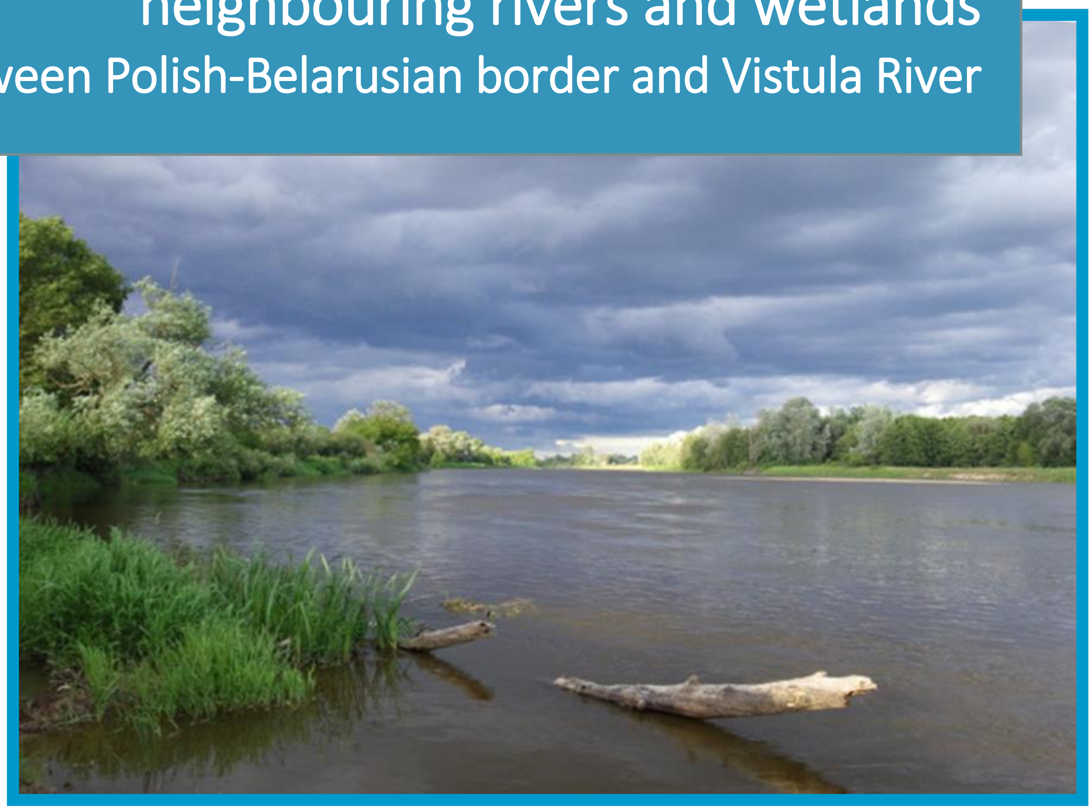
Analysis of selected possible impacts of potential E40 International Waterway development in Poland on hydrological and environmental conditions of neighbouring rivers and wetlands

- the section between Polish-Belarusian border and Vistula River



Mateusz Grygoruk
Ewa Jabłońska
Paweł Osuch
Paweł Trandziuk

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Analysis of selected possible impacts of potential E40 International Inland Waterway development in Poland on hydrological and environmental conditions of neighbouring rivers and wetlands – section between Polish-Belarusian border and Vistula River

Mateusz Grygoruk, Ewa Jabłońska, Paweł Osuch, Paweł Trandziuk,

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Summary

In this report, selected hydrological and environmental features of possible development of the E40 Inland Waterway (E40 IWW) were reviewed. In the report we managed to review some elements of the Feasibility Study of E40 IWW development in 3 variants in the area of Poland. These variants assume the need for constructing canals available to conduct the navigation through the catchments of Vistula and Bug. We reviewed assumptions of the Feasibility Study and drew some new conclusions. We revealed that the momentary water demand for channels in variants 1, 2 and 3 equals 13,69 m^3/s, 12,45 m^3/s and 10,96 m^3/s respectively. Approximately 97% of water demand is related to the sluicing (lockage) purposes. We also revealed that water resources of rivers Wieprz, Tyśmienica, Bystrzyca and Wilga are insufficient for operation of the channels. We revealed that using water from Bug in any of the variants of channel operation will result with average 17,5% reduction of overbank flows and 172% increase in frequency of droughts. We estimated that the channels in all variants analysed may have both draining/infiltrating role with respect to local groundwater. In our opinion the impact of channel design and operation on protected sites, habitats and species should be considered in a much larger area than just along the designated 10 km-wide buffer strips along the channels. The hydrological alterations may impact large areas of catchments (including peatlands and other wetlands in the region) and several Natura 2000 sites. Moreover, creation of E40 IWW in any variant may lead to violation of Water Framework Directive.

1. Introduction

The idea of improving navigation capability of Polish rivers has long been discussed under different political and economic scenarios, in different societal circumstances. One of the vital issues in the contemporary discussion on inland navigation development in Poland is to enhance navigation along the E40 Inland Waterway (E40 IWW) connecting Baltic Sea and the Black Sea through the river systems of Vistula, Bug, Pina, Pripyat and Dnieper. Along the majority of its course, the E40 IWW goes through rivers and existing channels. Plans of its development in Poland aim at construction of a channel between the river systems of Vistula and Bug. So far, three variants of the channel have been proposed as alternatives for regulation and modification of the Bug river (Fig. 1.1). One of the variants is expected to be selected as the best solution to enhance the navigation on E40 IWW.

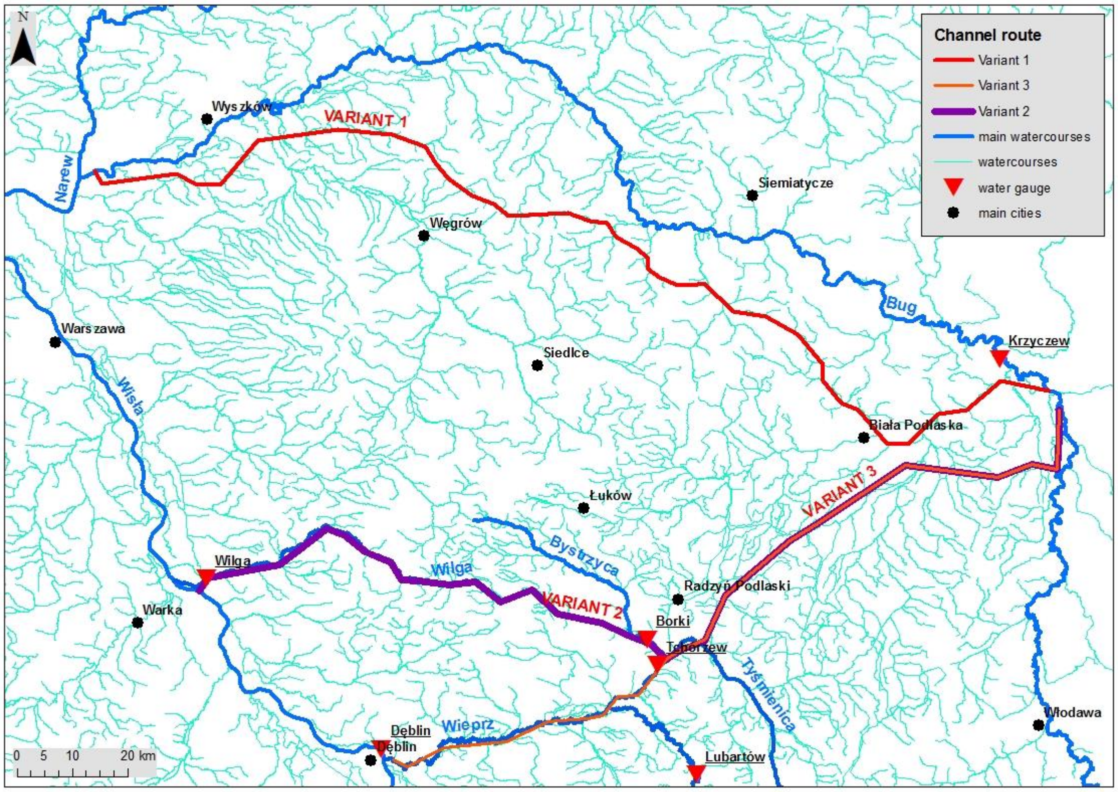

Fig. 1.1 Overview of the research area: natural river network and variants of channels planned as an element of the E40 Inland Waterway development.

The idea of making an artificial channel to be used for inland navigation between water bodies tends to have fewer negative environmental consequences than channelizing, dredging and construction of multiple groynes within natural river channels. However, these artificial channels as new elements of the landscapes and inter-catchment hydrological cycles, pose a number of environmental hazards with a potentially wide range of influence. These environmental hazards may be related to changing local water levels (draining-inundating role of the channel against the adjacent land) or to the changing flow regimes of rivers, the water of which is used to supply the channel and other hydrological alterations. The amounts of water required to be used to fill and – later on – to maintain the channel are expected to change distribution of low and medium flows of rivers that are source of the water. This alteration is expected to influence environmental flows and may threaten other users of water in catchments located along the courses of channels. Additionally, it is expected that the channel (in either of variants planned) might have a potential impact on water-dependent ecosystems, with a particular stress on peatlands. Peatlands are the most space-effective carbon stocks of all terrestrial ecosystems, storing in global average 1400 tons of carbon per hectare (Joosten 2015). Peatlands are also essential parts of regional water cycling, regulators of local and regional climates and hotspots of threatened biodiversity (Bonn et al. 2016). Peatland degradation causes large-scale environmental problems both globally (CO_2 emissions from drained peatlands represent almost 5% of the total global anthropogenic greenhouse gasses emissions; Joosten et al. 2016) and regionally (disruption of water cycling, nutrient loss to ground- and surface water, decline of biodiversity, peat fires; Limpens et al. 2008, Parish et al. 2008, Bonn et al. 2016). Finally, the channel to be constructed in either of the variants planned is likely to alter the unique natural values of the Bug river valley. The length of the Bug is 772 km, and the catchment area is ca. 39 000 km^2, almost half of which lies in Poland. Bug is one of the very few unregulated large rivers in Europe. The natural environment of the Bug river valley is characterized by an extremely high diversity of habitats and vascular plants species (Urban and Wójciak 2002). The fauna is also rich and contains over 100 species of butterflies (70% of species in Poland) (Pałka et al. 2002), 44 fish species (57%) (Błachuta et al. 2002), 158 species of breeding birds (69%) (Piotrowska et al. 2002), including many rare, protected species and species threatened with extinction. The valley is also an important ecological corridor. At the same time, Bug is the backbone of the cultural landscape of this part of the country providing multiple cultural ecosystem services. All of the listed elements of the environment are expected to be threatened by the loss of their quantity and quality in result of changes in water management of the area.

In this report we intend to review the ideas and assumptions standing behind the Feasibility Study of E40 Inland Waterway development (Maritime Institute in Gdańsk, 2015), emphasizing hydrological, geographical and environmental threats the channel poses on the regional water management and environmental management issues. We are aware of the fact that the Port of Gdańsk Authority recently contracted Halcrow Group Limited for a more detailed feasibility study, but we have no access to any information in it.

2. Research questions

The following report attempts to answer the following research questions:

1) What is the amount of water (expressed in m^3/s) required for the channels' function and maintenance?
2) What are the resources of surface water in Bug, Vistula and other rivers of the area available to be used for supplying the channels in three variants?
3) Will and, if so – how, the water resources of Bug, Vistula and other rivers analysed be shortened by the functioning of canals, according to certain assumptions used in this study?
4) How the channel will influence groundwater of adjacent areas?
5) How the construction of the channel can influence peatlands and other wetlands as well as how can it impact protected habitats and species?

Additionally, in the report we review the materials and assumptions presented in the Final Feasibility Study Report (Maritime Institute in Gdańsk, 2015) with respect to their accuracy and research protocol.

3. Materials and methods

3.1 Description and parameters of channel variants

Three channel variants are considered in this report. Their lengths varies from approximately 160 km to nearly 210 km (Tab. 3.1). All three variants of channels start in Bug, upstream of the Krzyczew water gauge (Fig. 1.1).

Tab. 3.1 Dimensions of channels and calculated volume for 3 variants.

Variant	Length [km]	Width [m]	Depth [m]	Volume [mln m^3]
1	207,8	37,8	4	***31,42***
2	195,9	37,8	4	***29,62***
3	159,6	37,8	4	***24,13***

Two of the variants join Vistula through the river channel of Wieprz (Variant 3) and Wilga (Variant 2). Variant 1 joins the lower course of the river Bug, just upstream from the backwaters of the Zegrzyńskie Lake. All of the channels are planned to handle large inland navigation units which require the widths of nearly 40 m and depths of minimum 4 m along the navigation trail. According to the materials of Maritime Institute in Gdańsk (2015), the longitudinal profiles of each of the channels are increasing elevations to the approximately middle part of the channel and then decrease elevations to the end (see differences in elevations along channel variants presented on the Fig. 3.1). Such a design of the channels entails the need to supply water approximately to the middle reach of the channels so it can flow in two antagonistic directions. This fact requires the water to be pumped from certain sources (e.g., Bug, Vistula or other smaller rivers of the area such as Wieprz, Wilga or Tyśmienica).

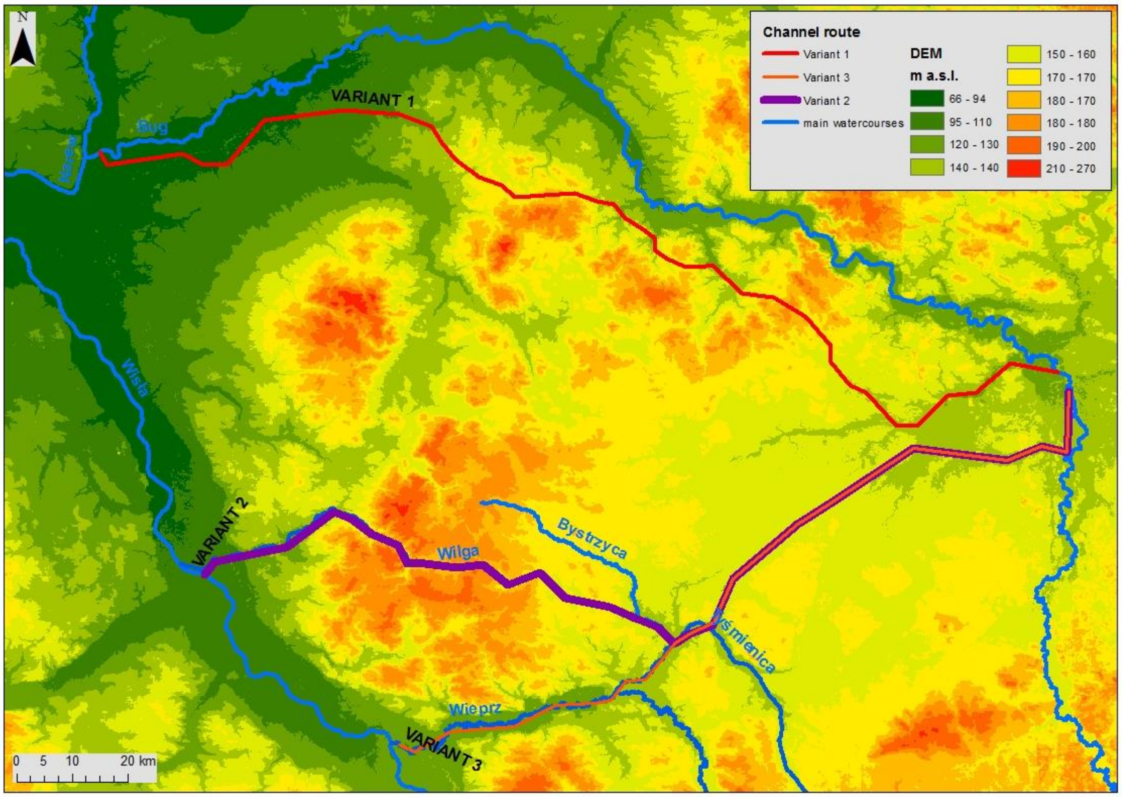

Fig. 3.1 Overview of the research area: natural river network and variants of channels planned as an element of the E40 IWW development.

