznik dwóch akwenów: Morza Bałtyckiego i Morza Czarnego. Jej trasa przebiega przez trzy kraje: Polskę, Białoruś i Ukrainę.

W artykule przedstawiono wyniki badań nad analizą dwóch bardzo istotnych odcinków MDW E40 na jej białoruskim odcinku tj. kanału Dniepr – Bug oraz rzekę Prypeć. Oba elementy z punktu widzenia możliwości prowadzenia żeglugi stanowią najbardziej istotne ogniwa na całym białoruskim odcinku drogi wodnej.

Artykuł będzie przydatny przy tworzeniu planów rewitalizacji międzynarodowej drogi wodnej E40 nie tylko Białorusi ale również w Polsce i na Ukrainie. W związku z przystąpieniem i podpisaniem przez Polskę w styczniu 2017 r. konwencji AGN, artykuł może stanowić materiał wspomagający politykę państwa w kontekście rozwoju systemu dróg wodnych śródlądowych w Polsce i Europie.

Słowa kluczowe: Kanał Dniepr – Bug, AGN, droga wodna E40, rewitalizacja, żegluga śródlądowa

Introduction

The length of the Belarusian section of international waterway E40, running along the Mukhavets river, Dnieper – Bug channel, Pina and Pripyat rivers (Brest and Gomel regions) amounts to 651 km. The Belarusian waterway E40 meets the parameters of a class IV waterway, with the restrictions on dead weight of vessels. From the Polish – Belarusian border to the Belarusian – Ukrainian border, there are four inland river ports of Brest, Pinsk, Mikashevichy, and Pchow (Mazyr). There are nine locks from Brest, along the Mukhavets river and Dnieper – Bug channel, and between Pinsk and Mikaszewicze - there are two. Clearances under bridges all the way are over 7 m and meet the requirements of a class Vb waterway. Depending on the weather conditions, the navigation season on a given section of IWW E40 is between 245 to 270 days a year.

The navigable section of the E40 waterway in the Republic of Belarus starts in Brest, where the closed with a dam section of the Mukhavets river flows into the Bug river. At a distance of 61.99 km, a river port (Brest) is situated three navigable lock, located on the following water nodes: no. 10 Triszyn (Brest), no. 9 Nowosady and no. 8 Zaluzie (both are in the Zabinecki region). As a result of the recent reconstruction of these locks, they meet the requirements of the European standard Va class.

The Dnieper – Bug channel (D-BC) joins with the Mukhavets river in Kobryn, and further runs along sparsely populated agricultural areas. The length of the section from the Mukhavets junction with D-BC to water junction no. 2 Pererub (Janowski area) is 92.42 km.

The data on the basis of which the text was elaborated were the result of research carried out by the Maritime Institute in Gdańsk as part of the work entitled “Development of Feasibility Study of E-40 Dnieper – Vistula Waterway Restoration” (ID No. IPBU809/E40/FSR/Service/2)

Dnieper – Bug Channel

The Dnieper-Bug channel crosses the watershed between the two rivers, is divided into three distinct parts:

- ◆ western section with a length of 64 km from Brest to Kobryn,
- ◆ watershed section with a length of 58 km from Kobryn to Lachowicze in the Drohiczynski area,
- ◆ eastern section with a length of 47 km from Lachowicze to the Duboj village.

The main part of the channel has a length of 156 km and a catchment area of 8,500 km². A channel width of 40 m, at a depth of 2.4 m in normal operation, changes its cross-section into half trench - half embankment.

Currently, there is no direct connection with Western Europe by inland waterway between the Dnieper – Bug channel. The

reason for this is the location of a fixed lock on the Mukhavets river in Brest. For successful implementation of the revitalization project along the E40 waterway, it is necessary to solve the problems of D-BC reconstruction and necessary hydrotechnical structures as well as provide an adequate water supply.

