Analysis of selected possible impacts of potential E40 Inland Waterway development in Belarus and Ukraine on hydrological and environmental conditions of neighbouring rivers and wetlands

Mateusz Grygoruk
Ewa Jabłońska
Paweł Osuch
Paweł Trandziuk

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Cover photo:

Floodplains of Pripyat in spring (Author: S. Płytkiewicz; picture given to CMok)

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Summary

In this report we inteneded to analyse the main impacts of possible development of E40 Inland Waterway (E40 IWW) on selected physiographical elements of the environment of adjacent valleys and wetlands. Descriptive analysis addresses the exposure of E40 IWW to prospective climatic changes, associated hydromorpological pressures. We paid special attention to the influence of the possible E40 IWW development on the most important environmental hotspots which are Olmany mire and Pripyatsky National Park. Results of analyses allow to state that one could expect significant influence and adverse effects of climatic change effects on availaibilty of water for the navigation purposes along the E40 IWW in the horizon of the following 50 years. It was foreseen that development of E40 IWW will likely pose high risk of degradation hydromorphology of the most natural stretches of Pripyat in Pripyatsky National Park. It was also defined that selected habitats of the Olmany mires will be exposed to the risk of the loss of water that will likely result in a regional groundwater supply. Additionally, we discussed the exposure of inland navigation along the planned E40 IWW to radiation from the reactor of the Chernobyl Nuclear Power Plant. We foreseen that the inland navigation along the E40 IWW will be exposed to severe changes of flow regime and though – is likely to be facing inrregularity of hydrological fenomena of Pripyat, Pina and Dnieper. We conclude that although the navigation is likely to be possible along the Belarus-Ukraine stretch of E40 IWW, environmental impacts related to the river maintenance are likely to affect the subjects of protection of Prypiatsky National Park and Olmany mire and – in general – negatively affect the environment.

1. Introduction

The idea of improving navigation along the E40 Inland Waterway (later on referred to as E40 IWW) assumes implementation of measures allowing trans-boundary and trans-catchment transport of goods between Ukraine, Belarus and Poland (Fig. 1.1) (Maritime Institute of Gdańsk, 2015). Its intention is to connect the harbours of Baltic Sea and the Black Sea by a navigable route following the rivers Dnieper, Pripyat, Mukhavets, Bug and Vistula. Part of E40 IWW located in Poland will, undoubtly, pose significant environmental risks and hazards. The most important part of this investment refers to the need of design and construction of a navigable canal between the rivers Bug and Vistula, followed by the extensive technical solutions assuring appropriate amounts of water allowing the canal to function as a waterway.

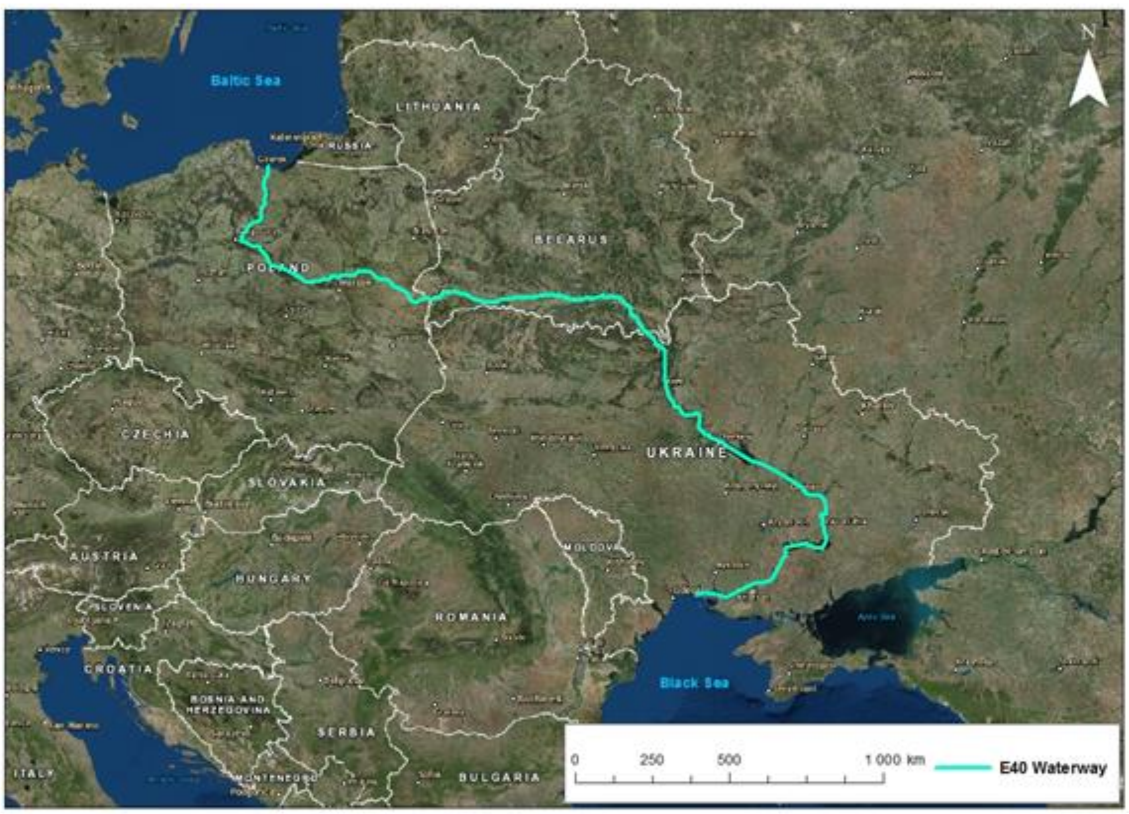

Fig. 1.1 E40 Inland Waterway – overview of the whole course of the route. Ortophoto: Google

The part of E40 IWW in Belarus and Ukraine does not seem to pose that significant engineering and design efforts, as a vast part of it is already a navigable canal. However, the lack of environmental monitoring and data related to hydrological variability, at least from the publicly available sources, does not allow to exclude similar, extensive environmental hazards as the ones defined for the Polish part of E40 IWW (Grygoruk et al., 2018).

In this report we intend to describe possible impacts of E40 IWW development and enhancement on its Belarusian and Ukrainian stretch. Main goals of this report are related to (1) identification of possible hydromorphological challenges of canal construction and restoration, (2) analyse possible ecological consequences of E40 IWW development on ecological status of watercourses along its way, including their tributaries and (3) identify and analyse the influence of projected climate-induced pressures on availability of water for the canal. Special attention in this report was paid for the possible response of protected areas to the E40 IWW development including Olmany Mires Reserve and Pripyatsky National Park. The report is summarized by the set of questions that must be addressed from the environmental perspective if ones wish to quantify the influence of E40 IWW development on selected elements of the environment of adjacent areas located in Belarus and Ukraine.

2. Description of the E40 IWW development

The E40 IWW connects the Baltic Sea with the Black Sea. It starts in Gdańsk and further in the Polish part runs along the Vistula river and the Bug river, all the way to Terespol, to the Polish-Belarusian border. The Belarusian stretch of the canal runs through the Mukhavets River, the Dnieper-Bug Canal, Pina River and Pripyat River to the Belarusian-Ukrainian border (Fig. 2.1).

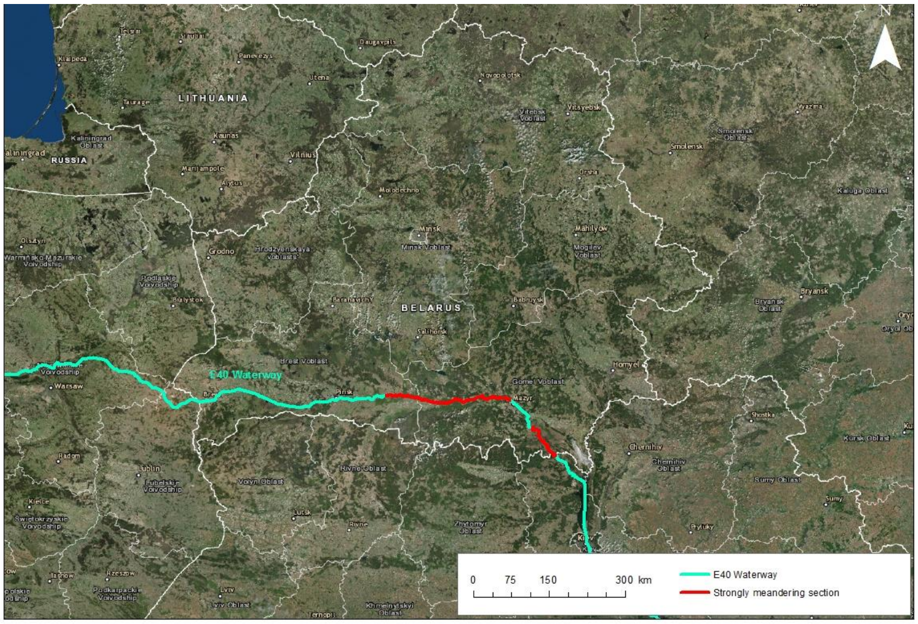

Fig. 2.1 Overview of the research area: distinguished channelized and natural stretches of E40 IWW. Ortophoto: Google.