3.2 Analysis of water levels in channels and groundwater levels in adjacent areas

As new elements of the hydrological cycle in the area, the channels are likely to interact with groundwaters. Analyses of this issue provided in the Feasibility Study (Maritime Institute in Gdańsk, 2015) assume that the channels will be infiltrating along the whole course (water levels in channels are always higher than groundwater levels in areas located around the channels). Analysing the course of channels we find this assumption highly unlikely. When analysing the impact of the potential construction of the E40 IWW on the hydrological conditions of neighbouring rivers and wetlands, it is necessary to identify the issues of the area related both to surface water and groundwater. The level of the groundwater table should be monitored at the stage of planning/designing the canals using water level recorders (e.g. automatic pressure transducers), which form a comprehensive groundwater monitoring network. For the purpose of this report, in order to make a preliminary, general recognition of water levels from the Polish Geological Institute-National Research Institute, we obtained data from 18 wells located in the area analysed (Fig. 3.2). For this analysis, wells were selected for which the measurement data were available and which were located as close as possible to the course of the channels in each of the variant analysed. A detailed analysis should include data from a larger number of measurement points than would be in the initial monitoring. In the monitoring wells analysed, groundwater levels were recorded in the procedure of both standard manual measurements and automatic measurements, depending on the available method for a given well at different time periods (availability of measurement data). In order to verify this assumption, the profiles of channels were analysed in GIS along with the data on groundwater levels in wells located in the surroundings of the channels. Locations of the monitoring wells analysed are presented on Fig. 3.2. We also analysed the longitudinal profiles of the channel versus ground elevations. We found that the methodology provided in Feasibility Study (Maritime Institute in Gdańsk, 2015) does not provide the quality materials for such an analysis: the approximation of ground elevations they used, i.e. the Digital Elevation Model originating from the Shuttle Radar Topography Mission (SRTM), is highly uncertain and should not be applied in hydraulic calculations (e.g., Gallant et al., 2012) due to the influence of noises and trees on the final quality of the model.

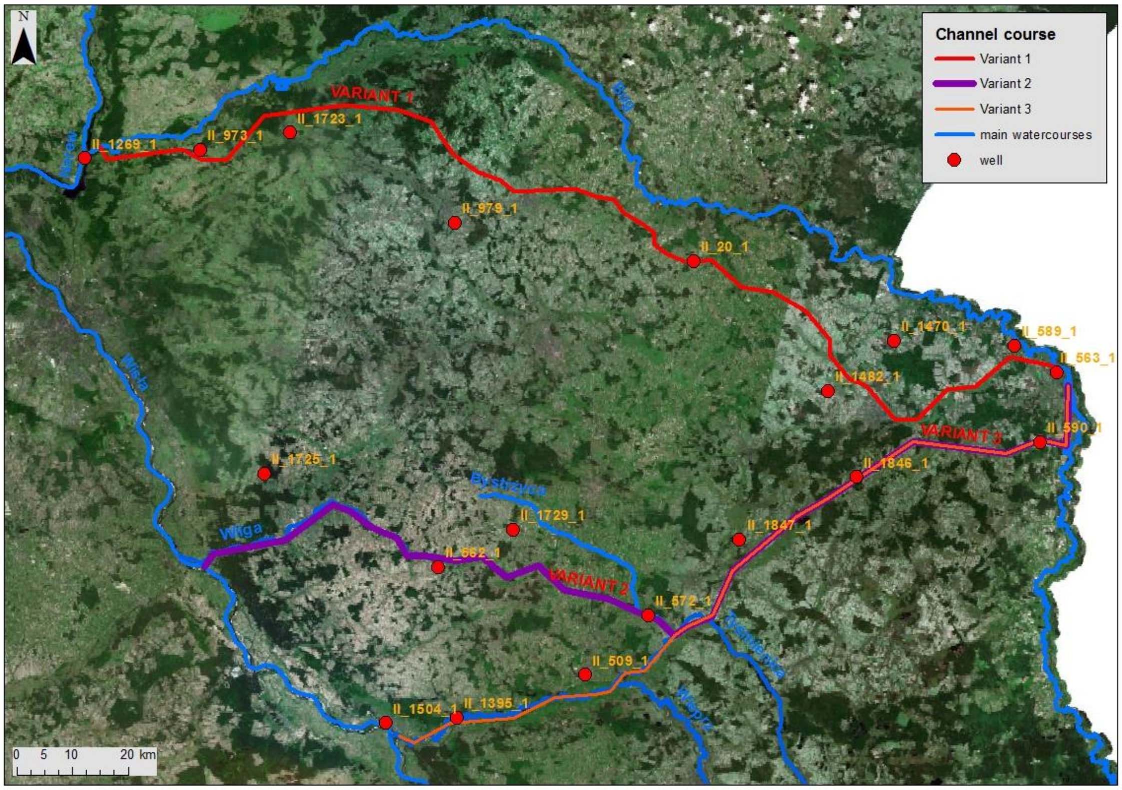

Fig. 3.2 Location of wells used to analyse groundwater levels with respect to the potential influence of channels on groundwater.

For this reason we used topographic maps of Poland (scale 1:10000; PUWG1965) as a better approximation of elevations within the study area. We assumed that in places, where the designed elevation of water table is situated below the elevation of the terrain, the channels will be draining (at least for the local overland flow). Along the stretches where water table in the channel is above the contemporary ground elevation we assumed the channel to be exfiltrating. Information about the role of the channel in shaping groundwater-surface water interaction was later on used as a proxy for the quantification of water gains and losses along the channel variants.

3.3 Calculation of water gains and losses of channels in particular variants

3.3.1 Filling the channels

The volume needed to fill the channel was calculated based on the dimensions of the channel from the study. The length of segments, width and depth, and the calculated volume of water required to fill the channels are shown in Tab. 3.2. The length means the total length of the planned channel, both sections and sluices. Width is the average width on a straight section of the channel at a height of 4 meters above the bottom, so as presented in Feasibility Study (Maritime Institute in Gdańsk, 2015). Depth is the average depth of the channel from the horizontal bottom to the normal water level in the channel on the straight section.

3.3.2 Current maintenance of the channel (sluicing)

The water needs of the current maintenance of the channel are considered to be the water necessary for the functioning of shipping, i.e., the movement of ships by water, along the channel and through the sluices. The water in this case will be used for the sluicing and possible generation of a directional flow from the upper sections. To calculate the current amount of water necessary for sluicing, the following assumptions were made:

- sluice length = 120 m; sluice width = 12 m (ref. Maritime Institute in Gdańsk, 2015),

- water levels in the peak (max) and bottom (min1 and 2) sections at both ends of the channels (ref. Maritime Institute in Gdańsk, 2015):

Variant 1: max 155 m asl[1], min1 78,10 m asl, min2 – 131,10 m asl;

Variant 2: max 162 m asl, min1 93,41 m asl, min2 – 131,10 m asl;

Variant 3: max 140,5 m asl, min1 115,00 m asl, min2 – 131,10 m asl;

- time of one sluicing – 1 hour,

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[1] asl – above the sea level

- the number of sluicings per day – 24, which results from the assumption of uninterrupted flow of vessels (ref. Maritime Institute in Gdańsk, 2015),

- all water from one sluicing is used for another sluicing in the sluices located downstream from the particular sluice,

- there is no slope of water levels in the sections of the channels between sluices (ref. Maritime Institute in Gdańsk, 2015),

- the water into the sluice operates both in gravity (inflated from the upper section) and goes gravitationally downstream (e.g., to the next sluice),

In order to calculate the amount of water necessary to sluice for each variant, how much water is needed for the current operation, the largest of sluices in one line of decline (each channel has two lines of decline – sloping up from one end to approximately middle of the channel and then sloping back down to the other end of the channel) for the channel and the sum for two lines of decline was considered the amount needed for the current functioning of the entire channel, ensuring the water flow at a given level:

Sluice width x Sluice length x (the sum of the heights of the two largest sluices on two lines of decline).

3.3.3 Evaporation

Water losses on the channel will occur through evaporation. Some assumptions have been made to estimate these values. To estimate the evaporation from the channel surface, the average annual value of 2000 mm was assumed (possible value occurring in the literature when measuring the annual evaporation from open water in Poland (Operat wodnoprawny…, 2010; Rozpoznanie…, 2005).

3.3.4 Filtration

To estimate water gains and losses that are likely to occur in the processes of water exfiltration from the channel to adjacent porous aquifers, it was necessary to specify the sections in which such filtration may occur and the size of this filtration. Zones of probable exfiltration and infiltration to the channel were delineated according to the procedure presented in the chapter 3.2. The amount of water exchanged in the process of exfiltration and infiltration was calculated on the basis of filtration coefficient (K). The value of K was adopted for low-permeable channel edges as for compact clays $K=10^{-3}$ m/d that represent very low permeability of the channel bed (close to be impermeable - as indicated in the Feasibility Study; Maritime Institute in Gdańsk, 2015). The direction of water exchange was defined roughly on the basis of the defined exfiltrating/infiltrating role of the channel, on the basis of the results of the analysis described in the chapter 3.2.

3.4 Hydrological analyses of river discharge in the neighbourhood of the canals

Channels to be designed in each of the variants will have to be continuously filled with water. Analysing water levels in the channels and roughly designed elevations of their bottoms presented in the Feasibility Study (Maritime Institute in Gdańsk, 2015) allow to hypothesize that the water supply will have to be provided to the highest-elevated point at the channel longitudinal profile. This can be achieved either in a way of (1) redirecting part of water from the rivers located near the highest-elevated point of the channel, (2) pumping groundwater to the highest-elevated point of the channel, (3) natural water supply to the highest-elevated point of the channel (e.g., accumulation of rainwater; locally occurring surface runoff) or (4) transfer of water from other sources through pumping.

The method of water supply to the highest-elevated point of the channel shall be dependent on the amount of water losses (including the number of sluicings per day) that occur along the whole 'arm' of the channel. By 'arm' we understand the part of the channel of one-directional slope. Thus, the channels in variants 1, 2 and 3 will have at least 2 arms each. Profiles of the terrain along the prospective channels are provided in Appendixes 1-3. Geographic location of the channels planned to be constructed allows to hypothesize which rivers may be considered as potential sources of water supply (Fig. 1.1; Tab. 3.2). For the variant 1. there is only one rational potential source of water, which is the river Bug. The other rivers located at the course of the planned channel are too small to be responsibly considered a source of water for the channel. River Bug can also be considered a rational source of water for all of the other variants. However, this would require translocation of water for the distances reaching roughly 100 km. The remaining 2 variants may be potentially supplied by water originating from Vistula, Wieprz, Tyśmienica, Wilga and Bystrzyca. The potential use of water from the listed rivers as a source for the channels' supply will be dependent on discharge parameters of these rivers, with special focus on low discharges (e.g., MLQ – the mean value of the lowest annual discharges from a multi-year period), forming the values of environmental flows.

Tab. 3.2 Overview of the rivers that may serve as a potential source of water for the planned channels in each of the variants considered.

Water gauge	River	Water withdrawal for the variant:	Remarks
Dęblin	Vistula	2,3	~ 60, 90 km pumping uphill
Krzyczew	Bug	1,2,3	~ 65-75, 140, 60 km pumping uphill
Lubartów	Wieprz	2,3	-
Tchórzew	Tyśmienica	2,3	-
Wilga	Wilga	2,3	-
Borki	Bystrzyca	2,3	-

Selected discharge characteristics were considered with respect to the losses of water in the canal and new discharge characteristics (including durations of low flows) were calculated showing the possible influence of the function of channels in particular scenarios on flow regime of the rivers analysed.

3.5 Influence of channels on wetlands and riverscapes

The water-dependent ecosystems may be strongly impacted be the hydrological changes in a region. We analysed distribution of peatlands in the catchments of Tyśmienica, Bystrzyca, Wieprz and Wilga (using GIS Mokradła database[2]), as well as distribution and conservation objectives of Natura 2000 sites (Special Protection Areas under the Birds Directive and Special Areas of Conservation under the Habitats Directive) in the catchments of Tysmienica, Bystrzyca, Wieprz and Wilga and in the Bug valley (using database of the General Directorate for Environmental Protection[3]).

4. Results and discussion

4.1 Analysis of water levels in channels and groundwater levels in adjacent areas

Groundwater levels (maximum, minimum and average) measured in different periods (depending on the availability of data for a given well) at observation points given on Fig. 3.2 are presented in Tab. 4.1 and on Fig. 4.1-4.4. Depths to the water table (maximum, minimum and average) for all wells are shown on Fig. 4.1. Depending on the location of a well, there is a difference in terms of deviations from the average level of the groundwater table (min, max). The smallest fluctuations in water levels over the years in which the measurement data were available occur in the well II/1482/1 located in the channel route in variant 1, and the largest in the well II/1504/1, which is near the beginning of the planned channels course in variant 3.

[2] http://www.gis-mokradla.info
[3] http://natura2000.gdos.gov.pl and http://geoserwis.gdos.gov.pl

Tab. 4.1 Medium, minimum and maximum levels of groundwater table. Data given in m asl. Source of data: Polish Geological Institute – National Research Institute.

Well's ID	Max	Min	Average
II/20/1	151.85	148.37	149.49
II/509/1	135.20	133.96	134.42
II/562/1	174.42	173.15	173.65
II/563/1	133.13	130.90	131.62
II/572/1	139.56	138.59	139.00
II/589/1	126.39	123.78	124.82
II/590/1	138.47	135.79	136.54
II/973/1	87.20	86.28	86.63
II/979/1	133.46	132.72	133.18
II/1269/1	75.90	75.33	75.52
II/1395/1	119.13	117.27	117.92
II/1470/1	142.03	141.17	141.74
II/1482/1	148.23	147.82	148.03
II/1504/1	114.64	110.55	111.49
II/1723/1	96.27	94.86	95.45
II/1729/1	164.95	163.67	164.21
II/1846/1	147.18	146.06	146.49
II/1847/1	148.22	146.95	147.54

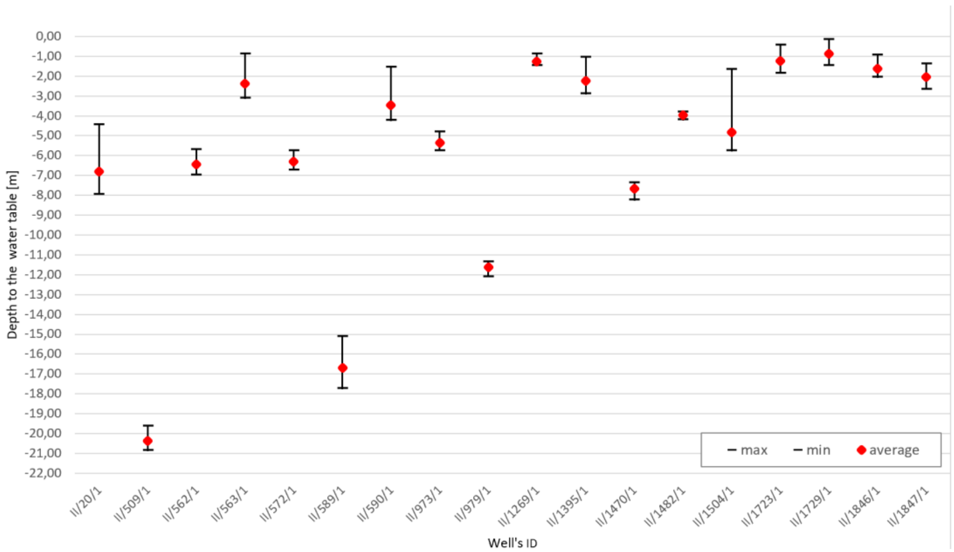

Fig. 4.1 Average, minimum and maximum depth to water table for every well. Source of data: Polish Geological Institute – National Research Institute.