The need to improve water relations in D-BC is due to problems of technical and ecological nature. Periodic shortages of water on the watershed are strictly connected with water collection in dry years from the upper Pripyat river in Ukraine by the Power System of White Lake (PSWL).

Reconstruction of Dnieper – Bug channel on the section from the Duboj water junction up to the Lachowicze junction

Reconstruction of D-BC hydrotechnical structures requires upgrading water junctions located to the east of the channel. Particular attention should be paid to the section from junction no. 1 Duboj up to junction no. 5 Lachowicze.

The developed outline of the Dnieper – Bug channel's reconstruction on a given section is focused on the reasons for the reconstruction of the eastern stretch of D-BC and defining actions to improve water relations for shipping on D-BC. This is a basis for the complex system of water management that affects the economic activity and natural balance of the upper part of the Pripyat river basin in Brest region¹.

Shipping locks and culvert at water junctions on eastern section no. 2 “Pererub”, no. 3 “Ragodoszcz”, no. 4 “Owzicze” and no. 5 “Lachowicze” do not meet the technical parameters for shipping or water flow conditions due to their total poor state, thus their reconstruction is required. Technical parameters are presented in tab. 1.

It is necessary to reconstruct infrastructures (locks, culverts) on all four water junctions of the D-BC section and maintain the required technical parameters. It is assumed that the reconstruction of hydrotechnical facilities will comply with the requirements of an international waterway – class Va. Water junctions no. 10 “Załuzie” was adopted as an example of such a reconstruction (Fig 1).

Reconstruction of the eastern section of D-BC is necessary also because hydrotechnical and navigational facilities were built in the years 1938-1941 from the unsound wooden structures,

¹Authors used for materials on water relations on D-BC and PSWL: operation studies, design studies and analyses of the Republican Unitary Enterprise Operation and Construction “Dneprobudvodput” (RUPEB “Dneprobudvodput”) and the Republican Unitary Enterprise Central Scientific Research Institute of Complex Use of Water Resources (RUP CINBKUZW) made during operation, as well as materials of Ukrainian specialists on the upper Pripyat river.

not suitable for modern automatic control. Continued use of these structures will require further substantial investments for maintaining their operational capacity.

At water junctions, two types of overflow devices were adopted: weirs and floodgates (Poirée system); the retention “peak” (20 m³/s) during spring floods in the Żyrowski reservoir was taken into account.

In order to improve the technical parameters, the following sequence of actions is advised:

- ◆ reconstruction of the Ragodoszcz water junction,
- ◆ reconstruction of the Pererub water junction,
- ◆ reconstruction of the Owzicze water junction,
- ◆ reconstruction of the Lachowicze water junction,
- ◆ Zyrowski reservoir.

The proposed technical solutions must take into account environmental protection requirements.

The above concept has been implemented since 2015. In particular, design and preparation works are being carried out for the construction of shipping lock no.3 Ragodoszcz. The total cost of reconstruction and locks’ construction on the eastern section will amount to EUR 19.5 million.



Fig 1. Water junctions no. 10 “Załużie” on the D-BC
Source: Republican Unitary Maintenance and Construction Enterprise “Dnepro-Bug Waterway, Pinsk, Belarus

Pripyat river

The Pripyat river running through the territory of Belarus on the length of 456.7 km is mostly a free-flowing river. On the canalised section of Pripyat from Pinsk to Stachowo (50 km), there are two locks on water juncture no. 11 Kaczanowicz and no. 12 Stachowo. Hydrotechnical facilities allow for water level increase at the given section providing navigation for vessels of a draft of up to 1.8 m. The condition of water junctions is sat-