Although part of the Belarusian stretch of E40 IWW runs through the navigable canal, vast parts of the course of the planned waterway goes through the heavily meandering stretch of Pripyat (Fig. 2.1 and 2.2), which is discussed in the latter part of this report.

Fig. 2.2 Meanders of Pripyat in the Pripyat National Park. Radius of meanders is smaller than 200 m, which can pose significant risk in navigation of the ships longer than 50 m. Ortophoto: Google.

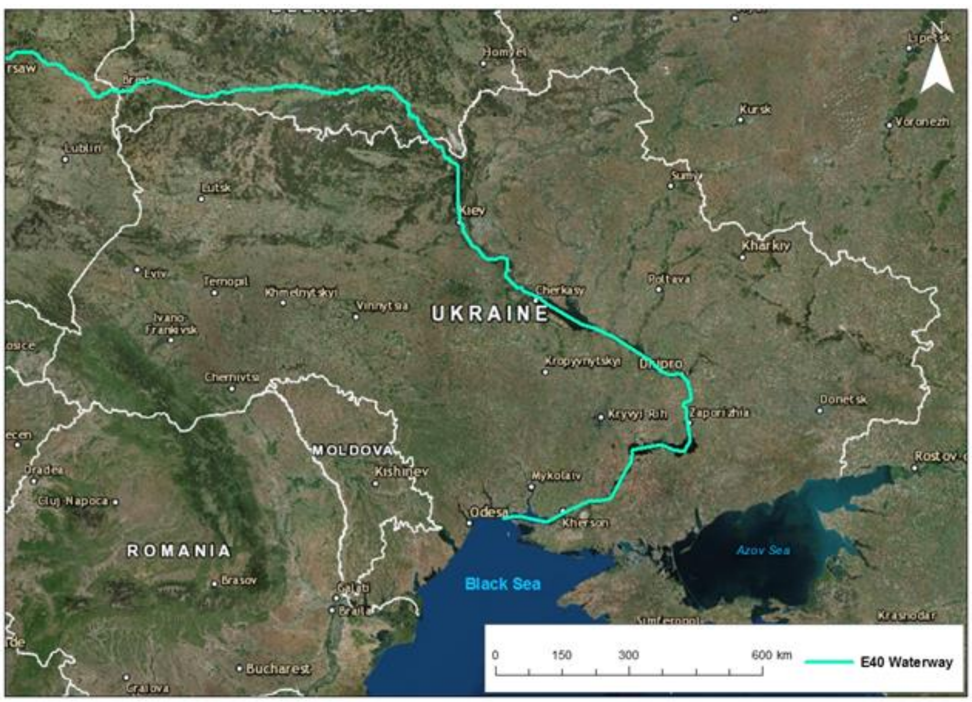

Fig. 2.3 Ukrainian stretch of the E40 Inland Waterway development. Ortophoto: Google.

Fig. 2.4 Location of the lower course of the Pripyat river belonging to the planned and enhanced E40 IWW route in a 2.5 km distance from the remnants of the Chernobyl Nuclear Power Plant. Please note that the zone of Chernobyl and Pripyat remains an enclosure and entrance to this zone is strictly regulated. Ortophoto: Google.

Ukrainian part of the E40 IWW runs through the navigable rivers of Pripyat and Dnieper, including a number of impounded stretches forming reservoirs (including Kremenchutskiy Reservoir). Interestingly, part of the E40 IWW passes the remnants of the Chernobyl (Pripyat) Nuclear Power Plant (Fig. 2.4), passing the Chernobyl Nuclear Reactor in a distance of 2.5 km. One should consider that up to now entering the zone of Chernobyl and Pripyat towns is strictly regulated and longer exposure of people to possible radiation in this zone is still considered hazardous. Development of inland navigation on the level of E40 IWW construction would require many efforts related to the management of works, assuring individuals and machines working in this area on possible river regulation to limit their exposure to radiation. Similarly, once the waterway is prepared (regulated) for the navigation, one should foresee possible problems related to the increased exposure of ships/staff on radiation when passing this zone. It is likely that the presence of individuals going upstream/downstream the Pripyat in the Chernobyl area would make them exposed to the radiation for longer than some 4 hours (Fig. 2.5). This fact, on top of the other environmental and technical issues, should also be considered in environmental assessment of the E40 IWW development and enhancement at its Ukrainian stretch.

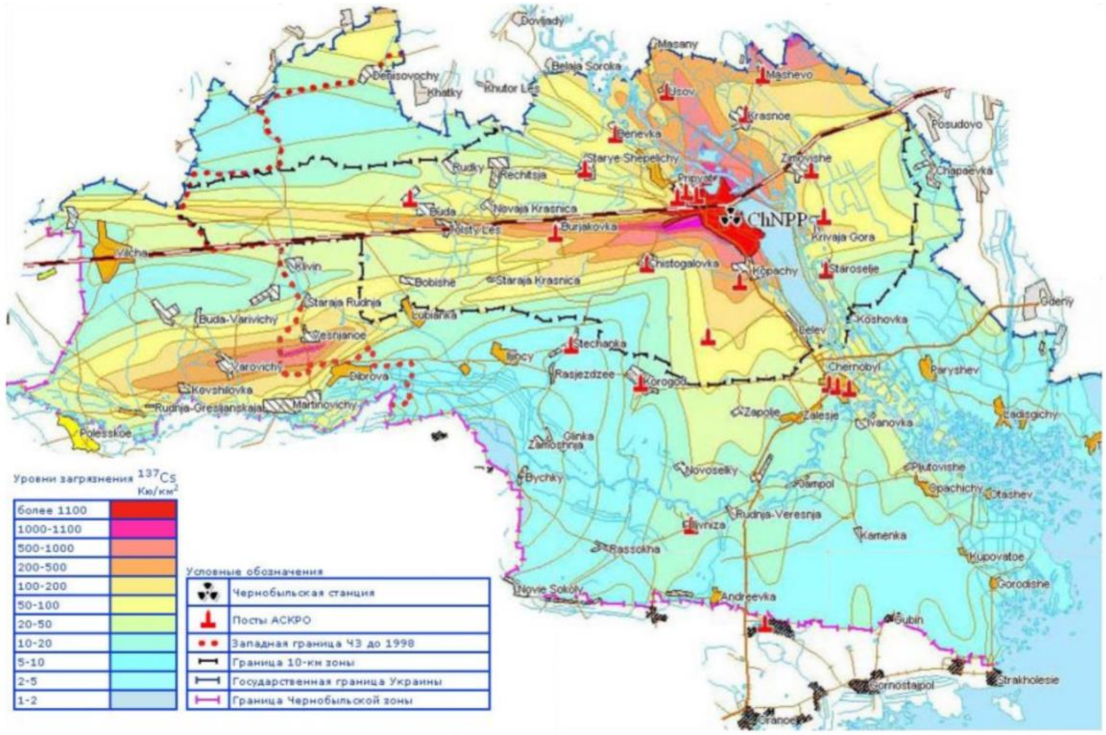

Fig. 2.5 Location of the lower course of the Pripyat river belonging to the planned and enhanced E40 IWW route. Note that the stretch of Pripyat located in the most upstream part of the Ukrainian Pripyat is located in the zone of limited entrance possibility due to the high exposure to radiation. Source of the map: http://chernobylplace.com/chernobyl-map/.

3. Impacts

3.1 Hydrology

Feasibility study about the E40 IWW development very roughly addresses hydrological issues, namely the discharges and variability of selected hydrological indicators of the E40 IWW in Belarus and Ukraine (Maritime Institute of Gdańsk, 2015). Although most of the E40 IWW in Belarus and Ukraine is navigable, some quantitative characteristics of the water system is required as a reference for further analyses. It was not possible to find hydrometric data of vast parts of E40 IWW (e.g., Dnieper-Bug Canal). In order to find out the distributions of river discharges and inter-seasonal variability of flows we attempted to search for the consistent datasets on hydrology. Apparently, the hydrological data one should use for the analysis of the probable influence of E40 IWW development and function do exist (standard monitoring of Belhydromet) but are not available in a public domain. It is compulsory to study long term dynamics of river discharges and related phenomena (e.g., ice phenomena and hydromorphology) in order to reveal the exact quantitative influence of E40 IWW development and function on water resources of Belarus and Ukraine. However, on the basis of the available datasets we managed to list average multi-year discharges of rivers belonging to the E40 IWW system in Belarus (Pina, Pripyat and Dnieper; Tab. 3.1 and Fig. 3.1) and Ukraine (Dnieper; Fig. 3.1) after Klimenko (2010). Average discharges of rivers that can be used as water supply for the E40 IWW vary from some 72 m^3/s (Pripyat in Mozyr) through some 170 m^3/s (Pina in Pinsk) up to some 1370 m^3/s (Dnieper in Kiev) and 1700 m^3/s (Dnieper by its mouth to the Black Sea).