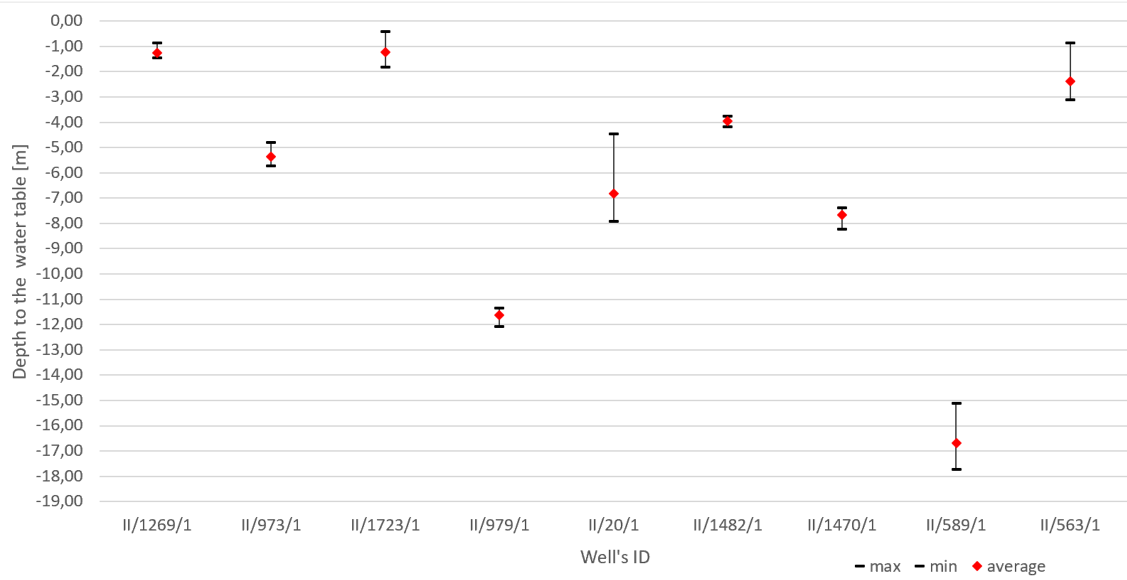

Fig. 4.2 Average, minimum and maximum depth to water table for every well along the channel in variant 1. Source of data: Polish Geological Institute – National Research Institute.

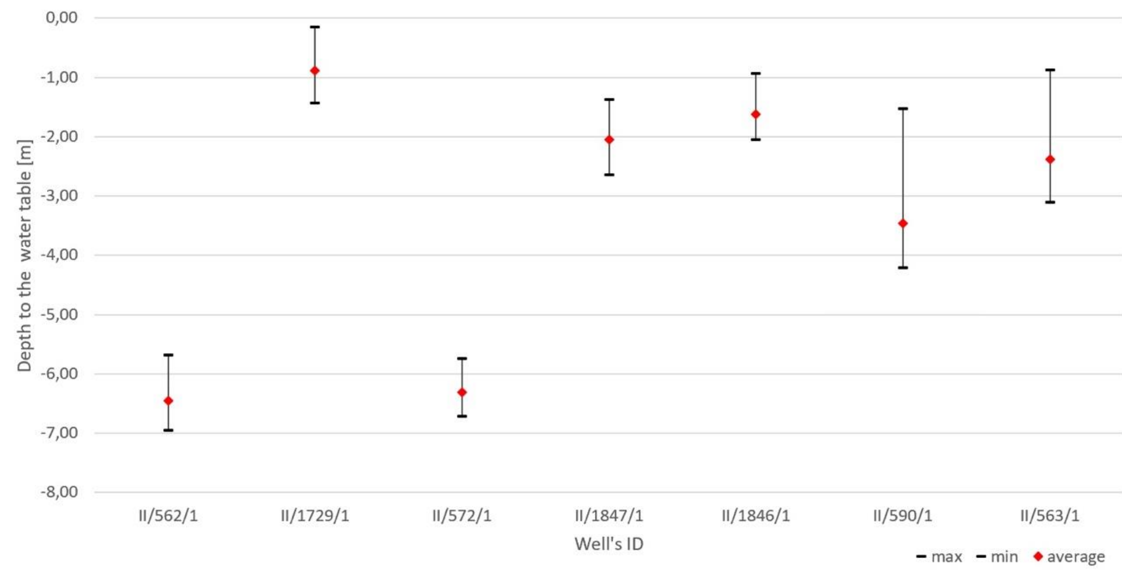

Fig. 4.3 Average, minimum and maximum depth to water table for every well along the channel in variant 2. Source of data: Polish Geological Institute – National Research Institute.

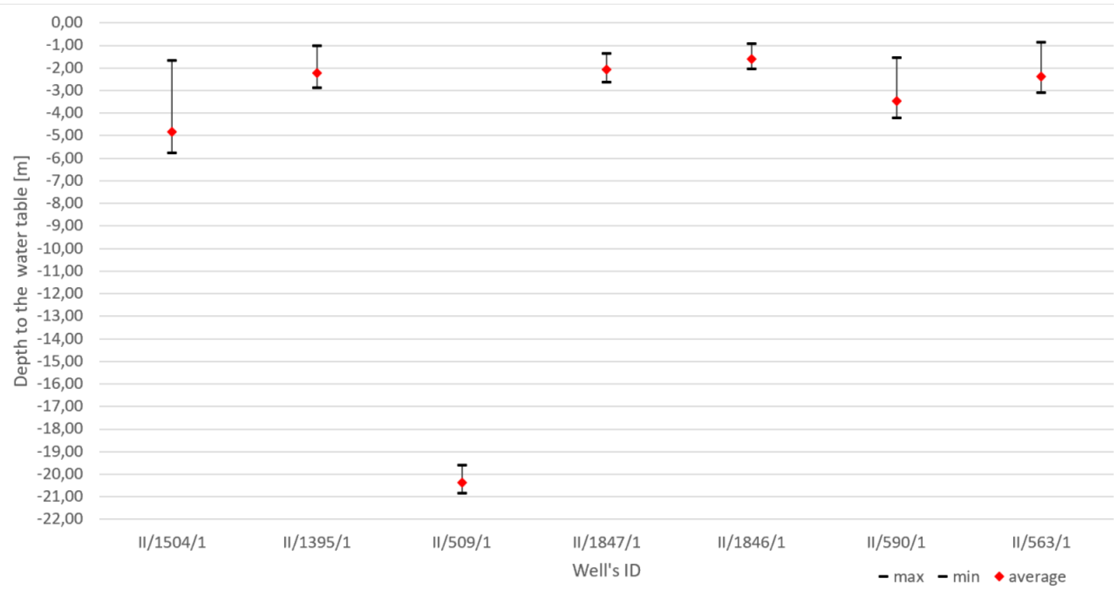

Fig. 4.4 Average, minimum and maximum depth to water table for every well along the channel in variant 3. Source of data: Polish Geological Institute – National Research Institute.

In the next stage of the analysis, an attempt was made to determine the role of particular sections of the channels' courses in particular variants. This characteristic was made in a spatial information systems based on DEM generated on the basis of topographic maps and Normal Damming Water Levels (NDWL; according to profiles from the study of Gdańsk Maritime Institute, 2015). It was assumed that sections of the canal in which the elevation of the terrain is above the NDWL have a draining effect on groundwater. In the opposite case, the stretch of the channel was defined as having a irrigating role to adjacent groundwater. The above assumption has been confirmed on the longitudinal profiles of the planned channel routes created in the particular variants (Fig. 4.5-4.7). On longitudinal profiles of channels in the 3 variants analysed, presented on the Fig. 4.5-4.7, the average groundwater elevations in the nearest wells in the given areas are marked based on the data obtained. On this basis, it was possible to indicate with some approximation the places where a given section of the canal can drain the groundwater. Therefore, the results of our analysis indicate that despite the design of the channels, due to the big differences between water levels in the channels and in groundwater in some areas, the role of the canals is variable in length in a given variant (draining or irrigating). Recorded differences between groundwater levels in wells along the channel that may reach more than 10 meters in short distances from the channels in each of the variants analysed allow to hypothesize that the influence of the channels on groundwater along their course may be much higher than expected in the Feasibility Study. For this reason we find it compulsory to provide groundwater modelling study of this area.

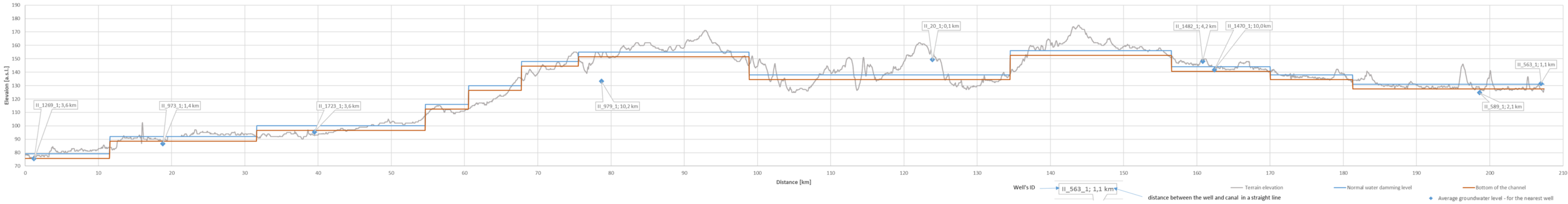

Fig. 4.5 Longitudinal profiles of the channel in variant 1 with markers representing average groundwater elevations in wells located along the channel. Distances between the wells and channels are provided in km in the labels marking the wells. Terrain elevations on the profile are derived from the DEM created on the basis of topographic maps of Poland in the scale of 1:10000.

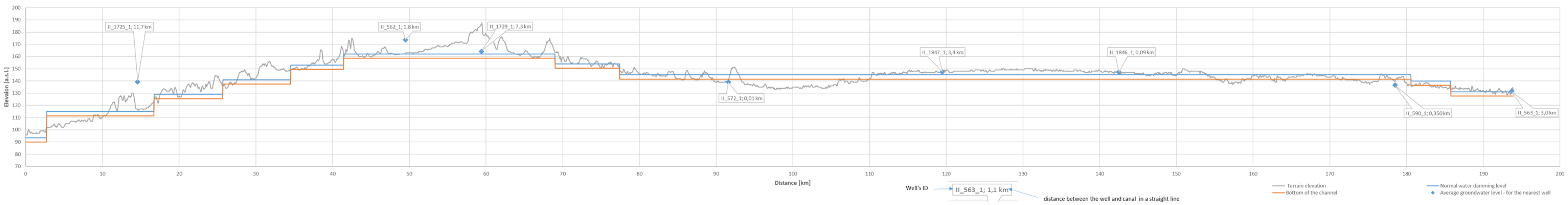

Fig. 4.6 Longitudinal profiles of the channel in variant 2 with markers representing average groundwater elevations in wells located along the channel. Distances between the wells and channels are provided in km in the labels marking the wells. Terrain elevations on the profile are derived from the DEM created on the basis of topographic maps of Poland in the scale of 1:10000.

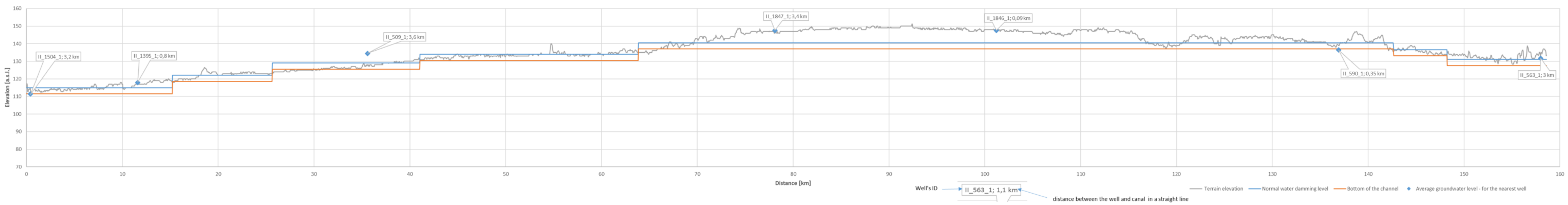

Fig. 4.7 Longitudinal profiles of the channel in variant 3 with markers representing average groundwater elevations in wells located along the channel. Distances between the wells and channels are provided in km in the labels marking the wells. Terrain elevations on the profile are derived from the DEM created on the basis of topographic maps of Poland in the scale of 1:10000.

Table 4.2 summarizes the total length of the channel sections, which can potentially act as irrigation and drainage. Sections that are characterized by a potentially draining and infiltrating canal's role in a given variant are shown in Fig. 4.8.

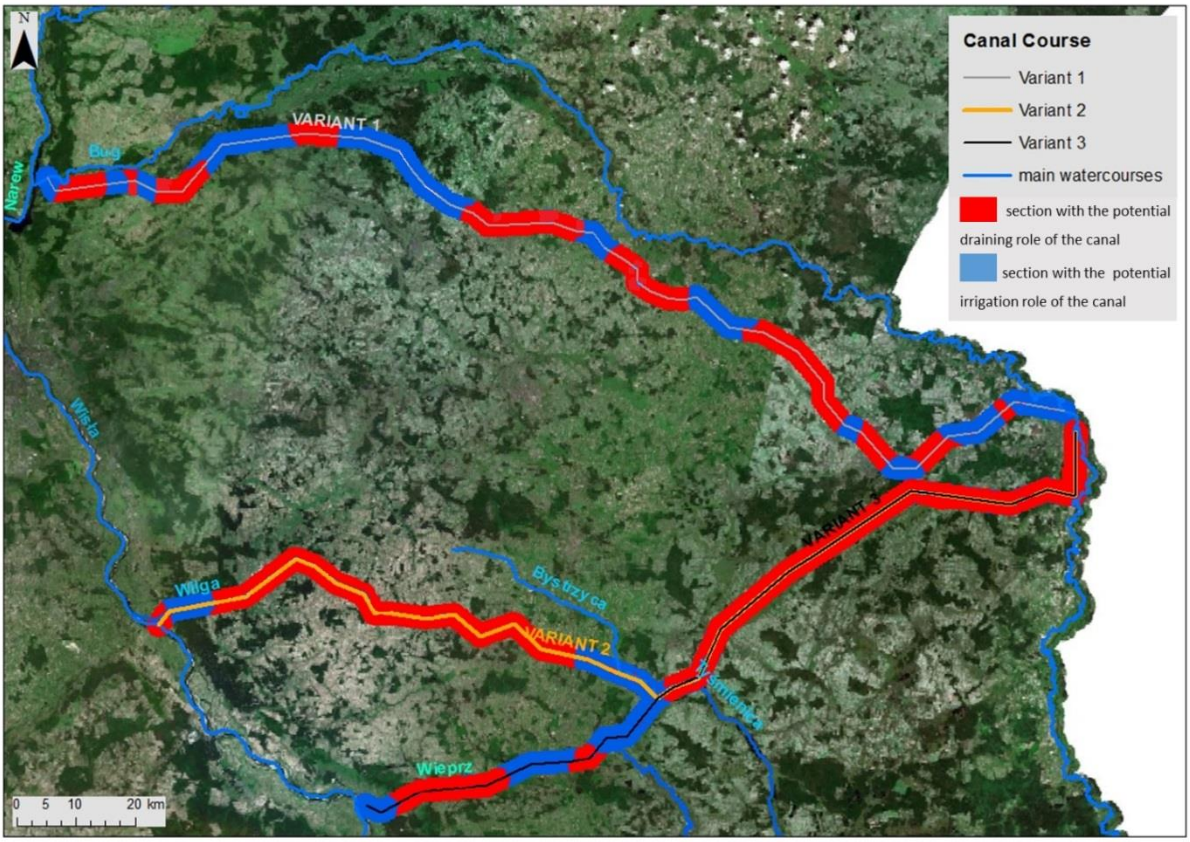

Fig. 4.8 Results of the calculations – possible draining and infiltrating stretches of the channels to be designed in 4 variants.