Tab. 1. Technical parameters of shipping locks on the Dnieper-Bug waterway

Name of water node	Year of construction	Node elements	Length of the lock chamber between abutments (serviceable), m	Building dimensions			Working capacity, m ³	Type of closure	Material of heads and wharf abutments
				Width of the lock chamber, m	Slope, m	Depth at the threshold, (top/ bottom), m			
№1 Duboj	2006	Lock	120	12.7	2.4	2.75 2.6	3,680	flap gates, double doors	Reinforced concrete
№2 Pererub	1938	Lock	80.00	11.26	2.10	3.9 1.76	3,920	double doors	Reinforced concrete Wood
№3 Ragodoszcz	1941	Lock	79.95	11.10	1.8	3.85 1.95	3,560	double doors	Wood Wood
№4 Owzicze	1941	Lock	78.85	11.06	1.8	3.8 2.0	3,560	double doors	Wood Wood
№5 Lachowicze	1941	Lock	79.80	11.10	1.90	4.1 2.17	3,825	double doors	Wood Wood
Kobryń	2009	Lock	120	12.7	5.35	2.7 2.55	8,640	flap gates, double doors	Reinforced concrete
№8 Załużie	2015	Lock	120	12.7	2.35	2.7 2.5	3,638	double doors	Reinforced concrete
№9 Nowosady	2003	Lock	120	12.7	2.4	2.75 2.5	3,658	double doors	Reinforced concrete
№10 Triszyn	2011	Lock	120	12.7	1.4	2.50 2.70	2,462	double doors	Reinforced concrete
№11 Kaczanowicze	1954	Lock	110	11.93	2.2	4.4 2.2	5,970	double doors	Coarse concrete Wood

Source: The Ministry of Transport and Communication of the Republic of Belarus - RUPEB “Dneprobugvodput”, Pińsk 2015

Tab. II Workload comparison on the Dnieper-Bug channel (DBC) in order to ensure a guaranteed depth of 2.6 and 3.0 m

WATERWAY SECTION	LENGTH, KM	TOTAL VOLUME OF DREDGING WORKS, THOUS. M ³		REALIZATION PERIOD IN YEARS	ANNUAL VOLUME OF DREDGING WORKS, THOUS. M ³	
		3.0 M	2.6 M		3.0 m	2.6 m
Port Brest – node	4.5	54.0	32.4	15	3.60	2.16
n. Triszyn – n. Nowosady	19.5	468.0	280.8	15	31.20	18.72
n. Nowosady – n. Kobryn	38.6	926.4	555.8	15	61.76	37.06
n. Kobryn – n. Duboj	104.7	2,512.8	1,507.7	15	167.52	100.51
n. Duboj – port Pinsk	18.6	446.4	267.8	15	29.76	17.86
port Pinsk – n. Kaczanowicze	32.2	772.8	463.7	15	51.52	30.91
n. Kaczanowicze – n. Stachowo	25.1	602.4	361.4	15	40.16	24.10
Total along DBC:	243.2	5,782.8	3,469.6	15	385.52	231.32
n. Stachowo – estuary Horyni	53.8	2,421.0	2,098.2	15	161.40	139.88
estuary Horyni – estuary Canal Mikaszewickiego	11.1	499.5	432.9	15	33.30	28.86
estuary Canal Mikaszewickiego – port Mikaszewicze	7	315.0	273.0	15	21.00	18.20
Total along Pripyat	71.9	3,235.5	2,804.1	15	215.70	186.94
Total:	315.1	9,018.3	6,273.7	15	601.22	418.26

Source: The Ministry of Transport and Communication of the Republic of Belarus - RUPEB "Dneprobudput", Pińsk 2015

isfactory, but dam and weir modernization on the Stachowo junction is necessary. The approximate cost of the investment will amount to EUR 1.7 million.

In order to maintain navigability of the remaining Belarusian section of the Pripyat river, a program of annual works has been put in operation, concerning: dredging, strengthening of river banks, cleaning of riverbed, trawling, as well as the maintenance of shipping facilities on the waterway. Performance of the above works allows to keep the depth of 1.45-1.6 m (maximum draft – 1.25 – 1.4 m). Such significant restrictions have a great impact on transport profitability, both of internal and international transport on IWW E40.