Tab. 3.1 Average multi-year discharges of selected watercourses belonging to the E40 IWW system in Belarus. Source of data: Klimenko, 2010. LQ – lowest annual discharge; MQ – average annual discharge; HQ – highest annual discharge; MMQ – average discharge from the multi-year period.

Map ID	Water gauge	River	Year	Characteristic discharge values [m^3/s]			
				LQ	MQ	HQ	MMQ
1	Pinsk	Pina	2017	92	132	209	170
			2016	62	121	197	
			2015	52	100	144	
2	Mozyr	Pripyat	2017	118	380	935	392
			2016	63	282	633	
			2015	48	184	395	
3	Pinsk (Lyubansky bridge)	Pripyat	2017	15	52	119	72
			2016	8	46	110	
			2015	11	44	86	
4	Rechytsa	Dnieper	2017	154	323	640	360
			2016	116	254	468	
			2015	88	189	420	

The Belarusian part of the E40 IWW seems to be resilient with respect to water resources required for running the waterway: increase of discharges between the hydrological profiles analysed is considerably high comparing to the sizes of catchments. This may be related to the fact that the neighbourhood of the E40 IWW in Belarus is rich in wetlands that assure continuous water supply to the draining rivers. Smaller stability of discharges is observed in the Ukrainian part of E40 IWW where the increase of average multi-annual discharges is relatively small comparing to the catchment size (only 20% increase of the average multi-annual discharge of river Dnieper along its course of nearly 800 kms between the Kiev and Kherson (Black Sea). However, nearly the whole Ukrainian stretch of E40 IWW is impounded. Regardless the negative influence of impoundments on water quality and species migration that have been observed long since, it is likely that available water resources in Belarus and Ukraine are sufficient to assure the function of E40 IWW.

Contradictorily to the Polish stretch of E40 IWW, where the main hazards for E40 IWW function were related to impossibility of getting water to the upstream parts of the Bug-Vistula canal, we hypothesize that the main environmental threats posed by E40 IWW are related to issues of periodic shortages of water (droughts; upstream stretch in Belarus) caused by the projected climatic change, hydromorphological pressures related to the requirement of river regulation in its natural stretches and affected water balances of valuable peatland sites.

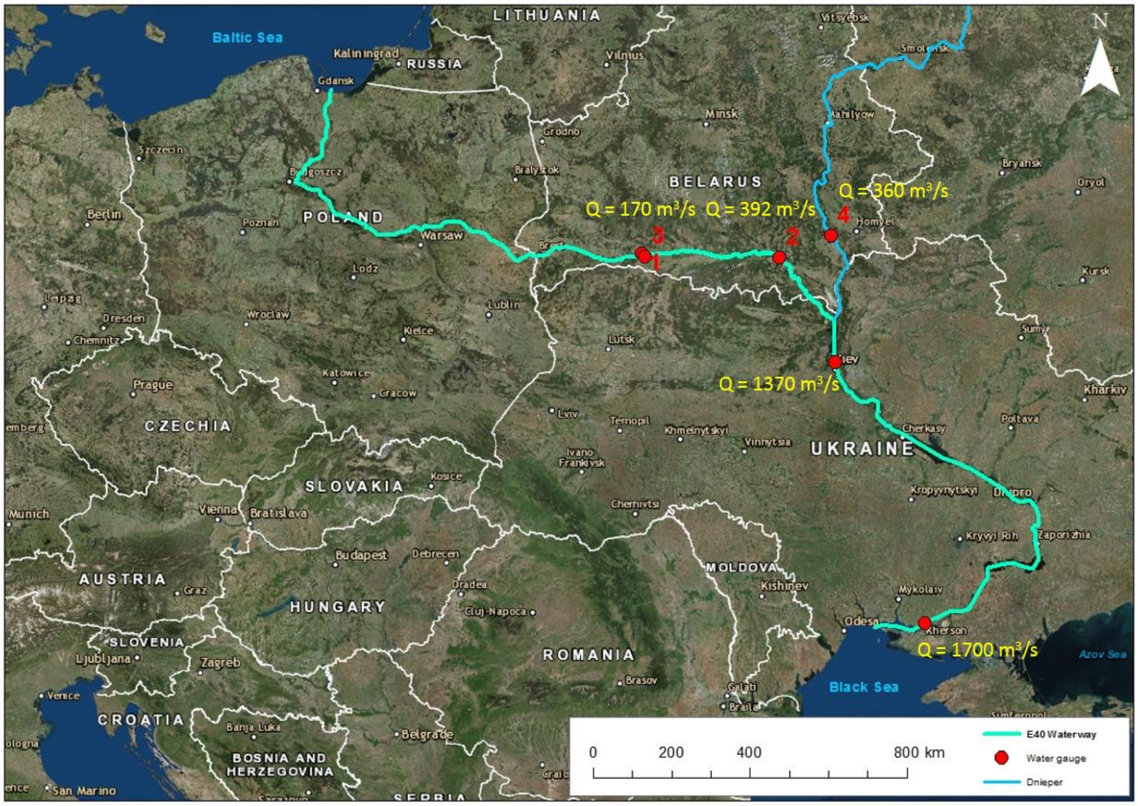

Fig. 3.1 Average multi-year discharges of selected watercourses along the E40 IWW. Sources of data: Klimenko, 2010.

Development of the E40 IWW is also likely to affect the natural icing processes. Channelization of Pripyat will require intensification of ice-sheet management as ice jams occurring during the thaw periods will be required to be removed for the navigation purposes. It is likely that in the future icing processes will be less regular and more variable in forms and durations (Bączyk and Suchożebrski, 2016), though requiring more specific preparation and management. However, this issue, similarly to the issues related to multi-year sets of river discharge data, would require detailed insights into the quantitative assessments of icing along longer periods.

3.2 Climate change

So as for the other regions of the Central Europe, water scarcity caused by the prospective climate change is likely to influence majority of the European rivers (Schneider et al., 2011), including the E40 IWW function. This element was, however, neglected in the feasibility study (Gdańsk Maritime Institute, 2015). In the framework of this report we managed to gather and list the most important probable climate change scenarios for the region, that may affect hydrology and functioning of the E40 IWW.

Tab. 3.2 **Pressures and impacts on flow regimes of Pina, Pripyat and Dnieper rivers originating from the modelled climate change scenarios in the time horizon 2050 referred to the baseline conditions. Quantification was based upon the results available in the literature.**

Pressure	Impact	References
Disturbances in agricultural production	Lack of water for canal/agriculture	IPCC 2014
Changed occurrence of extreme river discharges and floods	Instability of water resources	Melnik et al., 2017
Earlier arrival of migratory birds in Europe	Affection of bird migration	
Maximum air temperatures will increase	Severe droughts	
Frequency of occurrence and intensity of winters	Cold winters	
Frequency of occurrence and intensity the April frosts	Cold springs, growing season shorter	
Change in flood volume in the 2050s compared with the baseline period	Decrease of flood volumes by 25%-50%	Schneider et al. 2011
Change in duration of overbank flows in the 2050s compared with the baseline period	Decrease of overbank flow duration by up to 5 days a rear	
Change in timing of floodplain inundation in the 2050s	Occurrence of peak snowmelt flows 1 month earlier	
Increase of river discharge variability	Up to 40% increase of river discharge variability	Kirvel et al. 2016
Increased variability of ice phenomena	More frequent ice jams	Bączyk and Suchożebrski, 2016 [1]

[1] Adapted from the observations of river Bug.

Most of the international studies foresee shortages of water (IPCC, 2014), increase of evapotranspiration and instability of river discharges (Kirvel et al. 2016; Melnik et al., 2017), and decreasing flood volumes including earlier occurrence of spring floods (Schneider et al., 2011). Some authors for the region of Bug (Bączyk and Suchożebrski, 2016) foresee that variability of ice phenomena is likely to increase dramatically, posing additional challenges to the management of E40 IWW. We foresee that the most problematic would be the projected climate change influences on rivers located in the upstream part of E40 IWW in Belarus, as water resources of rivers forming the upper E40 IWW are relatively small (Tab. 3.1). Prospective 25-50% decrease of flood volumes in the tributaries of Pripyat (such like Pina) would dramatically decrease the availability of water for the functioning E40 IWW. Climate change pressures (longer and more severe droughts) are likely to entail increased use of water by agriculture, limiting at the same time possibilities of feeding E40 IWW with water in most critical periods of the year (June-September).

Fig. 3.2. Massive algal blooms and transfer of algae to the downstream section of Dnieper river in Switlovodsk (Kremenchutskiy Reservoir), Ukraine. Ortophoto: Google.

Longer and more severe droughts as well as greater polarization of precipitation are likely to entail increased use of water by agriculture, limiting at the same time possibilities of feeding E40 IWW with water in most critical periods of the year (June-September). It has already been documented that especially along the impounded stretch of the Dnieper in the Ukraine massive algal blooms occur (Fig. 3.2). It is likely that channelization of natural stretches of rivers (e.g., Pripyat in Belarus) may affect flow dynamics that along with more instable precipitation conditions and requirements of feeding rivers with water stored in the reservoirs will likely decrease water quality. This aspect must also be addressed in the extensive analysis of the E40 IWW impact on environmental conditions of adjacent areas.