Tab. 4.2 Total length of potential drainage (the channel drain adjacent groundwater) and irrigation (the channel supplies adjacent groundwater) sections in 3 variants of channels.

Variant	Total length of drainage sections [km]	Total length of irrigation sections [km]	Total length of the canal [km]
1	113,3	94,5	207,8
2	119,5	76,4	195,9
3	107,8	51,8	159,6

Hence, our results indicate that the assumption made in Feasibility Study (Gdańsk Maritime Institute, 2015) about the exfiltrating role of the channels along their entire lengths is incorrect. Therefore, it seems, that the channels can lower local drainage base and lead to the decline of groundwater levels in these areas. This phenomenon has not been foreseen in Feasibility Study and might be an important negative consequence of the channel design for local agriculture, aquaculture (fish farming), forestry, households and the environment.

4.2 Calculation of water gains and losses of channels in particular variants

The water demand for channel function including sluicing (according to the given assumptions and sizes of the biggest sluices in each 'arms' of the channels), evaporation and infiltration/exfiltration balance is presented in the Tab. 4.3.

Tab. 4.3 Water demand for the operation of channels in particular variants

Variant	Losses on sluicing	Losses on evaporation	Infiltration/exfiltration balance	Sum	Water demand calculated in the Feasibility Study[4]
	m^3/s				
	A	B	C	*(A+B)-C*	-
1	13,2	0,498	0,008	***13,69***	9,78-16,38
2	12,0	0,470	0,019	***12,45***	8,24-13,38
3	10,6	0,383	0,025	***10,96***	5,22-7,79

Among the analysed components of water demand, the most important seem to be the losses related to sluicing that consist of nearly 97% of the total losses of water. Reduction of water loses can be done by limiting the number of sluicings per day (in the present variant we assumed 24 individual processes of sluicing through one single, the biggest in the channel's 'arm'). However, limiting the number of sluicings means littler and less intensive use of the channels for the navigation purposes, which will have an effect on an economic balance of the investment. Particular elements of the losses that have been analysed in our approach have to be done in much more detail, with a special focus on the filtration parameters of aquifers along the draining and infiltrating stretches of the channels. At the moment, according to the methodology used and according to the given assumptions (homogeneous K coefficient, no regard to differences in groundwater and surface water heads along the channel) one can conclude that the infiltration/exfiltration balance of channels in each of the variants is positive. This means that each of the channels is likely to drain adjacent groundwater. Thus, one can expect that groundwater levels, especially along the draining stretches of the channels in each of the variants considered, will likely drop. Calculated water demand in variants 1 and 2 keeps in accordance to the values of water demand provided in Feasibility Study (Gdańsk Maritime Institute, 2015). Calculated water demand for the variant 3 is, however, larger than the one calculated for this variant by Gdańsk Maritime Institute (2015). Due to the fact that particular elementary values of water demand are fuzzy and not directly stated in the Feasibility Study, at this moment we cannot state the reason of the differences (Tab. 4.3). However, all of the

[4] Gdańsk Maritime Institute, 2015

values of water demand calculated on the basis of our assumptions seem to keep the same order of magnitude as the ones provided in the Feasibility Study (Gdańsk Maritime Institute, 2015).

4.3 Hydrological analyses of river discharge in the neighbourhood of the channels

Knowing the hypothesized value of water demand for the channels in each of the variants analysed, we managed to make an overview of the general hydrological situation of the hydrographic system that can potentially be affected by the construction, filling and operation of the channels. GIS analyses provided in our study allow to suspect that there will be 6 major rivers that can possibly be used as sources of water for the channels, namely: Vistula, Bug, Wieprz, Tyśmienica, Wilga and Bystrzyca (Fig. 1.1; Tab. 4.4). Supplying potential channels with water has to address the issues of water management in catchments of these rivers. Therefore, we used some multi-year statistics of river discharge of these water bodies in monitoring points (water gauges) located nearby the planned channels. Among hydrological variables important for the interpretation, there are mainly indices of low flows. This is because on the basis of the value of mean annual lowest discharges of particular rivers (later on referred to as MLQ) one can quantify the environmental flows. Environmental flows, referred to as the minimum discharge required for handling basic ecosystem and economic functions of the rivers, remain the threshold for water abstraction and other water management actions that may possibly result in shortening water resources of rivers.

Tab. 4.4 Selected discharge parameters of rivers analysed that can potentially be affected by the channel construction. MLQ – mean of the annual lowest discharges from a multi-year period. TQ – median of daily discharges from a multi-year period. Source of data: Institute for Meteorology and Water Management – National Research Institute.

Water gauge	River	MLQ	TQ (50%)
		m^3/s	m^3/s
Dęblin	Vistula	182,6	385
Włodawa	Bug	21,7	46
Lubartów	Wieprz	11,5	20,4
Tchórzew	Tyśmienica	2,6	7,75
Wilga	Wilga	0,9	1,47
Borki	Bystrzyca	0,6	2,25

Considering the values of water demand for the channels (ranging from 10,96 up to 13,69 m^3/s) and MLQ (Tab. 4.4) one can state that there are only two rivers capable to handle water demand of the channels. These are Bug and Vistula. MLQ of Wieprz (in Lubartów), Tyśmienica (in Tchórzew), Wilga (in Wilga) and Bystrzyca (in Borki) are a way too small to allow the hypothetical use of these rivers for supplying water to any of the channels in the variants analysed. If water from Wieprz, Tyśmienica, Wilga or

Bystrzyca is used to supply the channel, it will result in severe water shortage in the catchments of those rivers.

Water resources of Vistula, as the biggest Polish river, are high enough to cover the water demand of the channels in variants 2 and 3. However, consideration of the Vistula as a source of water to any of channels in these 2 variants would require water relocation and uphill pumping on distances higher than 60 km (Tab. 3.2). Moreover, use of water from Vistula for the variant 1 is (if not impossible) highly unlikely due to geographical reasons (distances). Therefore, if the economic criteria are met (costs of channel construction and continuous pumping of water in the amounts reaching 10,96-12,45 m^3/s are lower than the income from transportation in a given time), then the Vistula may feed channels in variants 2 and 3.

The case of river Bug as a source of water for channels is more complex and requires more advanced analyses. The river Bug is the only reasonable source of water for the variant 1 (Tab. 3.2, Fig. 1.1). However, the use of water from Bug to supply the channels will affect its minimum and highest discharges to the extent that water resources available for other water users along the course of the river (including the ecosystems) may be shortened.

MLQ of Bug in Włodawa and Krzyczew (respectively 21,7 m^3/s and 35,2 m^3/s) are relatively small comparing to the calculated water demands for channels in each of the variants (Tab. 4.3). Facing the fact that the river Bug is the only reasonable source of water for the variant 1, the difference between MLQ and water demand (reaching respectively 8.01 m^3/s and 21.51 m^3/s) is low enough to foresee shortage of water for Bug downstream from those water gauges. E.g., the use of water from Bug to feed the channel in variant 1 would result in decrease of the MLQ in Krzyczew to the value lower than MLQ in Włodawa.

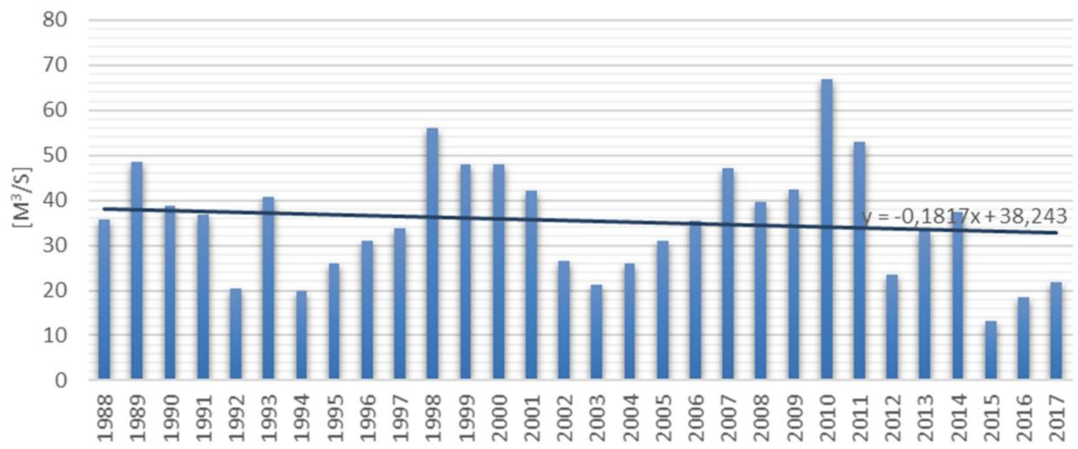

Fig. 4.9 Minimum annual rischarges of Bug in Krzyczew. Source of data: Institute for Meteorology and Water Management – National Research Institute.

Observing temporal variability of the lowest annual discharges of Bug in Krzyczew (Fig. 4.9) one can conclude that its values are decreasing. Statistical analysis of the trend would require more data, however it is obvious that during the last decade (especially 2015 and 2016) the lowest discharges of Bug in Krzyczew were approximately as low as the water demand for the channel. This means, that (1) in order to keep the operation of the channel in the driest periods of the year, the whole (or nearly the whole) water of Bug in Krzyczew during the most critical droughts would have be used to assure the functionality of the channel in variant 1 or (2) the operation of the channel in variant 1 (but also in other variants) would have to be limited (or even stopped) due to the lack of water for sluicing (locking) purposes. Both of the variants have critically negative impacts on society, economy and the environment. A similar, but slightly less severe situation, would occur when the discharges of Bug would be lower than the calculated values of MLQ. For the water gauges analysed, the number of days with flows below MLQ was calculated (this can be considered as a water deficit). The analysis for the Bug river shows that such days occurred more than 1000 times in the analysed period of 30 years, which gives 33 days on average for a year, which is 9% of occurrences (Tab. 4.5).

Tab. 4.5 Number of days below the MLQ for the water gauges. Calculated on the basis of data from the Institute of Meteorology and Water Management-National Research Intitute.

Water gauge	River	Number of days below MLQ		
		1988-2017	per year	%
Dęblin	Vistula	377	13	3%
Krzyczew	Bug	753	25	7%
Lubartów	Wieprz	1196	40	11%
Tchórzew	Tyśmienica	446	15	4%
Wilga	Wilga	418	14	4%
Borki	Bystrzyca	526	18	5%

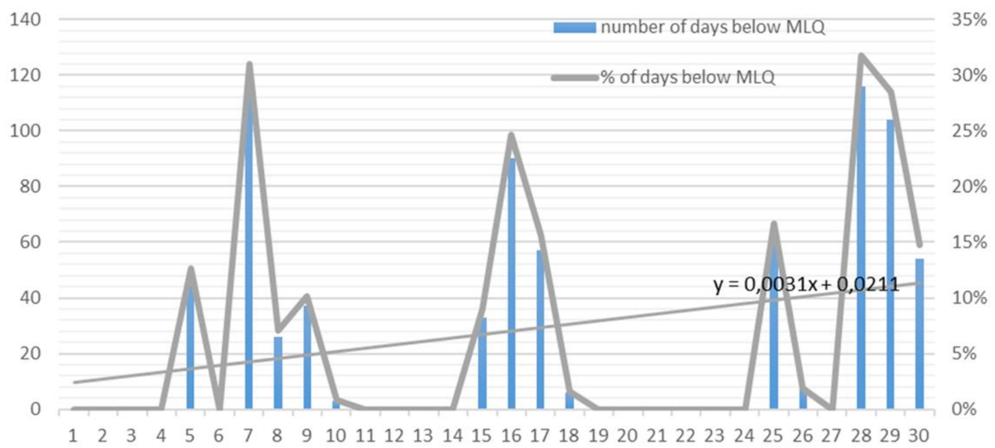

Fig 4.10 Number of days below MLQ – water gauge Krzyczew (Bug river). X axis – consecutive years; Y axis – number of days per year (frequency).

In addition, the number of days in the years with the discharge below MLQ on the Bug shows a significant increasing trend (Fig. 4.10). **This observation allows to suspect that the use of Bug as a source of water for any of the channel variants is likely to result in severe changes of flow regime of this river during droughts.**

Analysing the discharge of Bug and other rivers considered in other-than-drought periods, one could also see that possible extraction of water from these water bodies will result in decent changes of their flow regime. We calculated the 'typical discharge' (a median of daily flows from a multi-year period) for a particular river in selected water gauging profiles and the number (share) of this discharge if the operation of channels in particular variants was considered (Tab. 4.6).

Tab. 4.6 The size of water needs in% ratio to TQ (TQ – median of daily discharges from a multi-year period). Calculated on the basis of data from the Institute of Meteorology and Water Management-National Research Intitute.

Water gauge	River	TQ (50%)	Needs [%TQ]		
		m^3/s	V1	V2	V3
Dęblin	Vistula	385	-	3%	3%
Krzyczew	Bug	46	30%	27%	24%
Lubartów	Wieprz	20,4	-	62%	54%
Tchórzew	Tyśmienica	7,75	-	162%	143%
Wilga	Wilga	1,47	-	854%	752%
Borki	Bystrzyca	2,25	-	558%	491%

One can see that even in average discharge scenarios, rivers other than Bug and Vistula will likely dry-up if water from these rivers is extracted for the purposes of channels' operation. The possible appearance of additional demand for supplying channels in the quantities presented in Tab. 4.6 is likely to result in the increased frequency of water deficits expressed by the number of days with the momentary discharge lower than the MLQ + amount required by the channel operation.

Tab. 4.7 The incidence of deficits for the analysed water gauges. Q stands for the momentary discharge. Calculated on the basis of data from the Institute of Meteorology and Water Management-National Research Intitute.

Water gauge	River	Water shortage (Q<MLQ+demands)		
		V1	V2	V3
Dęblin	Vistula	-	6%	6%
Krzyczew	Bug	20%	19%	17%
Lubartów	Wieprz	-	63%	57%
Tchórzew	Tyśmienica	-	88%	84%
Wilga	Wilga	-	100%	99%
Borki	Bystrzyca	-	98%	98%

The incidence of deficits for the analysed water gauges will likely increase by 17-20% in the case of Bug, 57-63% in the case of Wieprz, 84-88% in the case of Tyśmienica, up to 98% in the case of Bystrzyca and up to 100% in the case of Wilga. Only in the case of Vistula the increase of discharge deficits is likely not to exceed 6% (Tab. 4.7). Again, it tends to be obvious, that amongst rivers analysed, water resources of Tyśmienica, Wieprz, Bystrzyca and Wilga do not allow to be used as water supply for the day-by-day channels' operation in neither of variants.

Tab 4.8 Numbers of days when the average daily discharge was higher than THQ (THQ – median of of the highest annual discharges from a multi-year period). Calculated on the basis of data from the Institute of Meteorology and Water Management-National Research Intitute.