In order to create conditions to ensure the water level appropriate for the organization profitable transport, it is necessary to conduct comprehensive regulatory works in the basin of the Pripyat river, including:

- ◆ Works aiming at creating and maintaining adequate parameters of the waterways – additional dredging works, strengthening banks, cleaning of riverbed, trawling, as well as alignment and straightening of certain Pripyat river sections.
- ◆ construction of additional dams – construction of new water junctions with shipping locks, corresponding to the parameters of class IV according to the international classification.

Works on the waterway relate mainly to dredging and an additional volume of dredging depends on the number and location of dam. The volume of dredging works on the section will range from 6.3 to 9.0 million m³. The cost of these works will amount to EUR 2–3 million (tab. 2).

In order to improve the stability of the waterway's increased dimensions and to reduce the volume of dredging works on its maintenance, timely execution of compensatory works is important, i.e. work on the construction of compensatory buildings and facilities.

Depending on their destination, compensatory buildings should provide:

- ◆ transport of sediment on the aligned sections, outside the waterway,
- ◆ dredging of riverbed within the limits of the waterway by improving the speed and direction of the current,
- ◆ protection of waterway banks, dredging material and special earth structures from erosion,
- ◆ preventing changes of the riverbed, affecting the conditions of the fairway.

In recent years, the problem of assessing the impact of works on the fairway on the morphology of riverbeds and hydraulics of water flow is particularly significant. In worldwide practice, buildings as an active protection method affecting the structure of the flows, slowing the flow in the coastal zone that promote the deposition of sediments are widely used.

Only at the section of Pchow–Usov of Pripyat river at the length of 126 km, there are currently 13 shallows that make shipping difficult. In order to ensure guaranteed parameters on those sections, the company responsible for the operation of the waterway (RUPEB "Dneprobudput") conducts dredging annually. The volume of works is approx. 360 thous. m³. The cost of dredging on those sections at the current price levels is about 98 thous. EUR per year.

To maintain adequate water levels and to form proper flow structure, RUPEB “Dneprobugvodput” uses active methods of protection by structure slowing down the water flow and fostering the accumulation of sediments. For this purpose, spurs of different length are used.

In the years 2013 – 2015, the company implemented compensatory works on five existing shallows on the discussed section of the Pripyat river by building spurs with long-effect (fig. 3). Operation of protective structures is calculated for the long-term and with proper maintenance, they are able to perform their functions for 15 years.

With the construction of spurs, it is not necessary to carry out dredging work on these sections, which will allow saving expenditures of up to EUR 1.4 million. The construction cost of compensatory structures at the Pchow – Usov section of the Pripyat river, including design-research works, will amount to EUR 2.5 million.

There is a need to carry out works on straightening the fairway on some strongly meandering stretches of the river. In particular, work on the following shallows is required:

- ◆ 67 – 68 km – “Trebuchowo-5”, “6-Trebuchowo” shallows,
- ◆ 75 – 78 km (outlet of the Cna river) – “Wertiacze-2”, “Kozan-Gorodok-1”, “Kozan-Gorodok-2” shallows,
- ◆ 93 – 95 km – “Jevreiskaia Jama -2” shallows,
- ◆ 100 – 102 km – “Polanka-1”, “Polanka-2” shallows.
- ◆ Straightening of the above-mentioned sections of the Pripyat river will allow for:
 - ◆ reduction of the total length of the waterway – reduction in transport costs and delivery time,
 - ◆ reduction of operating costs associated with a significant reduction in the volume of dredging works on the straighten section of the river.

The hydraulic calculations indicate that theoretically, the greatest possible water depth at the 95% confidence level on the section Stachowo – outlet of Wietlica river amount to 1.35 m, at Mazyr – Usov section – 2.8 m.