3.3 Hydromorphology and ecological state

The most significant influence of E40 IWW development in its Belarus stretch is likely to result from regulation of the Pripyat river in the meandering stretches, especially in the surrounding of the Pripyatsky National Park. River Pripyat itself remains one of the very few near-natural large lowland rivers of Europe. According to the classification of water bodies complementary to the definitions of Water Framework Directive[2] (WFD), river Pripyat (or at least vast part of it) can be considered a natural water body in very good and good hydromorphological state. Together, more than 250 km of the Pripyat river presents unique, naturally meandering state along its Belarusian stretch. Multiple segments of this river present unique variability of depths, widths and shallows, which are typical for the very few large natural European lowland rivers (Fig. 3.3).

Fig. 3.3. Sand banks and shallow flats of Pripyat in the area of Barbarov. Ortophoto: Google.

[2] Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy"

Knowing the intended sizes of vessels to be used on the E40 IWW and considering sizes the ones already used on the regulated stretches of Pripyat (Fig. 3.4; more than 125 m of length), it is likely that regulation of Pripyat for the purposes of inland navigation will pose significant modification and homogenisation of the Pripyat river channel. Some sets of vessels, longer than 200 m, may require broadening the river channel and cutting-off meanders in order to enhance safe navigation. Facing the fact that the river basin management plan for the Pripyat river is being prepared[3], one should assure the integration of the requirements of WFD to be met with the planned development and function of E40 IWW. Knowing the extensive plans of improvement of navigability of Pripyat which will result in degradation of the unique natural hydromorphology of this river we stress that the development of E40 IWW should be considered as action posing significant risk for keeping high hydromorphological status along the natural water bodies of Pripyat.

Fig. 3.4. Navigation - +/- 125 m long vessel on the river Pripyat near the Novy Most. Ortophoto: Google.

Regulation of Pripyat will require long-stretch modification of the river hydromorphology. Embanking the river will likely require to cut-off a number of meanders, which radius is too small to assure safe navigation in various water levels. Enforcement of the river banks

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3 https://www.euwipluseast.eu/ru/component/content/article/37-post-russian/139-belarus-1st-constituent- meeting-of-the-pripyat basin-council-in-belarus-2?Itemid=429;

will result in the limited river-floodplain connectivity. Due to the excessive sediment transport, especially along the Pripyat, regulated river will require continuous monitoring of depths along the navigable canal. It is likely that the enhanced sediment transport in high-flow periods will induce the modification of the navigable river channel. In multiple cases the construction of groynes will be required. Continuous pressure on hydromorphology of the Pripyat, as well as for any other large lowland river, is considered the biggest and the most extensive among the pressures on rivers in some strategic documents related to the national water management schemes (Biedroń et al., 2018). It is likely that E40 IWW development implemented by channelization of the meandering stretch or Pripyat will affect macroinvertebrates and fish communities.

Fig. 3.5. Meanders and floodplain lakes of Pripyat (near Versnica; Belarus). Ortophoto: Google.

Fig. 3.6. Inland navigation along the planned stretch of E40 IWW – a +/- 100 m long vessel on the Dnieper-Bug canal. Ortophoto: Google.

Although this issue may be considered of the secondary importance when planning strategic actions for E40 IWW, it might of the high interest for local communities and environmental management authorities. Hence, their opinions, which are not officially available at the level of preparation of this report, should be considered in the next steps of E40 IWW environmental impact assessment.

4. Possible influence of E40 IWW development on Olmany mire

4.1 Geographical description

Olmany mire is one of the most exceptional peatland sites of Central Europe. The area is located between right tributaries of Pripyat, within the fluvial lowlands of Horyn and Stviga. This area is very flat, its southern border is the Volhynian granite threshold (located on the territory of Ukraine). The surface developed on the foreground of this threshold falls slightly to the north and north east. Its inclination is negligible. Along the north and north-west coasts of the plain there are huge sand dunes, on the Olmany-Kopcewicze line. These dunes are arranged parallel to the lower Horyn in the direction of SW-NE and they close the natural directions of the outflow of water from the plain, following its natural decline - from the south to the north (Kulczyński, 1939). A similar series of high dunes, parallel to the aforementioned, crosses the plain in its central part, on the Jeziory-Kołki line. This series divides the plain into two parts: the northern lower one and the southern one slightly higher, and plays the role of an analogous barrier, stopping the flow of water towards the north and forcing it to take north-eastern direction (Kulczyński, 1939).

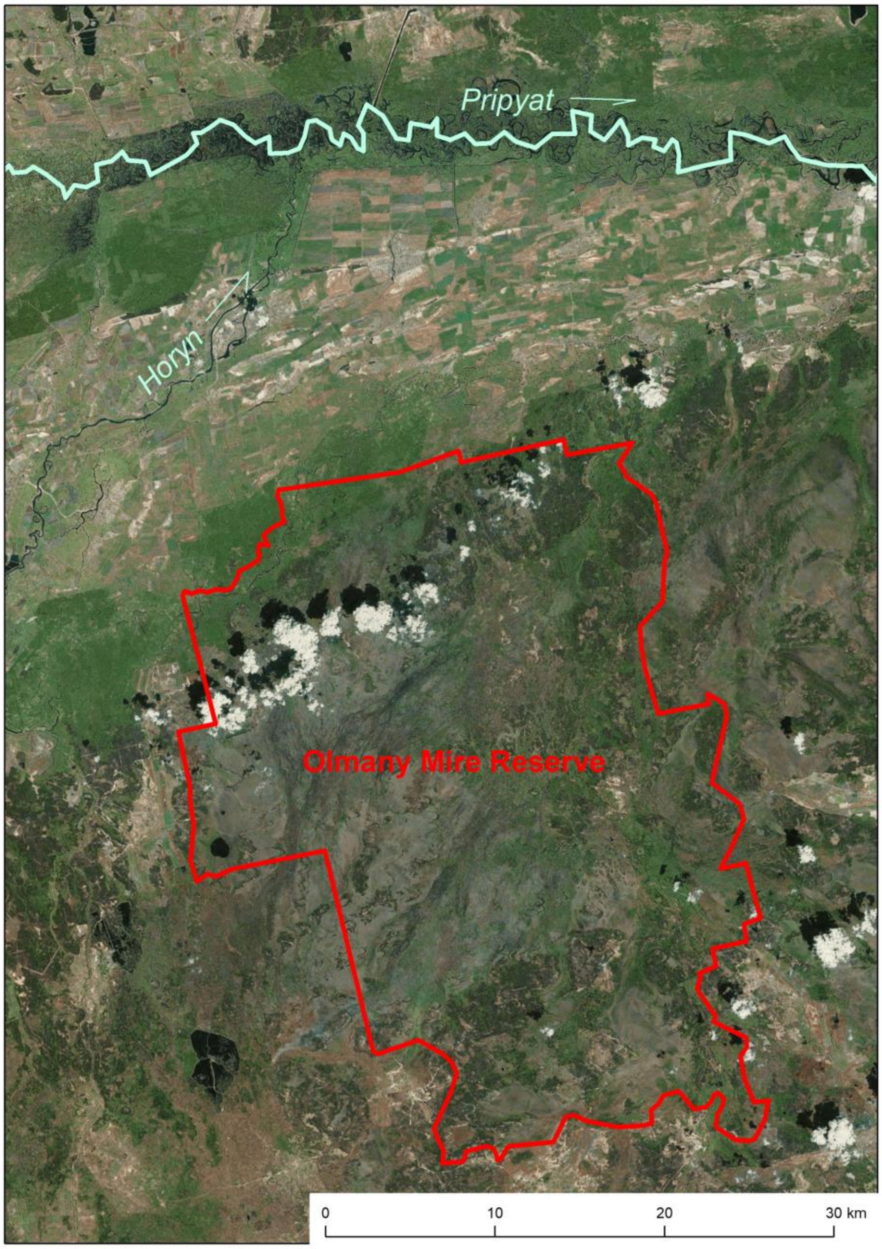

Fig. 4.1. Olmany Mire Reserve and the Pripyat river stretch planned for the development of E40 IWW. Ortophoto: Google.

In the entire area between Horyn and Stviga, the plain is crossed by one major drainage artery - the Lev river. It breaks through both ranges of dunes. The upper section of Lev (between Karpiłówka and Tomaszgród) has a relatively large slope, in the middle course (between Tomaszgród and Olmany) the river has a negligible fall.

The river flows there through an undefined bed among the huge peat areas. The river's waters spill widely and flood huge areas located east of the proper riverbed (Kulczyński, 1939). These areas, inclined slightly to the north-east and blocked from the north by two chains of dunes, are natural blind bays in which, with every concentration of waters of Lev, excess water accumulates and stagnates in the form of wide floodplains. As a result, huge mire complexes were created in areas located east of the Lev river. A particularly strong flooding is located in the northern part of the plain, enclosed between the Olmany-Kopcewicze sand dunes and the dunes of Jeziory-Kołki. This part of the plain is the lowest, and besides, a part of the water spilling from the Lev river to the area south of the belt of the Jeziory-Kołki dunes penetrates north through the somewhat broken line of the Jeziory-Kołka dunes. The mire area between two dune lines has practically no outflow. (Kulczyński, 1939).