Month/Year	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X	sum
1988	0	0	0	0	3	18	0	0	0	0	0	0	**21**
1989	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1990	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1991	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1992	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1993	0	0	0	0	0	10	0	0	0	0	0	0	**10**
1994	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1995	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1996	0	0	0	0	0	22	6	0	0	0	0	0	**28**
1997	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1998	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1999	0	0	0	0	27	13	6	0	0	0	0	0	**46**
2000	0	0	0	3	7	21	4	0	0	0	0	0	**35**
2001	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2002	0	0	0	27	14	0	0	0	0	0	0	0	**41**
2003	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2004	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2005	0	0	0	0	9	17	0	0	0	0	0	0	**26**
2006	0	0	0	0	0	25	0	0	0	0	5	0	**30**
2007	0	0	0	0	23	0	0	0	0	0	0	0	**23**
2008	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2009	0	0	0	0	5	17	0	0	2	0	0	0	**24**
2010	0	0	0	0	30	25	0	0	0	0	0	0	**55**
2011	0	0	26	24	19	4	0	0	0	0	0	0	**73**
2012	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2013	0	0	0	0	7	23	16	17	0	0	0	0	**63**
2014	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2015	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2016	0	0	0	0	2	0	0	0	0	0	0	0	**2**
2017	0	0	0	1	11	0	0	0	0	0	0	0	**12**
sum	**0**	**0**	**26**	**55**	**157**	**195**	**32**	**17**	**2**	**0**	**5**	**0**	**489**

In the next step we analysed the probable reduction of discharges higher than the bankful flow of the rivers analysed. After Schneider et al. (2011) we assumed that the median of the highest annual discharges from a multi-year period (THQ, equivalent of the flood of 50% recurrence interval) remains an appropriate approximation of the bankful flow. For the reasons mentioned above (Tyśmienica, Wieprz, Bystrzyca and Wilga are too small; water resources of Vistula would remain ambiguous to possible water transfer) we analysed the THQ values for Bug in the water gauge Krzyczew. The value of THQ of Bug in Krzyczew equals 225[5] m^3/s. We calculated the number of days in each month of the multi-year period (1988-2017) when the momentary river discharge exceeded THQ (Tab. 4.8). The most frequent occurrences of flooding during the multi-year period 1988-2017 were recorded in March and April. When daily discharges of Bug in Krzyczew were reduced by the value of a highest demand for channel operation, we managed to calculate the reductions of frequencies of overbank flow of Bug in Krzyczew, which reached some 16,8% up to 18% (Tab. 4.9).

Tab. 4.9 Reduction of frequency of overbank flow in Bug in the scenarios of water withdrawal from Bug to supply the daily operation of the channels. Calculated on the basis of data from the Institute of Meteorology and Water Management-National Research Intitute.

Variant	Reduction of frequency of overbank flow in Bug
V1	18,0%
V2	17,4%
V3	16,8%

Similar analyses were provided for MLQ. It was revealed that shortages of water ($Q < MLQ$) occur more frequently during the last decade then in former years (Tab. 4.10). This means that contemporary pressures on water resources in the river Bug, along with the impacts of the climate change, pose a significant threat to the flow regime stability of Bug. When analysing the number of days when the momentary discharge would be lower than MLQ reduced by the demand of water for the operation of channels in all variants, it was revealed that the increase of frequency of severe droughts is likely to reach from some 149% up to 195% (Tab. 4.11). Both of the analyses indicate that the **withdrawal of water from Bug in any of variants of channel operation will result in reduction of the frequency of days with overbank flow and increased frequency of severe droughts. The latter tends to be much more critical than the former.**

[5] Calculated on the basis of daily discharge data from Bug in Krzyczew. Source of data: Institute for Meteorology and Water Management-National Research Institute.

Tab 4.10 Numbers of days when the average daily discharge was lower than MLQ (MLQ – the mean value of the lowest annual discharges from a multi-year period). Calculated on the basis of data from the Institute of Meteorology and Water Management-National Research Intitute.

Month/Year	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X	sum
1988	1	4	0	0	0	0	0	0	0	0	0	0	5
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	11	25	23	8	0	67
1991	0	0	0	16	2	0	0	0	0	0	24	8	50
1992	0	15	7	0	0	0	0	0	23	31	12	1	89
1993	0	0	0	0	0	0	0	6	5	5	4	0	20
1994	17	12	0	0	0	0	0	4	30	31	30	14	138
1995	0	0	0	0	0	0	0	0	4	30	12	4	50
1996	2	8	31	30	22	0	0	0	11	17	17	0	138
1997	0	3	31	15	0	0	0	8	8	0	3	0	68
1998	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	11	0	0	0	0	11
2002	0	0	0	0	0	0	0	0	0	26	30	15	71
2003	0	0	6	0	0	0	0	11	30	31	30	31	139
2004	28	23	22	6	0	0	0	21	30	21	21	29	201
2005	16	0	0	0	0	0	0	0	3	0	29	31	79
2006	30	2	0	13	4	0	0	0	17	0	0	0	66
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	1	3	22	0	26
2009	0	0	0	0	0	0	0	0	0	0	8	5	13
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	18	28	30	28	104
2013	0	11	0	0	0	0	0	0	0	7	13	0	31
2014	0	0	0	0	0	0	0	0	0	24	27	28	79
2015	21	10	0	0	0	0	0	14	30	31	30	31	167
2016	16	0	2	0	0	0	0	15	30	31	30	24	148
2017	0	0	0	0	0	0	0	16	30	31	30	3	110
sum	131	88	99	80	28	0	0	117	295	370	410	252	1870

Tab. 4.11 Reduction of frequency of overbank flow in Bug in the scenarios of water withdrawal from Bug to supply the daily operation of the channels. Calculated on the basis of data from the Institute of Meteorology and Water Management-National Research Intitute.

Variant	Increase of frequency of severe droughts in Bug
V1	195%
V2	171%
V3	149%

4.4 Influence of channels on wetlands and riverscapes

4.4.1 Possible impact of water deficits in Tyśmienica, Bystrzyca, Wieprz and Wilga on water-dependent ecosystems in the region

If the water for filling the canal was taken from the rivers Tyśmienica, Bystrzyca, Wieprz or Wilga, severe water deficits would occur in these rivers, which can result in lowering the groundwater level in their whole catchments. In such a case, a negative impact on all water-dependent species and habitats in the catchments of these rivers cannot be excluded. In the catchments of the four aforementioned rivers there is over **62 500 ha of peatlands** (Fig. 4.11). A decrease of groundwater level may result in destruction of those that are still well-preserved and may contribute to the progressive degradation of peatlands already drained.

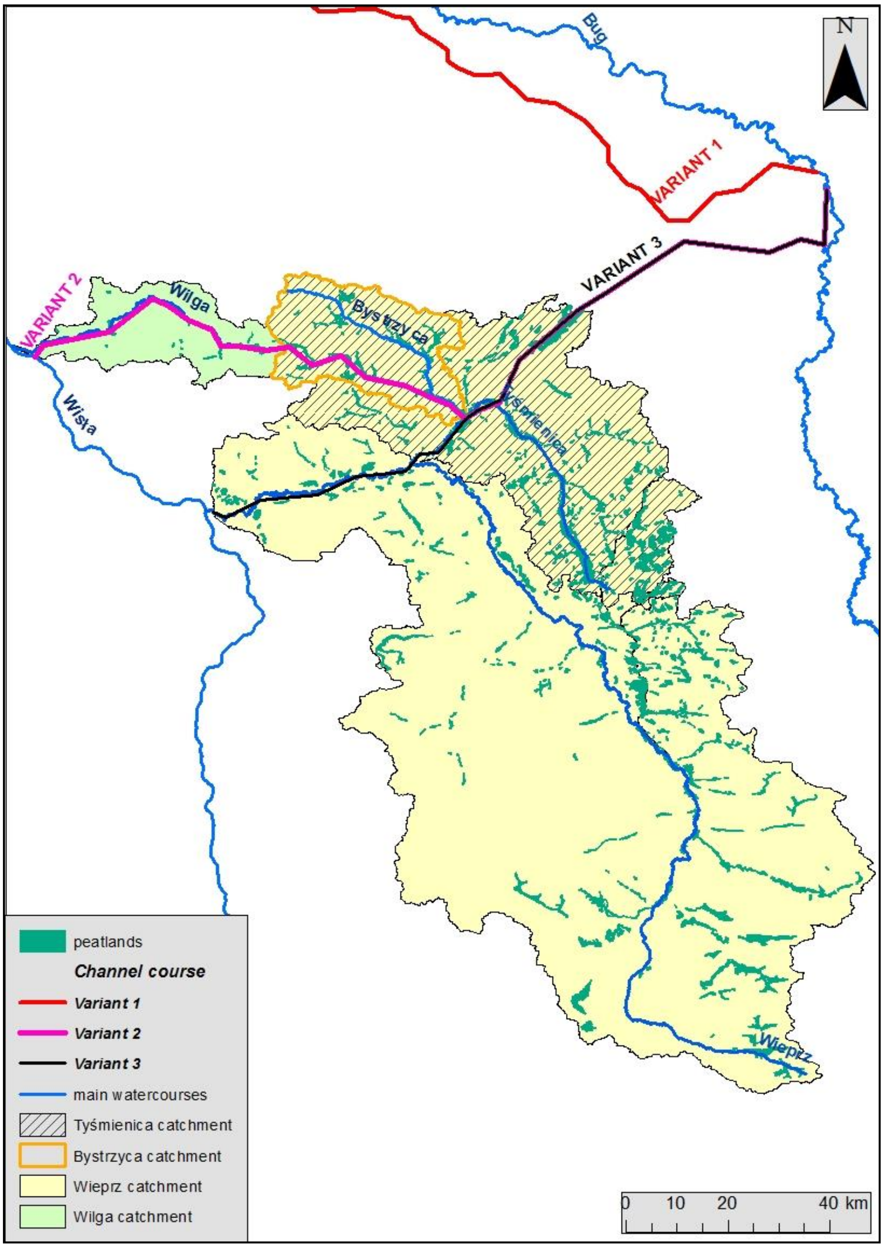

Fig. 4.11 Peatlands in the catchments of Tysmienica, Bystrzyca, Wieprz and Wilga.

In the catchments of the four aforementioned rivers there are **10 Special Protection Areas covering in total ca. 85 500 ha** (Fig. 4.12, Tab. 4.12) and **45 Special Areas of Conservation covering in total ca. 395 ha** (Fig. 4.13, Tab. 4.13).

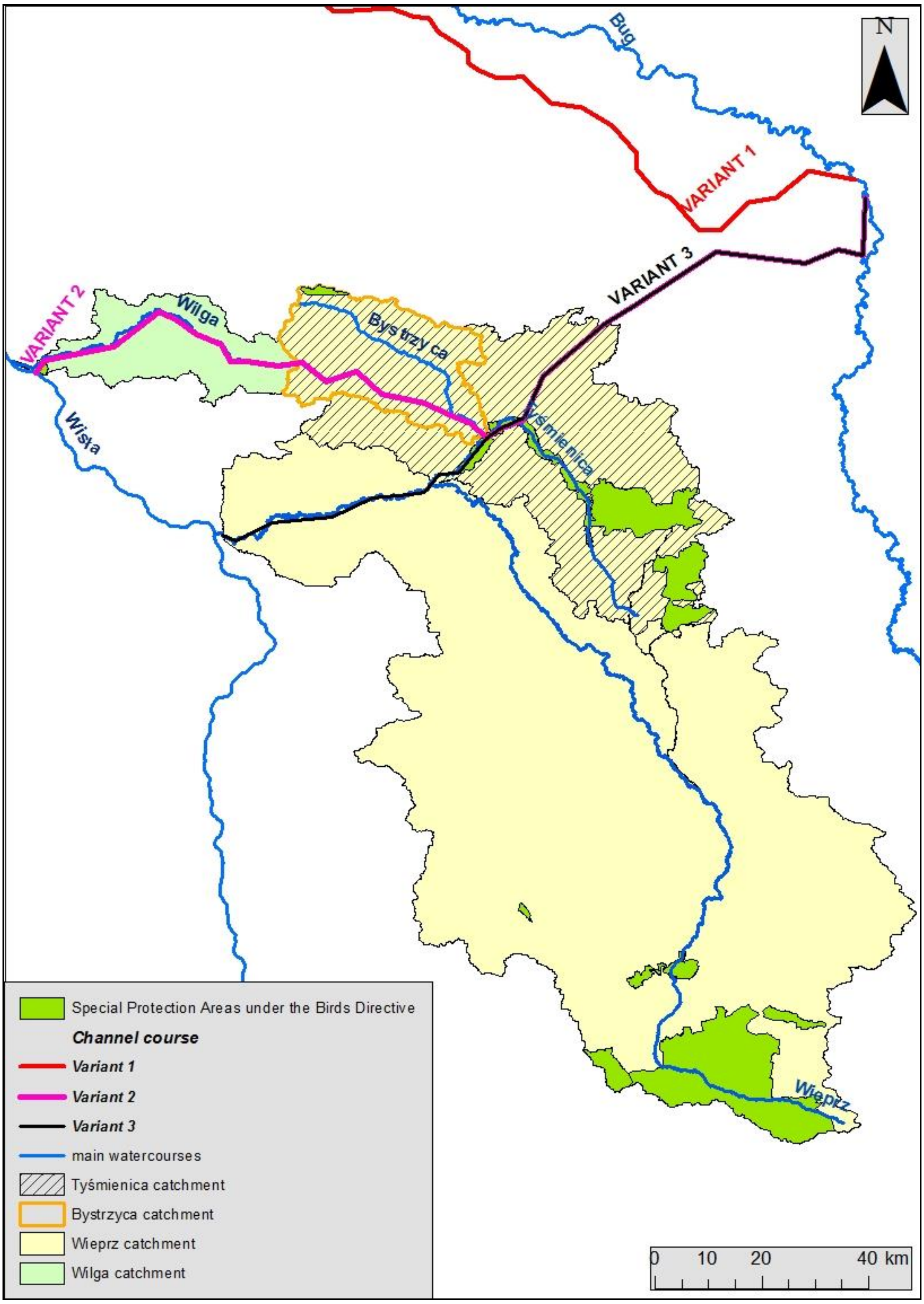

Fig. 4.12 Special Protection Areas under the Birds Directive in the catchments of Tysmienica, Bystrzyca, Wieprz and Wilga.

All Special Protection Areas in the region have several bird species of water-dependent habitats as conservation objectives (Tab. 4.12). Water deficit in the rivers and the groundwater level drop in the region may negatively affect all these conservation objectives of Natura 2000 sites, not only within those sites that would be directly crossed by E40 IWW (Tab. 4.12).

Tab. 4.12 Special Protection Areas under the Birds Directive in the catchments of Tysmienica, Bystrzyca, Wieprz and Wilga. Sites directly crossed by the planned E40 IWW are marked with bold.