In 1981-1990, it was planned to build a transport water junction near Nogorcy, Ukraine. Since it was not allowed to build the water junction in the excluded Chernobyl zone, the currently existing stepped character of the riverbed in Ukraine should be eliminated by compensatory and dredging works. Moreover, the company responsible for the operation of the relevant section of the waterway (DP “Ukrwodzliach”), since the disaster at Chernobyl NPP, does not perform any operations to improve navigation conditions and eliminate “bottlenecks” on this stretch. It should be pointed out, that if no compensatory works are implemented, deep-water transport artery is impossible to be created.

Analysis of the Pripyat river’s longitudinal profile indicates that even full implementation of hydrotechnical works required to improve the fairway will not allow full use of vessel



Fig. 2. Example of a side-spur on the Pripyat river

Source: The National Academy of Sciences of Belarus

capacity during low water levels. To ensure the fairway’s depth through the entire navigation season for fully loaded vessels, comprehensive regulatory works in the basin of the Pripyat river should be implemented, including the construction of dams with lockages of individual sections.

The need for the construction of new hydrotechnical facilities on the Pripyat river has been repeatedly considered. Detailed evidence supporting regulation of the Pripyat river basin, taking into account the needs of the water national economy and improvement of shipping conditions, was developed in 1981 by the institute called Republican Unitary Enterprise Design and Research “Belgiprovodkhoz”.

The study of “Belgiprovodkhoz” considered two possibilities for improving navigation conditions on the Pripyat river:

- ◆ Construction of 7 water junctions with 3 to 6 m of water height of fall (lock chambers’ size - 180x15x3 m), that provide a shipping depth of 3 m for vessels with 1,250-ton capacity. Approximate cost of the investment - EUR 67 million.
- ◆ Construction of 6 water junctions with 3 to 6 m of water height of fall (lock chambers’ size - 120x12x2 m), ensuring the maintenance of the fairway’s current dimensions with a depth of 1.5 m. In this version of the seventh water junctions is not foreseen, the study takes into account the existing “Kaczanowicze” and “Stachowo” water junctions.

The third variant is based on the design of the “Belgiprovodkhoz” institute, however it contains a number of adjustments, taking into account the existing conditions. In particular, this variant takes a more balanced approach, considering both the need to create conditions on the Pripyat river to maintain shipping parameters, allowing for economically efficient transport of goods throughout the navigation season, and the need to minimize the possible negative environmental impact, primarily within the protected areas of Polesie Prypeckie. With regard to the issue of flora and fauna biodiversity, the Pripyat section within the Prypecki National Park was considered, in the Gomel region, in the area between Stwihy and Uborci rivers, as well as the area of the “Middle Pripyat” nature park between Pinsk and Turow (Pripyat river

flooding areas)². In addition, adjustments also include hydrological conditions of navigation, analysis of the Pripjat riverbed, negative dredging impact caused by the Chernobyl NPP disaster.

The creation of dams and performance of hydrotechnical works on the river will allow to create conditions ensuring permanent parameters of the fairway at the Belarusian section of Pripjat for fully loaded vessels during the entire shipping season. Project implementation will affect the distribution of water flows and regulate the use of transboundary waters, which is particularly important in conditions of severe droughts.

The revitalization gives priority to the variant, which is focused not only on the development of transport waterways, but also on the need to minimize the impact on protected areas. The cost of building water junctures in this case will amount to EUR 19 million.

To conclude, it is necessary to progressively create conditions for the operation of vessels with higher drafts along the entire IWW E40. Based on the analysis of cargo streams, the following minimum parameters are proposed:

- ◆ in short-term (within 5 years) – up to 2.0 m depth,
- ◆ in the medium-term (15 years) – 2.4 m depth (on the western stretch of the D-BC – 2.3 m depth).

The total volume of dredging works on D-BC and the Pripjat river (route length – 315.1 km) required to ensure a guaranteed depth of 2.6 m, will be approximately 6.3 million m³. The cost of such works at current price levels is EUR 2 million. It is worth mentioning, that in the case of sufficient funding, the time of these works can be reduced significantly³.