4.2 Conservation status of the Olmany mire

The main part of the Olmany mire complex is located in Belarus, where the mires are protected as Republican Landscape Reserve (1998), IBA BY018, Ramsar Site (2001, Fig. 4.2) and are a potential site of the Emerald Network.

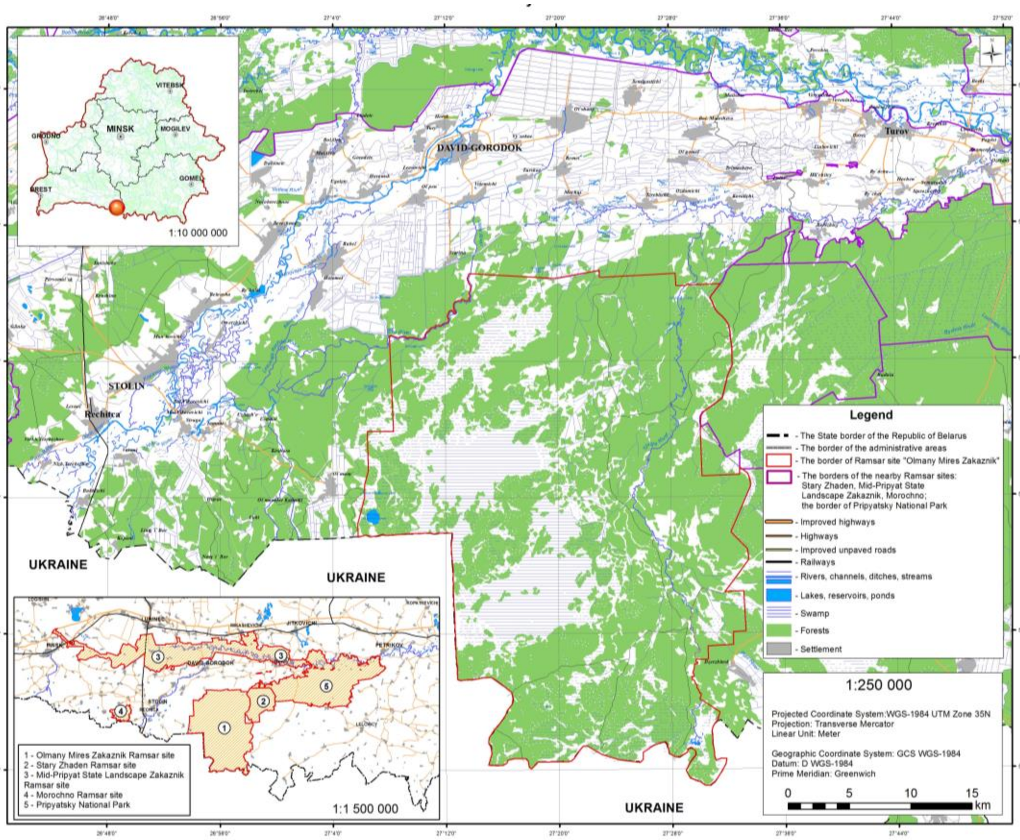

Fig. 4.2 Situation scheme of the Ramsar Site Olmany Mires[4].

[4] https://rsis.ramsar.org/ris/1091

Natural or little transformed areas occupy 90% of the Republican Landscape Reserve, including forest - 50% (with large areas of pine and birch bog woodlands), open mires - 40% (mainly transition mires), rivers and reservoirs - 5%, other land - 5%. The key importance is to preserve mire ecosystems – both open (active raised bogs (Natura 2000 code: 7110), occupying over 2 000 ha within the Belarusian part of the Olmany mire complex, and transition mires and quaking bogs (7140), occupying over 37 000 ha) as well as forested (bog woodlands (91D0), occupying over 13 000 ha) (Abramčuk et al. 2015).

The reserve avifauna includes more than 20 species under national protection status and more than 40 under international. Many of them are wetland-related species, including: the Europe's largest population of Greater Spotted Eagle *Aquila clanga* (18-20 pairs); the largest populations in Belarus of Short-toed Eagle *Circaetus gallicus* (10-30 pairs), Crane *Grus grus* (100-200 pairs), Greenshank *Tringa nebularia* (50-70 pairs), Aquatic Warbler *Acrocephalus paludicola* (50-100); as well as a number of other species – *Aquila pomarina, Asio flammeus, Botaurus stellaris, Ciconia nigra, Crex crex, Gallinago media, Haliaeetus albicilla, Ixobrychus minutus, Limosa limosa, Numenius arquata, Tetrao urogallus, Tringa glareola* (Abramčuk et al. 2015).

Basing upon the hydrological typology of mires done by Kulczyński (1939) (Fig. 4.3) one can see that the area of Olmany and the whole set of mires located south from the Olmany Reserve originally consisted of the full spectrum of the variety of mires, from ombrotrophic bogs, through transitional sedge and forest mires to minerotrophic fens.

Olmany Mire reserve remains an element of the environmental network of the southern Belarus, which together with the meandering stretch of Pripyat and Pripyatsky National Park form a biodiversity hotspot, which main environmental features are related to low touristic penetration and low pressure of forestry and agriculture.

In 2016, pursuant to the Decision of Gomel Regional Executive Committee and Brest Regional Executive Committee, dated 11 July 2016, № 622/522[5], the Biosphere Reserve Pripyatskye Polesie was established. The Reserve includes Olmany Mires Reserve, Pripyatsky National Park and Stary Zhaden reserve, which highlights importance of the whole region for nature conservation in Belarus as well as functional interconnectedness between these three nature protection areas.

The area of the Biosphere Reserve Pripyatskye Polesie is 213030 ha. According to the Decision, the main goals of the Reserve are: (1) ensuring the conservation of biodiversity and landscape diversity resources of the central part of Pripyatskye Polesie, which has a recognized national and international significance; (2) promoting socio-economic

[5] http://www.pravo.by/document/?guid=12551&p0=R916g0078033&p1=1

development of territories based on sustainable development, (3) creating conditions for research, environmental monitoring, environmental education and training, (4) development and implementation environmental management methods appropriate to local environmental conditions and cultural traditions; (5) restoring disturbed ecological systems to the state close to natural.

The core zone of the Biosphere Reserve is intended to provide protection of natural ecological systems, biological and landscape diversity. The buffer zone of the Biosphere Reserve is for preventing or mitigating external negative impacts on the main zone, ensuring protection of natural and cultural landscapes of Pripyatskye Polesie, creating conditions for development tourist and recreational activities as well as traditional environmental management.

Fig. 4.3 Inventory of mires in Polesye region: 1 – ombrotrophic mires (bogs); 2 – transitional mires (e.g., *Caricion lasiocarpae*); 3 – transitional mires (forest); 4 – transitional mires (e.g., *Magnocaricion*); 5 – minerotrophic mires (fens), a – Volhynian granite threshold, b – Jeziory-Kołki dunes line, c – Olmany-Kopcewicze dunes line. Red circle – approximate area of the Olmany Mire Reserve. Scale of the figure: approximately 1:600 000. Source: (Kulczyński, 1939).

4.3 Possible exposure of Olmany mire to hydrological alterations related to E40 IWW

Due to the location of Olmany mire at the water divide of Horyn and Stviga (Fig. 4.3) it is likely that the flow regime changes of Pripyat and associated changes of flow regime of Horyn and Stviga will affect the conservation status of mires. Channelization concept implementation will affect the stretch of Pripyat where the most important rivers draining the Olmany mire confluence. Stabilization of banks and discharges of Pripyat will induce decreased connectivity between the Pripyat and its floodplains that will affect capacity to receive waters from the upper Horyn and Stviga. This will influence groundwater flows in the bog and floodplain systems, which will directly influence fens of the area. On top of this impact, it was described in similar areas of presence of a natural fen-bog gradients, that rainwater accumulation is related to drainage capacities of adjacent rivers and groundwater discharges (e.g., Grygoruk, 2013). Hence, possible environmental impact assessment studies should also address the issue of Pripyat-Horyn connectivity that may affect mires of Olmany and adjacent areas. Similar elements of the hydrological analysis should be considered in the face of climatic change and described probable water demands of E40 IWW for water originating from the tributaries of Pripyat.

5. Possible influence of E40 IWW development on Pripyatsky National Park

5.1 Geographical description

Pripyat River, thanks to its uniqueness and is known to be called the “Amazon of Europe”. Numerous meanders, tributaries, oxbows, streams and islands alternate with swamps, wet grasslands and swamp forests, creating an actual water maze. During spring flood it turns into one big lake with a width from a few to 10 km and a length of almost two hundreds kilometres with a large number of archipelagos (Fig. 5.1). The meandering part of the middle Pripyat stretches aproximately from Luniniec to Mozyr, i.e. over 160 km in a straight line (Fig. 5.2). The Pripyatsky National Park is located in the Gomel region (Petrikov, Zhitkovichi, Lelchitsa districts), which is approximately in the middle of the meandering section of Pripyat River (Fig. 5.2). Only a part of the meandering Pripyat section is located within the National Park.