	Name	**Code**	**Area within the impacted catchments [ha]**	**Bird species associated with wetlands, conservation objectives of Natura 2000 sites**	**Source**
1	Dolina Górnej Łabuńki	PLB 060013	1907	*Crex crex, Gallinago media, Limosa limosa*	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/28670/Zarzadzenie_RDOS_Lublin_24_listopada_2014.pdf
2	**Dolina Środkowej Wisły**	**PLB 140004**	**668**	***Ixobrychus minutus, Ciconia nigra, Tadorna tadorna, Anas platyrhynchos, Anas clypeata, Aythya nyroca, Mergus merganser, Haliaeetus albicilla, Crex crex, Haematopus ostralegus, Charadrius dubius, Charadrius hiaticula, Limosa limosa, Tringa totanus, Actitis hypoleucos, Larus melanocephalus, Larus ridibundus, Larus canus, Sterna hirundo, Sternula albifrons, Alcedo atthis, Riparia riparia, Carpodacus erythrinus***	**http://bip.lublin.rdos.gov.pl/files/obwieszczenia/20815/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_1853.pdf**
3	**Dolina Tyśmienicy**	**PLB 060004**	**7364**	***Ixobrychus minutus, Ciconia nigra, Aythya nyroca, Circus aeruginosus, Circus pygargus, Porzana parva, Crex crex, Hydrocoelus minutus, Sterna hirundo, Chlidonias hybridus, Chlidonias niger, Asio flammeus, Podiceps grisegena, Anser anser, Anas penelope, Anas strepera, Anas acuta, Anas querquedula, Limosa limosa, Numenius arquata, Tringa totanus, Panurus biarmicus***	**http://bip.lublin.rdos.gov.pl/files/obwieszczenia/37828/Zarzadzenie_RDOS_Lublin_Dolina_Tysmienicy.pdf**
4	Lasy Łukowskie	PLB 060010	970	*Aquila pomarina, Asio flammeus, Ciconia coconia, Ciconia nigra, Grus grus*	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
5	Lasy Parczewskie	PLB 060006	14025	*Ixobrychus minutus, Aythya nyroca, Haliaeetus albicilla, Crex crex, Anas strepera, Anser anser*	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/37812/Zarzadzenie_RDOS_Lublin_Lasy_Parczewskie.pdf
6	Ostoja Nieliska	PLB 060020	3136	*Ixobrychus minutus, Aythya nyroca, Porzana porzana, Gallinago media, Chlidonias hybrida, Chlidonias niger, Anas querquedula, Anas clypeata, Limosa limosa, Grus grus, Larus cachinnans*	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/37808/Zarzadzenie_RDOS_Lublin_Ostoja_Nieliska.pdf
7	Polesie	PLB 060019	9655	*Acrocephalus paludicola, Alcedo atthis, Aquila pomarina, Asio flammeus, Aythya nyroca, Botaurus stellaris, Chlidonias hybridus, Chlidonias leucopterus, Chlidonias niger, Ciconia coconia, Ciconia nigra, Circus aeruginosus, Circus pygargus, Crex crex, Gallinago media, Grus grus, Ixobrychus minutus, Porzana parva, Porzana porzana, Sterna hirundo, Tetrao tetrix*	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
8	Puszcza Solska	PLB 060008	3363	*Alcedo atthis, Aquila pomarina, Botaurus stellaris, Charadrius dubius, Circaetus gallicus, Ciconia coconia, Ciconia nigra, Circus aeruginosus, Crex crex, Grus grus, Haliaeetus albicilla, Ixobrychus minutus, Porzana parva, Porzana porzana, Scolopax rusticola, Tetrao tetrix, Tetrao urogalus, Tringa ochropus*	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
9	Roztocze	PLB 060012	44049	*Alcedo atthis, Aquila pomarina, Botaurus stellaris, Chlidonias hybridus, Chlidonias niger, Ciconia coconia, Ciconia nigra, Circus aeruginosus, Circus pygargus, Crex crex, Egretta alba, Gallinago media, Grus grus, Haliaeetus albicilla, Ixobrychus minutus, Porzana parva, Porzana porzana, Sterna hirundo*	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
10	Staw Boćków	PLB 060016	327	*Alcedo atthis, Botaurus stellaris, Chlidonias niger, Ciconia coconia, Ciconia nigra, Circus aeruginosus, Circus pygargus, Crex crex, Gallinago media, Ixobrychus minutus, Porzana parva, Porzana porzana*	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
Total			**85464**		

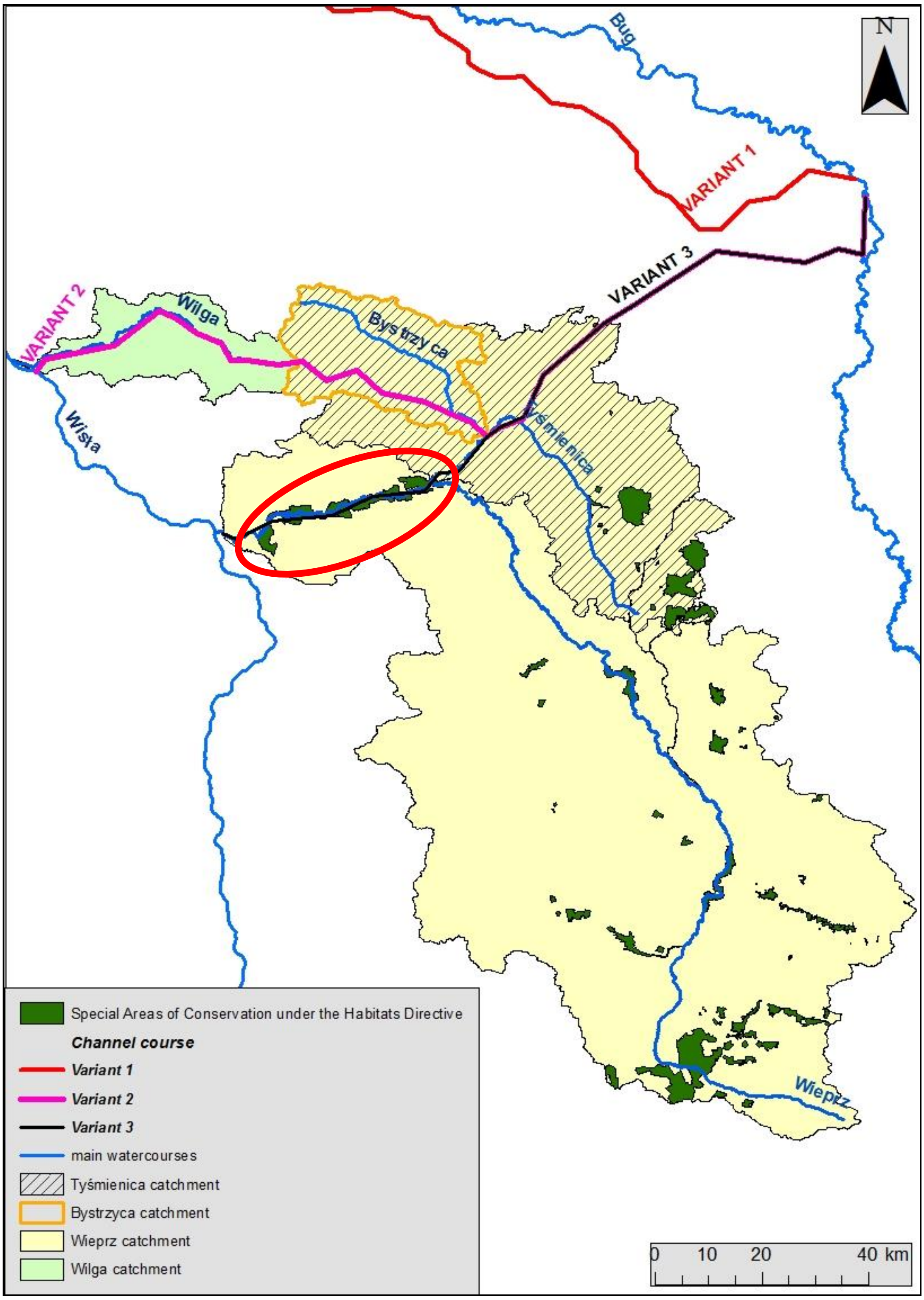

Fig. 4.13 Special Areas of Conservation under the Habitats Directive in the catchments of Tysmienica, Bystrzyca, Wieprz and Wilga. PLH Dolny Wieprz encircled with a red elipse.

Water-dependent species and habitats are conservation objectives in 17 of 45 Special Areas of Conservation in the region, covering in total 354.5 ha (Tab. 4.13). A special attention should be paid to the Special Area of Conservation Dolny Wieprz (Tab. 4.13), where the most evident and severe losses are expected, in the case of building the E40 channel along the variant 3 (Fig. 4.13), because the channel would use the Wieprz valley route, destroying the river valley totally. The area is valuable for the nature conservation in the region. The Wieprz riverbed has a natural, strongly meandering nature, the river is accompanied by numerous oxbow lakes and extensively used wet meadows. Nevertheless, water deficit in rivers and the groundwater level decrease in the region may negatively affect all conservation objectives of the Natura 2000 sites, not only those sites that would be directly crossed by E40 IWW (Tab. 4.13).

The region is particularly important for the protection of butterflies *Lycaena helle, Lycaena dispar, Maculinea teleius, Maculinea nausithous* associated with *Molinia*-meadows on calcareous, peaty or clayey-silt-laden soils (habitat type 6410). Other habitat types protected within the Special Areas of Conservation in this region are (Tab. 4.13):

<u>Lakes, rivers and riverbank vegetation:</u>

3140 – Hard oligo-mesotrophic waters with benthic vegetation of *Chara spp*.,
3150 – Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation,
3160 – Natural dystrophic lakes and ponds,
3260 – Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation,
3270 – Rivers with muddy banks with *Chenopodion rubri* p.p, and *Bidention* p.p. vegetation,
6430 – Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels.

<u>Alluvial meadows and forests:</u>

6440 – Alluvial meadows of river valleys of the *Cnidion dubii*,
91E0 – Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*).

<u>Peatlands:</u>

7110 – Active raised bogs,
7120 – Degraded raised bogs still capable of natural regeneration,
7140 – Transition mires and quaking bogs,
7150 – Depressions on peat substrates of the *Rhynchosporion*,
7210 – Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae,*
7230 – Alkaline fens,
91D0 – Bog woodlands.

Additionally, it cannot be excluded that the groundwater level would decrease in the region negatively impacting above mentioned water-dependent ecosystems, even if the water was pumped to the canal from Bug or Vistula and not taken from Tyśmienica, Bystrzyca, Wieprz or Wilga. This is due to the potential draining role of the E40 IWW canal in many sections along each of the analysed variants.

Tab. 4.13 Special Areas of Conservation under the Habitats Directive in the catchments of Tyśmienica, Bystrzyca, Wieprz and Wilga. Site directly crossed by the planned E40 IWW is marked with bold.

	Name	Code	Area within the impacted catchments [ha]	Conservation objectives of Natura 2000 sites: Species associated with wetlands	Conservation objectives of Natura 2000 sites: Water-dependent habitats	Source
1	Bródek	PLH060085	1.68	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
2	Brzeziczno	PLH060076	0.98	*Leucorrhinia pectoralis*	3160, 7110, 7140, 91D0	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/25476/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_2909.pdf
3	Bystrzyca Jakubowicka	PLH060096	4.57	*Angelica palustris, Bombina bombina, Misgurnus fossilis, Ophiogomphus cecilia, Maculinea teleius, Lycaena dispar, Lycaena helle, Maculinea nausithous, Leucorrhinia pectoralis*	3150, 6410	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/37830/Zarzadzenie_RDOS_Lublin_Bystrzyca_Jakubowicka.pdf
4	Chmiel	PLH060001	0.26	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
5	Czarny Las	PLH060002	0.2	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
6	Debry	PLH060003	1.72	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
7	Dobromyśl	PLH060033	6.37	*Emys orbicularis, Bombina bombina, Rhodeus sericeus amarus, Phoxinus percnurus, Maculinea teleius, Maculinea nausithous, Lycaena helle, Lycaena dispar, Euphydryas aurinia*	3140, 6410, 7140	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/37832/Zarzadzenie_RDOS_Lublin_Dobromysl.pdf
8	Dolina Łętowni	PLH060040	11.35	*Angelica palustris, Lycaena dispar, Lycaena helle, Maculinea teleius, Maculinea nausithous*	3140, 6410, 7140, 7230	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/23502/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_2337.pdf
9	Dolina Środkowego Wieprza	PLH060005	15.24	*Bombinma bombina, Castor fiber, Lutra lutra, Leucorrhinia pectoralis, Ophiogomphus cecilia, Lycaena dispar, Lycaena helle, Maculinea teleius, Maculinea nausithous, Misgurnus fossilis*	3150, 6410, 91E0	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
10	Dolina Wolicy	PLH060058	9.39	*Angelica palustris, Rhodeus sericeus amarus*	3150, 6410, 7230, 91E0	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/28671/Zarzadzenie_RDOS_Lublin_24_listopada_2014.pdf
11	Doliny Łabuńki i Topornicy	PLH060087	20.55	*Angelica palustris, Bombina bombina, Castor fiber, Emys orbicularis, Lutra lutra, Lycaena dispar, Lycaena helle, Maculinea teleius, Maculinea nausithous*	6410	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
12	**Dolny Wieprz**	**PLH060051**	**81.61**	***Aspius aspius, Bombina bombina, Castor fiber, Emys orbicularis, Lutra lutra, Misgurnus fossilis, Marsilea quadrifolia***	**3150, 3270, 6430, 7230, 91E0**	**http://natura2000.gdos.gov.pl/wyszukiwarka-n2k**
13	Drewniki	PLH060059	0.66	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/25474/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_2907.pdf
14	Gliniska	PLH060006	0.17	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/21030/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_1942.pdf
15	Guzówka	PLH060071	7.42	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
16	Horodysko	PLH060060	0.03	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
17	Hubale	PLH060008	0.35	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/21028/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_1943.pdf
18	Izbicki Przełom Wieprza	PLH060030	17.79	*Bombina bombina, Maculinea nausithous, Maculinea teleius, Lycaena dispar, Misgurnus fossilis*	3150, 3270, 6430	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/37826/Zarzadzenie_RDOS_Lublin_Izbicki_Przelom_Wisly.pdf
19	Jelino	PLH060095	0.09	*Phoxinus percnurus*	7140	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/20817/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_1876.pdf

Tab. 4.13 cont.

20	Jeziora Uściwierskie	PLH06 0009	20.44	*Bombina bombina, Rhodeus sericeus amarus, Misgurnus fossilis, Cobitis taenia, Phoxinus percnurus, Maculinea teleius, Lycaena dispar, Maculinea nausithous*	3140, 3150, 3160, 6410, 6430, 7110, 7140, 7230, 91D0	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/37815/Zarzadzenie_RDOS_Lublin_Jeziora_Usciwierskie.pdf
21	Kąty	PLH06 0010	0.24	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/29346/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_4158.pdf
22	Kornelówka	PLH06 0091	0.29	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/21024/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_1944.pdf
23	Las Orłowski	PLH06 0061	3.68	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
24	Łabunie	PLH06 0080	0.04	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
25	Łopiennik	PLH06 0081	1.58	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
26	Maśluchy	PLH06 0105	0.92	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/28668/Zarzadzenie_RDOS_Lublin_24_listopada_2014.pdf
27	Niedzieliska	PLH06 0044	0.18	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/29347/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_4159.pdf
28	Niedzieliski Las	PLH06 0092	2.68	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/23466/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_2328.pdf
29	Nowosiółki (Julianów)	PLH06 0064	0.34	*Angelica palustris, Emys orbicularis, Liparis loeselii, Lycaena dispar, Maculinea teleius, Maculinea nausithous*	3140, 6410, 7110, 7140, 7230	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
30	Obuwik w Uroczysku Świdów	PLH06 0106	0.37	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
31	Olszanka	PLH06 0012	0.11	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
32	Ostoja Parczewska	PLH06 0107	35.92	*Leucorrhinia pectoralis, Maculinea teleius, Lycaena dispar, Maculinea nausithous, Lycaena helle, Bombina bombina, Emys orbicularis, Castor fiber, Lutra lutra*	3160, 7110, 7120, 7140, 91D0, 91E0	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/37790/Zarzadzenie_RDOS_Lublin_Ostoja_Parczewska.pdf
33	Ostoja Poleska	PLH06 0013	36.5	*Aldrovanda vesiculosa, Angelica palustris, Bombina bombina, Castor fiber, Cobitis taenia, Dytiscus latissimus, Emys orbicularis, Euphydryas aurinia, Hamatocaulis vernicosus, Liparis loeselii, Lutra lutra, Lycaena dispar, Maculinea teleius, Maculinea nausithous, Misgurnus fossilis, Rhodeus amarus, Rhynchocypris percnurus, Triturus cristatus*	3140, 3150, 3160, 6410, 6430, 7110, 7120, 7140, 7150, 7210, 7230, 91D0, 91E0	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k

Tab. 4.13 cont.