According to preliminary calculations, the increase in the minimum depth of the fairway to the parameters corresponding to the requirements of the AGN agreement to Class IV (conditions for the passage of vessels with a draft of 2.8 m)⁴ is possible due to adequate water supply and will contribute to improving the attractiveness of transport on IWW E40. Analyses indicate that currently, there is no need to achieve this parameter in a short time, and it requires a separate study. This is due to several factors:

- ◆ lack of a vessel fleet of draft exceeding 2.1 m (maximum draft of barges popular in Belarus – a draft barge-platform),

²Korniejew W., Denisow N., (2010). Water resources management of the upper Pripjat river and the Beloozerskaya Water Feed System of the Dnieper – Bug canal, Mińsk

³Rekonstrukcja Kanału Dniepr-Bug na odcinku od węzła wodnego „Duboj” (km 26) do węzła wodnego „Lachowicze” (km 73) z poprawą warunków żeglugi, Ministerstwo Transportu i Komunikacji Republiki Białoruś, Krajowe Unitarne Przedsiębiorstwo Eksploatacyjno-Budowlane „Droga wodna Dniepr-Bug”, Pińsk 2010

⁴ European Agreement on Main Inland Waterways of International Importance (AGN); Economic Commission for Europe, Inland Transport Committee; ECE/TRANS/120/Rev.4, Geneva (1996)

- ◆ limitations of already reconstructed water junctions on the western stretch of the D-BC,
- ◆ a wider range of investments needed to ensure an increased volume of work on the fairway, reconstruction and construction of hydrotechnical structures and a significant amount of compensation measures to protect the environment.

When planning improvement of the channel parameters, the need to ensure additional water supply for the waterway was taken into account. This role can be performed by the planned Zyrowski reservoir.

Investment needs on the analysed section of IWW E40

While planning works on the gradual increase of the permitted vessels drafts in the Belarusian part of the IWW E40, adequate technical conditions for a possible further increase in the guaranteed depth of 3.0-3.5 m should be foreseen. The cost of the whole action aimed at improving the attractiveness of the Belarusian part of the IWW E40 will amount to:

- ◆ EUR 19.5 million – reconstruction of the existing hydrotechnical structures on the eastern section of the D-BC,
- ◆ EUR 5 million – hydrotechnical works in the fairway aiming at higher vessel drafts up to 2.4 m,
- ◆ EUR 19-67 million – construction of new water junctions on the Pripjat river with locks that will meet the requirements of class IV of international classification,
- ◆ EUR 5-15 million – construction of the navigable section of IWW E40 on the Belarusian-Polish border
- ◆ EUR 11.7 million – modernization of the water supply system of D-BC, including construction of the Zyrowskiego Reservoir.

The total cost of all these activities, excluding the costs of environmental compensation will amount to approx. EUR 60-120 million.

Identification of barriers and missing links on the Belarusian section of IWW E40

- ◆ The Mukhavets river at the section from the Brest city to the Kobrin city – small permissible maximum draft (1.60 m).
- ◆ The Dnieper - Bug channel section from the Kobrin city to the Pererub village – small permissible maximum draft (1.60 m).
- ◆ The Pina river on the stretch from the Pererub village to the Pinsk city – small permissible maximum draft (1.60 m).
- ◆ The Pripjat river on the stretch from the Stachowo village to the Pchow (Mozyr) port – small permissible maximum draft (1.30 m).
- ◆ The Pripjat river on the section from the Pchow port to the Belarusian-Ukrainian border – small maximum permissible draft (1.50 m).