The Pripyatsky National Park covers mostly a large floodplain located of the valley of the Pripyat River. The modern relief of the territory is flat and a little bit terraced. Wetlands within the site are a complex hydrographic network, especially within the floodplain; the area has more than 500 lakes, mostly of oxbow type. Areas above the floodplain terraces are occupied by pristine bogs and transition mires (Abramčuk et al. 2015).

Fig. 5.1 Floodplains of Pripyat River in spring. Fot. S. Płytkiewicz[6].

[6] Source: https://wildlife.by/ecology/photostories/more-gerodota-ili-kak-mozhet-razlivatsya-reka-pripyat/

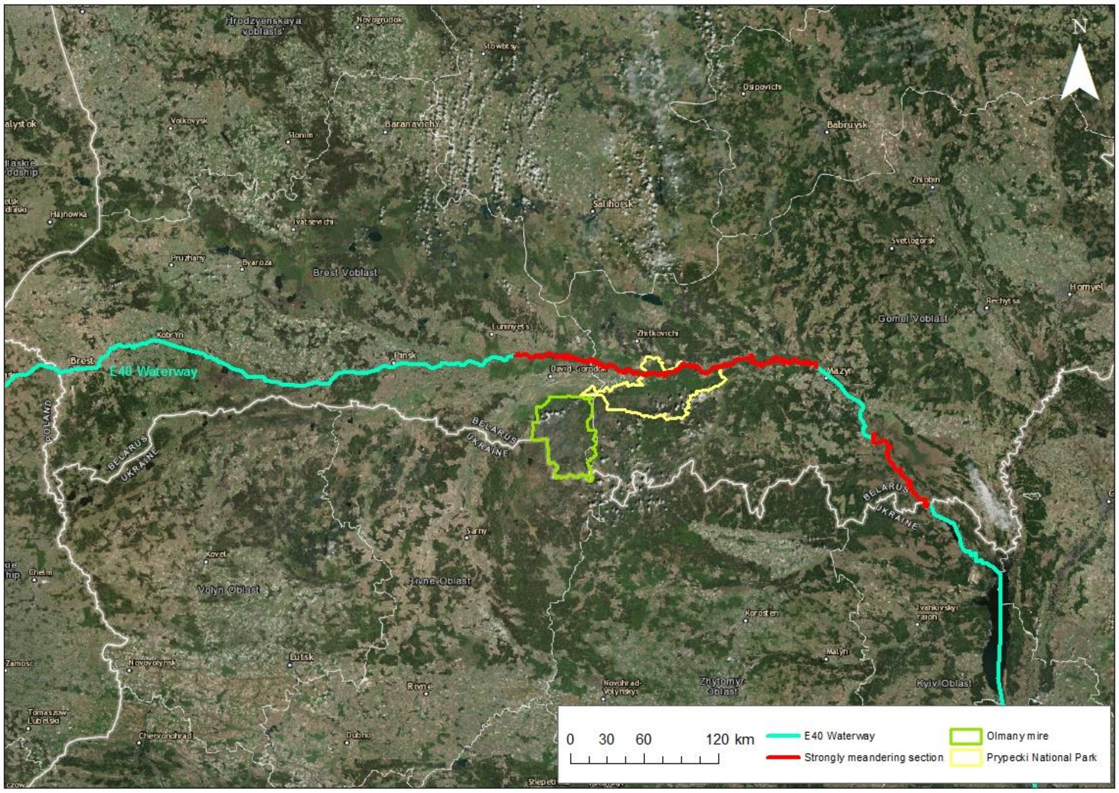

Fig. 5.2 Location of the Olmany mire reserve and Pripyatski National Park along the heavily modified and meandering stretches of the E40 IWW course. Ortophoto: Google.

5.2 Conservation value of the Pripyatsky National Park

The area is protected was protected since 1969 as a Reserve and later as a National Park (88 000.6 ha), it is an Important Bird Area (no. BY036, 82.461 ha) and since 2013 it is a Ramsar Site (no. 2197, 88 553 ha, Fig. 5.3).

In 2016, pursuant to the Decision of Gomel Regional Executive Committee and Brest Regional Executive Committee, dated 11 July 2016, № 622/522[7], the Biosphere Reserve Pripyatskye Polesie was established, including Olmany Mires Reserve, Pripyatsky National Park and Stary Zhaden reserve, which highlights importance of the whole region for nature conservation in Belarus as well as functional interconnectedness between these three nature protection areas.

[7] http://www.pravo.by/document/?guid=12551&p0=R916g0078033&p1=1

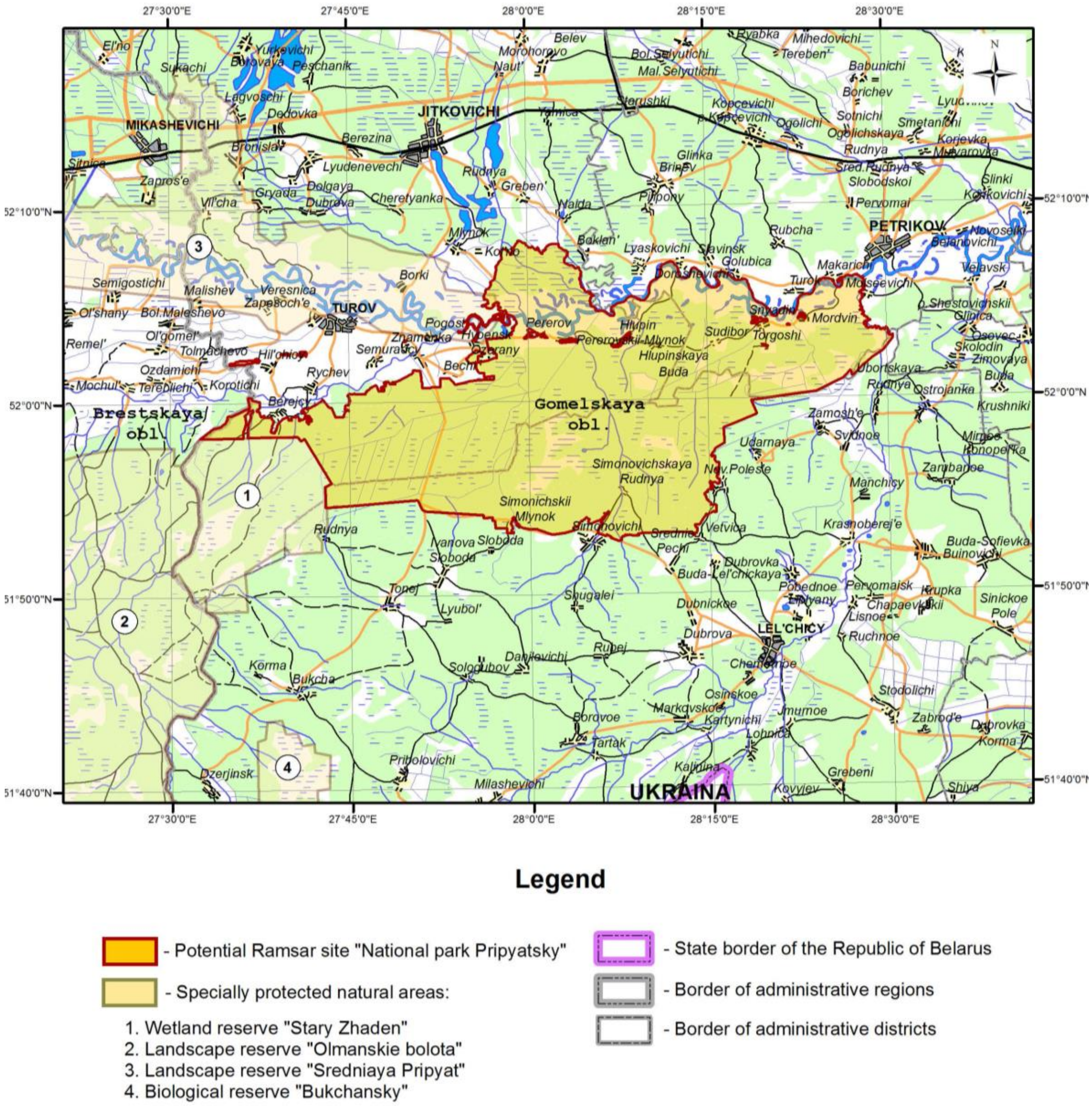

Fig. 5.3 Situation scheme of the Ramsar Site Pripyatsky National Park[8].