34	Pawłów	PLH060065	8.71	*Angelica palustris, Bombina bombina, Emys orbicularis, Euphydryas aurinia, Leucorrhinia pectoralis, Liparis loeselii, Lutra lutra, Lycaena dispar, Lycaena helle, Maculinea teleius, Maculinea nausithous, Misgurnus fossilis, Ophiogomphus cecilia, Rhynchocypris percnurus, Triturus cristatus*	3140, 6410, 7140, 7230, 91E0	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
35	Rogów	PLH060062	0.12	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/55021/Zarzadzenie_RDOS_w_Lublinie_z_4_maja_2016_pzo_dla_obszaru_Natura_2000_Rogow.pdf
36	Roztocze Środkowe	PLH060017	78.22	*Bombina bombina, Cobitis taenia, Cottus gobio, Emys orbicularis, Lampetra planeri, Lutra lutra, Lycaena dispar, Maculinea teleius, Maculinea nausithous, Misgurnus fossilis, Rhodeus amarus, Triturus cristatus*	3150, 3260, 6410, 7110, 7140, 7150, 91D0, 91E0	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
37	Siennica Różana	PLH060090	1.34	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
38	Świdnik	PLH060021	1.23	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/23475/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_2331.pdf
39	Święty Roch	PLH060022	2.03	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/23512/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_2340.pdf
40	Uroczyska Lasów Adamowskich	PLH060094	11.01	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
41	Uroczyska Puszczy Solskiej	PLH060034	6.47	*Bombina bombina, Castor fiber, Cobitis taenia, Cottus gobio, Emys orbicularis, Euphydryas aurinia Hamatocaulis vernicosus, Lampetra planeri, Leucorrhinia pectoralis, Lutra lutra, Lycaena dispar, Misgurnus fossilis, Ophiogomphus cecilia, Triturus cristatus*	3150, 3160, 3260, 6410, 6430, 7110, 7120, 7140, 7150, 91D0, 91E0	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
42	Wodny Dół	PLH060026	1.89	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
43	Wrzosowisko w Orzechowie	PLH060098	0.19	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/20821/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_1875.pdf
44	Wygon Grabowiecki	PLH060027	0.09	-	-	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/23491/Zarzadzenie_RDOS_Lublin_Dz_Urz_Woj_Lub_2014_2334.pdf
45	Zarośle	PLH060028	0.07	-	-	http://natura2000.gdos.gov.pl/wyszukiwarka-n2k
Total			**395.09**			

4.4.2 Possible impact of water deficits in Bug on water-dependent ecosystems in the Bug valley

Even if the E40 IWW does not go directly through the Bug valley, the construction channels in any variant, with the need to pump water from the Bug river to supply the channel, may have a significant negative impact on the ecosystems of the Bug valley. One of possible negative effects is reduction of the duration and/or ranges of river water flooding on the vast floodplains of Bug, which serve as unique habitats for large populations of many bird species. **Special Protection Areas were established along almost the entire Bug valley in Poland (Fig. 4.14) covering over 102 000 ha** and hosting rare and endangered species associated with floodplain meadows or wetlands e.g.: *Ciconia ciconia, Ciconia nigra, Circus aeruginosus, Crex crex, Gallinago gallinago, Limosa limosa, Numenius arquata, Philomachus pugnax, Tringa totanus* (Tab. 4.14).

Tab. 4.14 Special Protection Areas under the Birds Directive in the Bug valley.

	Name	**Code**	**Area within the impacted catchments [ha]**	**Bird species associated with wetlands, conservation objectives of Natura 2000 sites**	**Source**
1	Dolina Środkowego Bugu	PLB060003	28097	*Crex crex, Limosa limosa, Tringa totanus, Philomachus pugnax, Actitis hypoleucos, Chlidonias hybryda, Chlidonias niger, Chlidonias leucopterus, Alcedo atthis, Acrocephalus paludicola*	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/76122/Zarz%C4%85dzenie_RDO%C5%9A_Lublin_Dolina_%C5%9Arodkowego_Bugu.pdf
2	Dolina Dolnego Bugu	PLB 140001	74310	*Ciconia ciconia, Ciconia nigra, Anas querquedula, Anas clypeata, Crex crex, Gallinago gallinago, Limosa limosa, Tringa totanus, Circus aeruginosus, Numenius arquata, Rallus aquaticus, Porzana porzana, Porzana parva, Charadrius dubius, Charadrius hiaticula, Sterna hirundo, Sternula albifrons*	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/28665/Zarzadzenie_RDOS_Warszawa_Bialystok_Lublin_5_wrzesnia_2014.pdf
Total			**102407**		

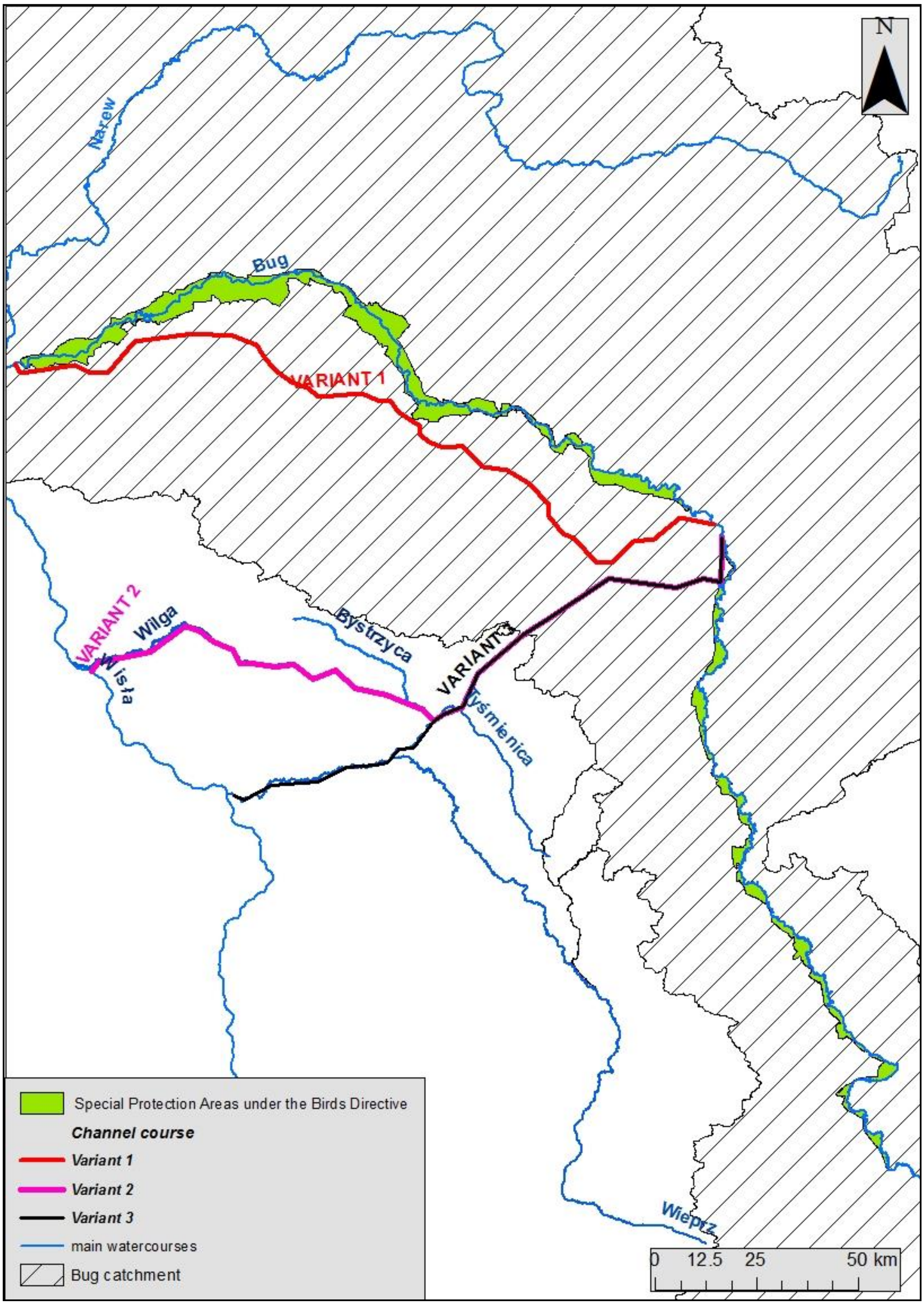

Fig. 4.14 Special Protection Areas under the Birds Directive in the Bug valley.

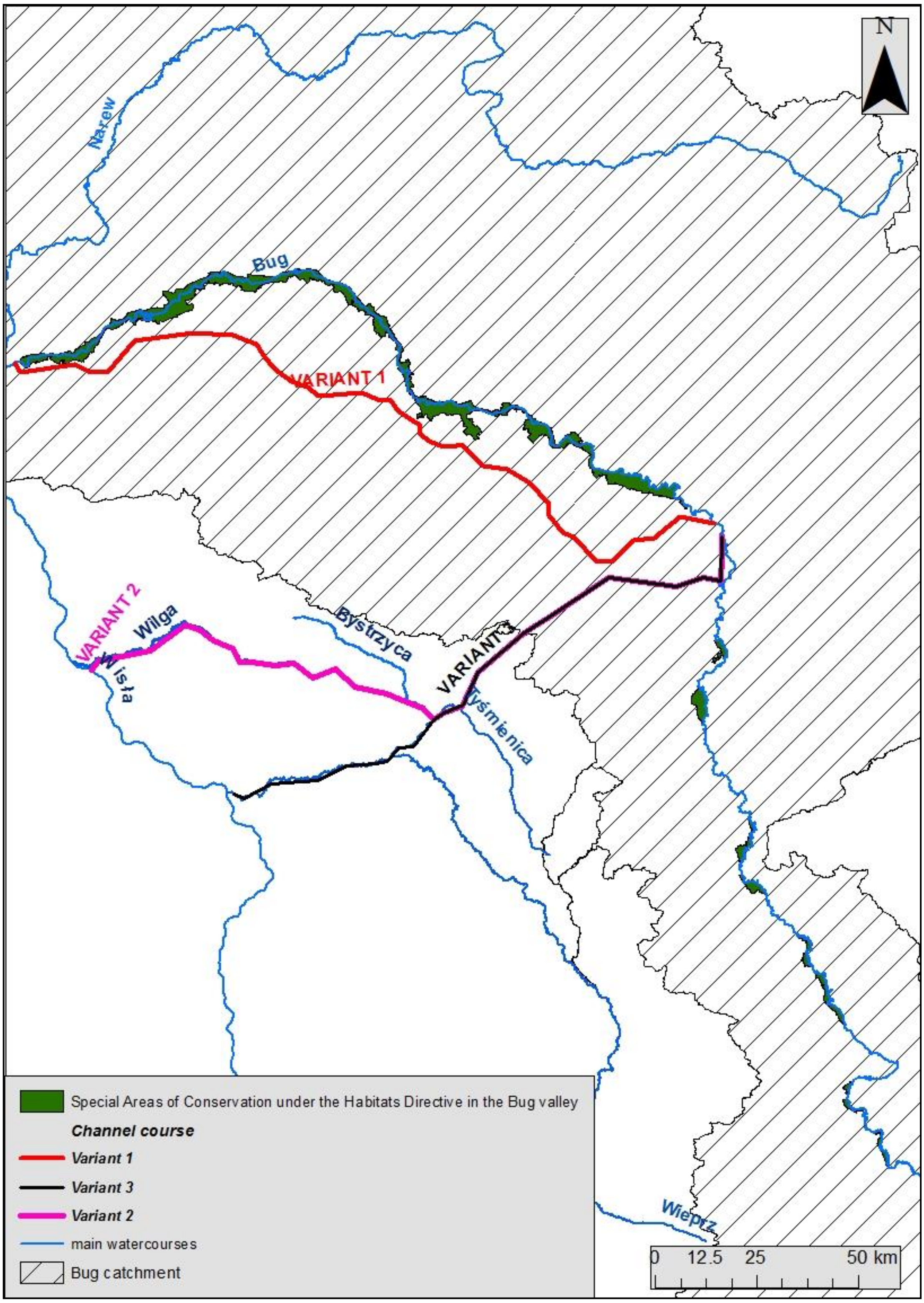

Fig. 4.15 Special Areas of Conservation under the Habitats Directive in the Bug valley.

Special Areas of Conservation were designated along the entire lower Bug and in some places along the middle Bug river (Fig. 4.15) **covering ca. 55 700 ha** (Tab. 4.15). Particularly noteworthy is the lower section of the Bug, where the river is large and is accompanied by habitats typical of a natural large river, which are becoming less frequent in Europe due to the regulation of rivers. This part of the valley would be especially affected by water deficits in case of water intake for suppling the canal. The habitat type specific for riverbanks of large natural rivers is 3270 – rivers with muddy banks with *Chenopodion rubri* p.p, and *Bidention* p.p. vegetation; and for floodplains of large natural rivers: 6440 – alluvial meadows of river valleys of the *Cnidion dubii*. A significant part (15%) of the total area of the 6440 habitat in Europe is located in Poland (Šeffer et al. 2008) where it occurs mainly in the lower Bug valley and in the middle Odra valley (Załuski 2012). A possible degradation of the 6440 habitat in the Bug valley due to the E40 IWW construction can, therefore, threaten the conservation status of this habitat in the entire Natura 2000 network in Europe.

Tab. 4.15 Special Areas of Conservation under the Habitats Directive in the Bug valley.