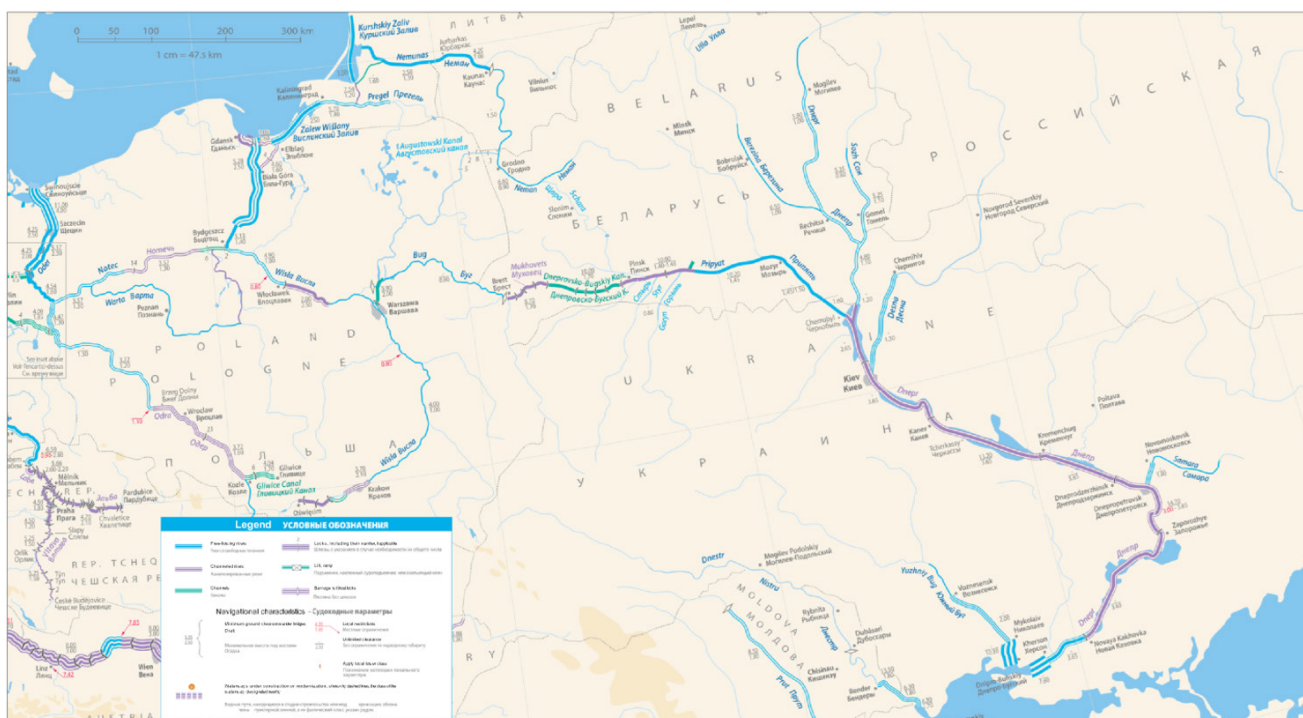


Fig. 3. Map of traffic restrictions on the international waterway E 40
Source: Inventory of Most Important Bottlenecks and Missing Links in the E Waterway Network, Resolution No. 49, Economic Commission for Europe – Inland Transport Committee, New York and Geneva 2013.

Conclusions

Taking into account the current hydrotechnical and navigation conditions on both sections analysed in the article, it can be said that both require revitalization. Despite the fact that in comparison to the Polish section of IWW E40, they present satisfactory operating parameters, the two sections remain the weakest links of the Belarusian part of IWW E40. Invest-

ment expenditures will increase their shipping parameters and considerably improve the quality of navigation and water management within the regions located in the influenced areas. When planning E40 waterway revitalization, the Dnieper-Bug Channel and the Pripjat river sections should not be treated as separate projects. Only a comprehensive approach to the whole IWW E40 will make the most effective use of its role in the socio-economic development of the country and regions.

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Corresponding author: Marcin Kalinowski; Maritime Institute in Gdańsk, Department of Economics and Law, Długi Targ 41/42, 80-830 Gdańsk, Poland, tel. (+48) 58 301-16-41 ext. 36, e-mail: marcin.kalinowski@im.gda.pl



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