The Pripyatsky National Park is one of the least disturbed areas of Belarusian Polesie and can be regarded as the reference of its natural ecosystems (Abramčuk et al., 2015). The site harbours numerous nationally-rare species of flora and fauna which are important for the conservation of biological diversity within the Continental biogeographic region. The floodplain plays an important role in flood regulation, water supply and the maintenance

[8] https://rsis.ramsar.org/ris/2197.

of water quality and groundwater recharge. The peatland areas also store and sequestrate carbon contributing to global climate regulation.

Most of the surface of the site is afforested; open ecosystems occupy less than 15% of its area. The structure is dominated by pine forests, with admixture of oaks, birch and alder. The floodplain oak forests are especially valuable (Abramčuk et al. 2015).

There are about 1073 species of vascular plants at this area, what means more than ¾ of the total species composition of Polesie. It is recorded 362 species of vertebrates (95% of the fauna of the Belarusian Polesie), and 2057 species of macroinvertebrates animals, including 1768 species of insects. 76 species of vertebrates and 43 invertebrate species are included in the Red Data Book of Belarus. This concentration of diversity of flora and fauna in a limited area is due to the high diversity of habitats (Abramčuk et al., 2015).

The area hosts the high diversity of birds. According to an inventory conducted in 2011, it has been found nesting of 173 birds species, including globally threatened Greater Spotted Eagle *Aquila clanga* (six pairs) and Snipe *Gallinago media* (> 20 pairs). There are also Pintail *Anas acuta*, Bittern *Botaurus stellaris*, Black Stork *Ciconia nigra*, Black Kite *Milvus milvus*, White-tailed Eagle *Haliaeetus albicilla*, Short-toed Snake Eagle *Circaetus gallicus*, Crane *Grus grus*, Golden Plover *Pluvialis apricaria*, Curlew *Numenius arquata*, Little Tern *Sterna albifrons*, White-backed Woodpecker *Dendrocopos leucotos* and other protected and rare bird species (Abramčuk et al., 2015). The Pripyat is also extremely important as a migration site for birds.

5.3 Possible exposure of Pripyatsky National Park to hydrological alterations related to E40 IWW

Channelization, straightening of meanders and homogenization of river habitats, which would be inevitable effects of Pripyat regulation and E40 IWW creation (according to the Feasibility Study, "*there is a need to carry out works on straightening the fairway on some strongly meandering stretches of the river. In particular, work on of the following shallows are required: • 67-68 km - "Trebuchowo-5", "6-Trebuchowo" shallows • 75-78 km (outlet of 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*" (Maritime Institute of Gdańsk, 2015)), will cause irreversible damage in the nature of the Polesie region. The losses will also be irreparable in the European scale, as Pripyat, with its naturally dynamic riverbed inseparably connected with floodplains, is a unique ecosystem in the whole of Europe.

Possible effects of the Pripyat river straightening are:

- reduction of variability of microhabitats in the riverbed, resulting in the disappearance of nesting grounds for birds nesting on sandbanks in the river and

in the reduction of microhabitats for fish, making the fish community less resilient to the fluctuations of the water level in the river;
- reduction of the length of the riverbed – the smaller the distance the water has to flow, the faster it leaves the area;
- reduction of extent or duration of spring flooding in the river floodplains, caused by a faster outflow of water from the area and resulting in vegetation shifts, decrease of area of habitat suitable for wetland birds, reduction of fish spawning grounds;
- decrease of groundwater level in the valley and in the surrounding area, resulting in water deficits in the mires located in the region (e.g. mires on the Pripyat floodplain terraces) leading possibly to cessation of the peat-forming process, peat decomposition and increasing CO_2 emissions to the atmosphere. Quicker outflow will enhance draining capacity of the rivers which is likely to induce groundwater level decline.

It should be noted that changes in the dynamics of flooding and water levels in the Pripyatsky National Park may be the result of transformations of the riverbed not necessarily in the Park itself, but sections upstream or downstream from the Park. Such a situation took place in the Narew National Park in Poland. The valley of the Narew River remained a pristine, meandering swamp valley until the end of the 1970s. Since 1970s, the programme of Narew regulation started. The upper and the lower Narew sections were regulated, whereas the middle section was left unregulated and became a National Park later. Comparisons of hydrological conditions in the area of present National Park revealed that after the regulation of the upstream and downstream section of the river, the water level in the Park area has dropped by about 2m and vegetation has changed from wetland peat-forming communities into the non-peat-forming ones (Szewczyk, 2008).

6. Overview of impacts of inland navigation on ecosystems

6.1 Navigation as a driver of pressures on aquatic and riparian ecosystems

Inland navigation due to its excessive pressures on ecosystems was defined an important source of disturbances posed on rivers and riparian zones. In the available analyses presenting the probable environmental footprint of IWW E40, however, most of the authors focus on probable societal and economic benefits that are foreseen to be achieved due to the increase of navigation intensity along its Polish, Belarussian and Ukrainian stretches (Maritime Institute of Gdańsk, 2015). However, the issue of the influence of inland navigation on ecosystems has already been excessively discussed in the literature and defined a serious management issue (Fig. 6.1; Gabel et al., 2017).

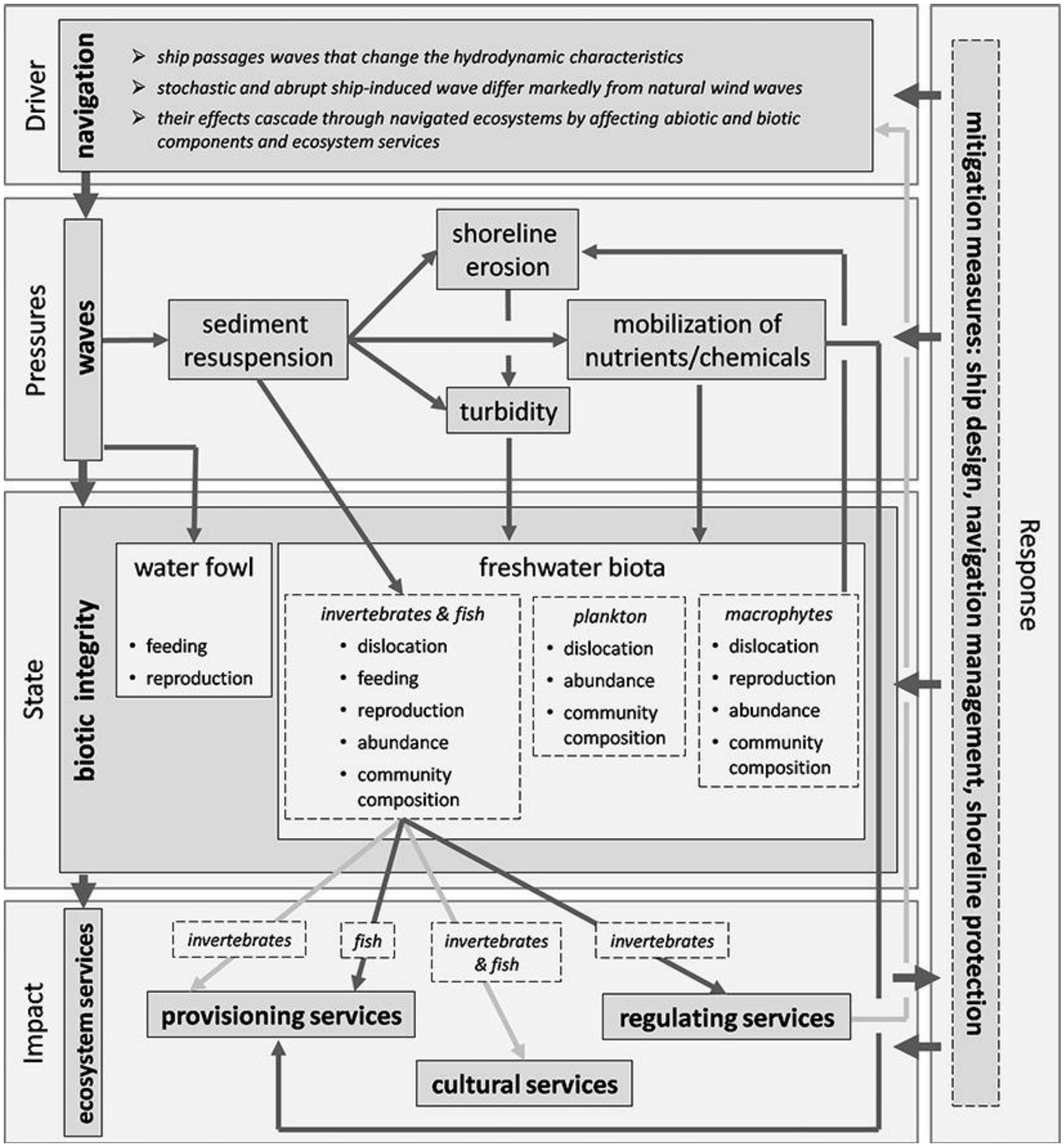

Fig. 6.1 An example of a DPSIR framework provided for identification and sustainable management of threats and pressures that navigation pose on aquatic and riparian ecosystems. Source: Gabel et al. (2017).

The influence of inland navigation on ecosystems is driven by a number of pressures. Vessels and other ships when pass certain stretch, change hydrodynamic characteristics of the river stretch (Gabel et al., 2017). Vessel-induced waves differ markedly from natural wind waves (have higher magnitudes and remain more sudden) though they specifically interact with abiotic and biotic components of the riverine environment. Ship/vessel passage increase sediment suspension and increase shoreline erosion. At the same time it increases the turbidity of water entailing mobilization of nutrients/chemicals deposed in sediments by the moment. These pressures result in decreasing ecological status of aquatic and riparian ecosystems. Macroinvertebrates and fish remain dislocated, which affects their guilds, reproduction, abundance and community composition. Changing hydraulic conditions affect distribution of macrophytes which remain key element inducing the formation of biodiversity of lowland rivers.

Results of the 3rd Joint Danube Survey[9] provide some quantitative insights into the influence of the ongoing navigation and river-channel maintenance works on ecosystems. They indicate that sediment management in navigable rivers should be planned in order to place it in a specified stretches, which due to the flow velocity and slope are the most vulnerable to the loss of sand- and gravelbars. They showed that navigation bottlenecks remain stretches of the lowest hydromorphological quality and as such require specific maintenance. They also indicated that dredging of the navigable channel enlarges river bed incision which may result in groundwater level declines and increase of the flood risk.

Study of Bączyk et al. (2018) included the analysis of regular river dredging on ecological status of lowland river ecosystems. Their research, which was based on the analysis of >200 scientific studies dealing with the quantification of influence of river maintenance measures on aquatic ecosystems revealed that 96% of the examples analysed result in negative response of riverine ecosystems to any technical actions. In lowland rivers transporting vast loads of fine-grained sediments (such as the mid- and lower Pripyat), it is likely that intensive dredging of the navigable channel will be required. This aspect has not been addressed so far in available studies tackling the issues of IWW E40 development.

6.2 Effects of waves

As stated by Wolter and Arlinghaus (2003), ‘under common navigation conditions, with respect to inland waterway morphology, channel cross section, vessel speeds, and dimensions of commercial vessels, the navigation-induced return currents along the shore are usually around 0.8 m/s (0.7–1.0 m/s), accompanied by a 0.1–0.3 m drawdown. Under such conditions, the proposed threshold for small fish survival was estimated to be 147 mm total length at critical swimming performance (>20 s – 60 min without fatigue) and 47 mm at burst performance (<20s)’. Their observations, which were based on the metaanalysis of >200 scientific studies allow to suspect that the fishery management, especially of the so-far natural water bodies such as vast parts of the Pripyat, may be endangered. Together with adverse effects resulting from the changes of macrophytes, macroinvertebrates and invasive species migration, development of navigation along the IWW E40 may seriously impede resilience and stability of aquatic ecosystems modified.

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[9] https://www.danube-navigation.eu/uploads/files/5_IAD_Navigation_and_River_Ecology.pdf

6.3 Migration of invasive species

Panov et al. (2009) provide very interesting analysis of the probable enhancement of invasive species migration along the IWW E40. They provide a sound DPSIR analysis of invasion potential of non-native species along with the increased navigation in Pripyat and Pripyat-Bug Canal. In their study (Fig. 6.2) they admit that certain stretches of a natural Pripyat river remain in a good ecological status that may be endangered by biological contamination.

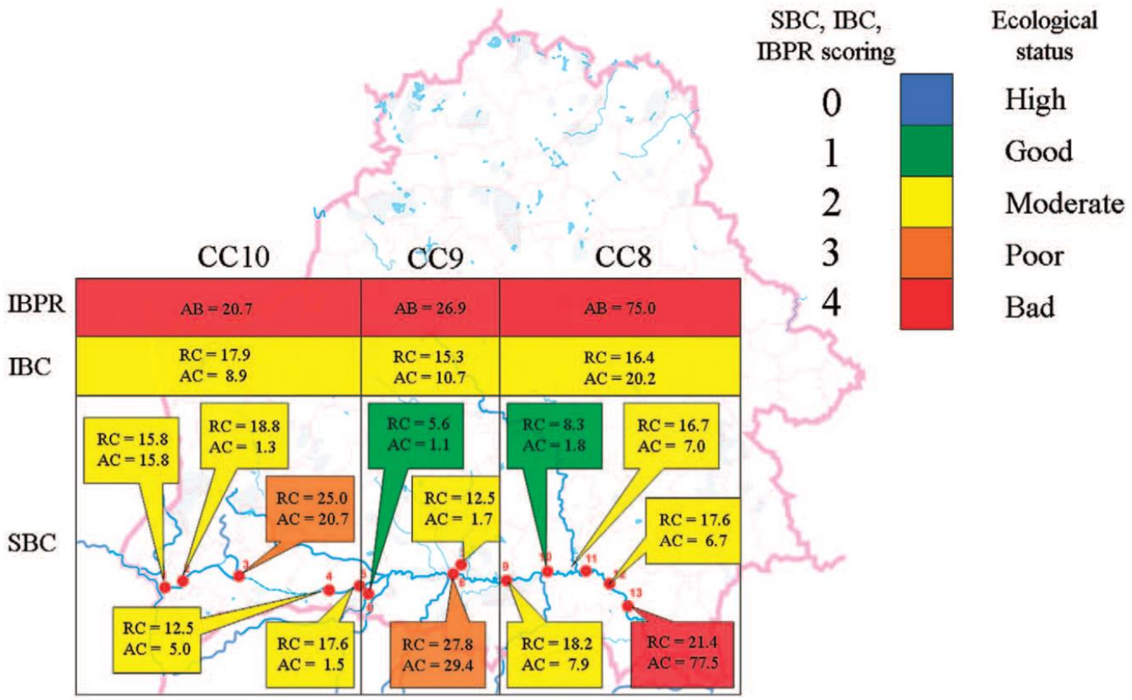

Fig. 6.2. Assessment of site-specific biological contamination (SBC), integrated biological contamination (IBC), and integrated biological pollution risk (IBPR) indices in Lower Pripyat River (CC8), middle Pripyat River (CC9) and Pripyat–Bug Canal (CC10). Numbers in boxes, in %, indicate ordinal richness contamination (RC), abundance contamination (AC), and maximal relative abundance of black-list species (AB) as estimate of the IBPR index. Source: Panov et al., 2009.

Similar issues are pointed by Nehring (2005), who specifies the threat of invasive species appearance due to the increased intensity of the inland navigation in Germany.

7. Conclusions and questions to be addressed when processing the implementation of E40 IWW development

Inland navigation along the E40 IWW in Belarus and Ukraine is likely to be possible with no major infrastructure investments. However, modification and adjustment of the existing E40 IWW route to the requirements of intensive navigation will affect the environment of the region. Direct impacts will be associated with the required hydromorphological changes and related habitat issues along with the probable hydrological alterations. First and foremost we state that the detailed analysis of the influence of E40 IWW development is hard to be conducted due to the problems we faced with the accessibility of hydrological data. When addressing questions related to the probable influence of the development and function of E40 IWW on adjacent areas one should rely on thorough analysis of coherent discharge data of rivers along the E40 IWW course from a multi-year periods. Additional information may be drawn from the analysis of groundwater levels.

In our opinion, the following questions should be addressed when proceeding with any planning of E40 IWW development:

- Was there any evaluation done oriented at the analysis of the navigation intensity (ship movement, waving) on biodiversity of the Pripyat river?
- What are the prognoses of icing processes on the Pripyat river and which actions are planned for management of ice phenomena? Will these actions affect the environment of riparian ecosystems (especially riparian forests)?
- Have E40 IWW development plans in Ukraine and Belarus addressed the issues of probable negative effects of climatic changes on economic and technical efficiency of inland navigation along the Dnieper, Pripyat and Pina? Which probable climate-induced changes have been considered?
- How river regulation works on the river Pripyat at the stretch close (< 2.5 km) to the Chernobyl Nuclear Reactor will be planned and conducted in order to reduce the exposure of workers/machinery to highly probable increased radiation in that zone?
- How management of inland navigation will mitigate the exposure of people/vessels to the increased radiation in the zone close to the Chernobyl Reactor?
- What will be the influence of modification and regulation of the meandering stretch of Pripyat river on Horyn-Pripyat connectivity and groundwater flow in the Olmany mire?
- How the issues of enhancement of invasive species migration are addressed in the development of IWW E40?
- Which environmental risks related to the influence of navigation on IWW E40 were identified and what are the proposed methods of risk reduction and risk management?

- Are water quality issues (related to algal blooms in reservoirs) are addressed in the E40 IWW-development environmental impact assessment?
- How will the natural status of Pripyat as a surface water body be guaranteed on a long-term in order to secure the river's good ecological status?[10]
- Are stakeholders aware of issues related to probable alterations in local hydrology that may be faced during the development and function of E40 IWW? Have these concerns been addressed in preparation of the Pripyat's River Basin Management Plan?

10 Assuming that within the framework of the EUWI+East project, Pripyat will be classified based on the guidance of Water Framework Directive, http://ec.europa.eu/environment/water/water-framework/facts_figures/guidance_docs_en.htm.

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