	Name	**Code**	**Area within the impacted catchments [ha]**	**Species associated with wetlands, conservation objectives of Natura 2000 sites**	**Water habitats, peatlands, wet/moist meadows, conservation objectives of Natura 2000 sites**	**Source**
1	Ostoja Nadbużańska	PLH 140011	46037	*Angelica palustris, Unio crassus, Lycaena dispar, Aspius aspius, Rhodeus sericeus amarus, Misgurnus fossilis, Cobitis taenia, Sabanejewia aurata, Cottus gobio, Bombina bombina, Triturus cristatus, Lutra lutra, Castor fiber*	3150, 3270, 6410, 6430, 6440, 91E0, 91F0	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/28664/Zarzadzenie_RDOS_Warszawa_Bialystok_Lublin_5_wrzesnia_2014.pdf
2	Poleska Dolina Bugu	PLH 060032	8173	*Angelica palustris, Lutra lutra, Bombina bombina, Misgurnus fossilis, Cobitis taenia, Euphydryas maturna, Phengaris teleius, Lycaena dispar, Phengaris nausithous, Eupydryas aurinia, Lycaena helle*	3150, 6410, 6430, 91E0	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/37786/Zarzadzenie_RDOS_Lublin_Poleska_Dolina_Bugu.pdf
3	Zachodniowołynska Dolina Bugu	PLH 060035	1556	*Lutra lutra, Bombina bombina, Aspius aspius, Rhodeus sericeus amarus, Misgurnus fossilis, Cobitis taenia, Ophiogomphus cecilia, Maculinea teleius, Lycaena dispar, Maculinea nausithous*	3150, 6410, 6430, 91E0	http://bip.lublin.rdos.gov.pl/files/obwieszczenia/37777/Zarzadzenie_RDOS_Lublin_Zachodniowolynska_Dolina_Bugu.pdf
	Total		**55766**			

4.4.3 Relationship between E40 IWW construction and ecological status of Bug, Tyśmienica, Bystrzyca, Wieprz and Wilga rivers

The Water Framework Directive obliges Member States to protect, enhance and restore all natural bodies of surface water with the aim of achieving good surface water status at the latest in 2015. In the River Basin Management Plans for Wisła catchment, prepared to fulfil the requirements of Water Framework Directive, all of the rivers analysed (Bug, Tyśmienica, Bystrzyca, Wieprz and Wilga) were described as uniform surface water parts with bad status (Tab. 4.16) and most of them were indicated as water parts for which it is impossible to achieve good status by 2015 (for explanations why it is impossible and could be probably achieved later – see Tab. 4.16). Firstly, we think that **possible shortages of water in the mentioned rivers occurring due to E40 IWW construction will not help to achieve good status of the rivers but rather make it more difficult to achieve this goal.**

Secondly, Water Framework Directive requires that any „new modifications to the physical characteristics of a surface water body or alterations to the level of bodies of groundwater" that may deteriorate water status meet several conditions including this one: „the beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option". We understand that: (1) creation of E40 IWW in any of its variant as an action leading to new modifications to the physical characteristics of a surface water body and alterations to the level of bodies of groundwater; (2) beneficial objective of E40 IWW creation is to enable transport of goods; (3) there are available other means of transport that are more effective, cheaper and technically more feasible, like railways. **Thus, we think that creation of E40 IWW is contrary to the objectives of Water Framework Directive.**

Tab. 4.16. Uniform Surface Water Parts (JCWP, *Jednolite Części Wód Powierzchniowych*) along Bug, Wieprz, Tyśmienica, Bystrzyca nad Wilga rivers; their present status and reasons why they are not in a good status (as they should be according to the Water Framework Directive); on the basis of the River Basin Management Plans for Wisła catchment (*Rozporządzenie Rady Ministrów z dnia 18 października 2016 r. w sprawie Planu gospodarowania wodami na obszarze dorzecza Wisły, Dz.U. poz. 1911*, accessed on: http://www.dziennikustaw.gov.pl/DU/2016/1911).

JCWP code	JCWP name	Status	Explanation of not achieving a good status of the JCWP until 2015
PLRW200021266199	Bug od granicy RP do Huczwy	bad	Lack of technical possibilities; municipal pressure.
PLRW2000212663113	Bug od Huczwy do Studzianki	bad	Lack of technical possibilities; municipal pressure.
PLRW2000212663133	Bug od Studzianki do Zołotuchy	bad	Lack of technical possibilities; municipal pressure.
PLRW2000212663159	Bug od Zołotuchy do Wełnianki	bad	Lack of technical possibilities and to high costs.
PLRW2000212663199	Bug od Wełnianki do Udalu	bad	Lack of technical possibilities and to high costs.
PLRW2000212663319	Bug od Udalu do Kanału Świerżowskiego	bad	Lack of technical possibilities; municipal pressure.

Tab. 4.16 cont.

PLRW200021266339	Bug od Kan. Świerżowskiego do Uherki	bad	Lack of technical possibilities; municipal pressure.
PLRW200021266359	Bug od Uherki do Włodawki	bad	Lack of technical possibilities; municipal and industrial pressure.
PLRW2000212663939	Bug od Włodawki do Grabara	bad	Lack of technical possibilities; municipal and industrial pressure.
PLRW2000212663999	Bug od Grabara do Krzny	bad	Lack of technical possibilities; municipal pressure.
PLRW2000212665533	Bug od Krzny do Niemirowa	bad	Lack of technical possibilities; municipal pressure.
PLRW200021266559	Bug od granicy w Niemirowie do Kamianki	bad	Lack of technical possibilities; municipal and industrial pressure.
PLRW200021266591	Bug od Kamianki do Kołodziejki	bad	Lack of technical possibilities.
PLRW200021266759	Bug od Kołodziejki do Broku	bad	Lack of technical possibilities; municipal, industrial and agricultural pressure.
PLRW200021266979	Bug od Broku do dopływu z Sitna	bad	Lack of technical possibilities; municipal and industrial pressure.
PLRW20002126699	Bug od dopływu z Sitna do ujścia	bad	Lack of technical possibilities.
PLRW20002324136	Wieprz do Jacynki	bad	Lack of technical possibilities.
PLRW2000924159	Wieprz od Jacynki do Zbiornika Nielisz	bad	Lack of technical possibilities; municipal pressure.
PLRW2000152435	Wieprz od Zbiornika Nielisz do Żółkiewki	bad	Lack of technical possibilities; hydromorphological pressure.
PLRW200019243931	Wieprz od Żółkiewki do oddzielenia się Kanału Wieprz-Krzna	bad	Lack of technical possibilities.
PLRW20001924513	Wieprz od oddzielenia się Kanału Wieprz-Krzna do dopływu spod Starościc	bad	Lack of technical possibilities.
PLRW2000192453	Wieprz od dopływu spod Starościc do Stoków	bad	Lack of technical possibilities and to high costs.
PLRW2000192459	Wieprz od Stoków do Bystrzycy	bad	Good status should achieve good ecological status in 2015.
PLRW2000192479	Wieprz od Bystrzycy do Tyśmienicy	bad	Lack of technical possibilities.
PLRW20001924999	Wieprz od Tyśmienicy do ujścia	bad	Lack of technical possibilities.
PLRW200023248129	Tyśmienica od źródeł do Brzostówki	bad	Lack of technical possibilities and to high costs.
PLRW20002424819	Tyśmienica od Brzostówki do Piwonii	bad	Lack of technical possibilities and to high costs.
PLRW20002424859	Tyśmienica od Piwonii do Bystrzycy	bad	Lack of technical possibilities and to high costs.
PLRW2000242489	Tyśmienica od Bystrzycy do ujścia	bad	Lack of technical possibilities.
PLRW200017248649	Bystrzyca do Samicy	bad	Good status should achieve good ecological status in 2015.
PLRW200024248699	Bystrzyca od Samicy do ujścia	bad	Good status should achieve good ecological status in 2015.
PLRW200017253634	Wilga od źródeł do Dopływu z Brzegów	bad	Lack of technical possibilities; municipal and industrial pressure.
PLRW200019253659	Wilga od Dopływu z Brzegów do Dopływu z Miętnego	bad	Good status should achieve good ecological status in 2015.
PLRW200019253699	Wilga od Dopływu z Miętnego do ujścia	bad	Lack of technical possibilities; municipal pressure.

Besides, considering probable alteration of the hydrological processes and river flow regimes (especially in smaller rivers analysed) one could expect that the fishery management of these water bodies can be critically endangered. However, not having detailed materials of fish species composition and mesohabitat mapping of these rivers (especially Bystrzyca, Tyśmienica, Wilga and Wieprz) makes the detailed analysis of this issue impossible. One could expect that the reduction of high flows may alter fish migration and spawning of certain fish species (such as the European pike *Esox lucius*) and increased frequency of droughts for these rivers may result in oxygen deficits and increased water temperatures in summer periods, so the whole aquatic ecosystems of these rivers can face the risk of severe damage.

Additionally, as Bug is a transboundary river and the E40 IWW is planned be a Va class waterway (compare Appendix 4), meaning that it would permit the passage of vessels of over 1 350 tonnes – the E40 IWW construction should be also environmentally assessed in accordance with the rules of the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention).

5. Conclusions

On the basis of the preliminary and general research presented in this report we attempted to answer the research questions stated in the beginning of this study:

1) What is the amount of water (expressed in m^3/s) required for the channels' function and maintenance?

According to the assumptions used in this study we calculated that the momentary water demand for channels in variants 1, 2 and 3 equals 13,69 m^3/s, 12,45 m^3/s and 10,96 m^3/s respectively. Whilst the values for variants 1 and 2 are similar to the values of water demand calculated in Feasibility Study (Maritime Institute in Gdańsk, 2015), the value of water demand for the variant 3 is higher than in Feasibility Study. Approximately 97% of water demand is related to the sluicing (lockage) purposes. The remaining 3% are the losses for evaporation and balance of the groundwater exchange. Such variation of values may lead to conclusions that limiting water demand of possible channels should be oriented at reduction of the number of sluicings (lockages). However, this would directly influence the possible navigation.

2) What are the resources of surface water in Bug, Vistula and other rivers of the area available to be used for supplying the channels in three variants?

Results presented in this report clearly show that only Vistula and Bug have water resources available for the possible use in the channel operation. Other rivers analysed do not have such a potential. However, in the case of Bug, one could expect severe flow regime changes, especially during periods of droughts. The use of water from Bug (for channels in variant 1) or from Vistula (variant 2 or 3) would require uphill pumping of large amounts of water depending on the channel variant (10,96-13,69 m^3/s). Costs of such an operation are in our opinion abnormally high and the technical feasibility of translocation of such big amounts of water in a given time is very low. The use of water from Bug to supply channel in variant 1 will cause severe changes in flood and drought balance of this river.

3) Will, and if so – how, the water resources of Bug, Vistula and other rivers analysed be shortened by the functioning of canals, according to certain assumptions used in this study?

Water resources of Wieprz, Tyśmienica, Bystrzyca and Wilga are critically endangered if one decides to use their water resources (even in a combination of multiple rivers) for any purposes related to operation of the planned channels in the whole set of variants analysed. A withdrawal of water from Bug in any of the variants of channel operation will result with average 17,5% reduction of frequency of days with overbank flow and average 172% increase in frequency of severe droughts. The latter tends to be much more critical than the former.

4) How will the channel influence groundwater of adjacent areas?

Results presented in this study revealed that the assumption made in Feasibility Study (Gdańsk Maritime Institute, 2015) about the unilateral exfiltrating role of the channels in all of the variants along their entire lengths is incorrect. It seems that the channels can lower local drainage base and cause the decline of groundwater levels in these areas. This phenomenon has not been foreseen in Feasibility Study and might be an important negative consequence of the channel design for local agriculture, households and the environment. The channels are likely to influence groundwater levels in the adjacent areas both by supplying groundwater (exfiltration from the channel) and by draining adjacent aquifers (infiltration to the channel). These processes must be therefore analysed in detail, as both directions of water exchange at the interfaces of channels and groundwater are likely to end up with increased loses from the channel or decreasing groundwater levels.

5) How the construction of the channel can influence peatlands and other wetlands as well as how can it impact protected habitats and species?

In our opinion the impact exerted on protected sites, habitats and species should be considered in a much larger area than just along the designated 10 km wide buffer strips along the channels. Hydrological alterations may impact large areas of peatlands and other wetlands in the region, including several Natura 2000 sites. In addition, despite the fact that none of the variants is run in the Bug riverbed, for all the variants one should not exclude a significant negative impact on the Bug river and its valley, resulting from the possible water deficits in the Bug and a reduction of river water flooding on its vast floodplains. Moreover, the creation of E40 IWW in any variant may lead to violation of Water Framework Directive.

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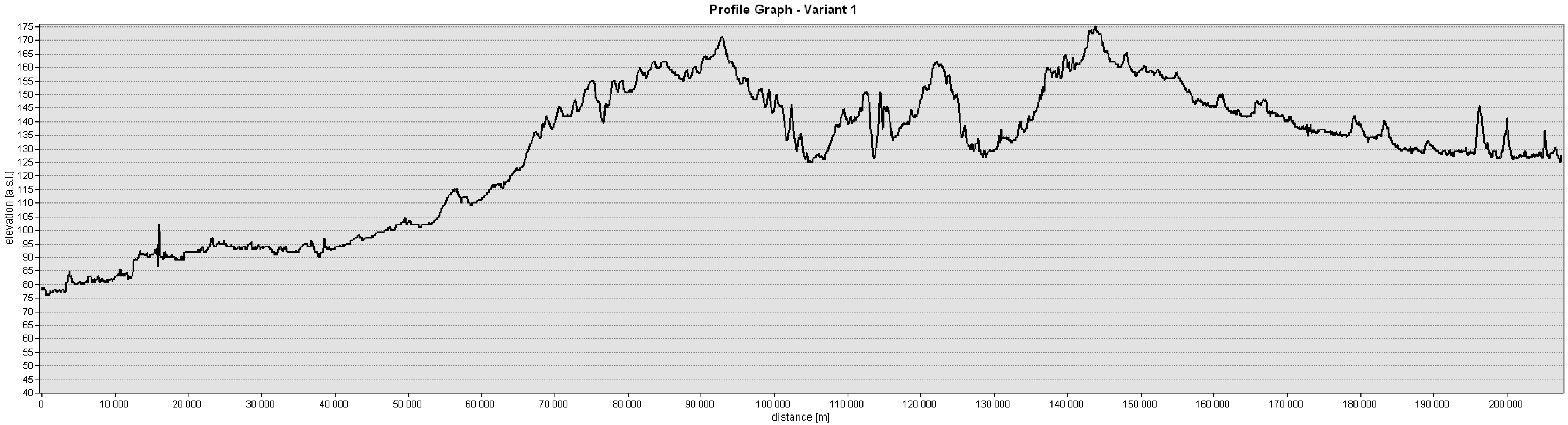
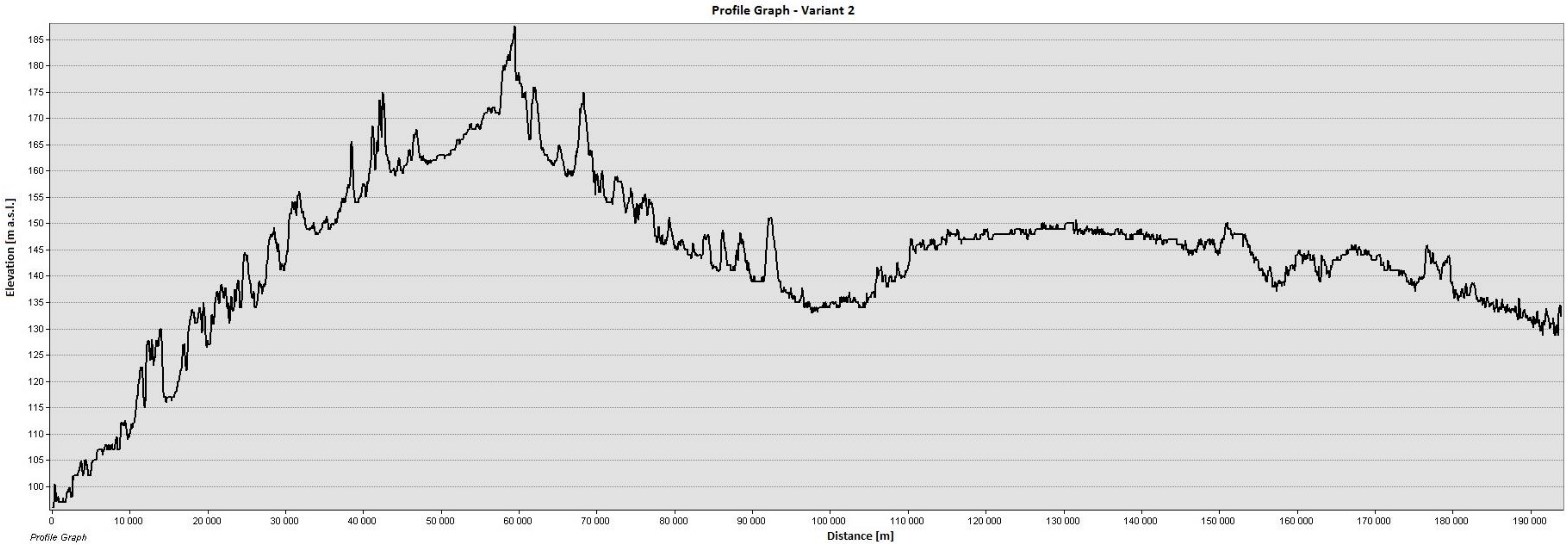
7. Appendixes

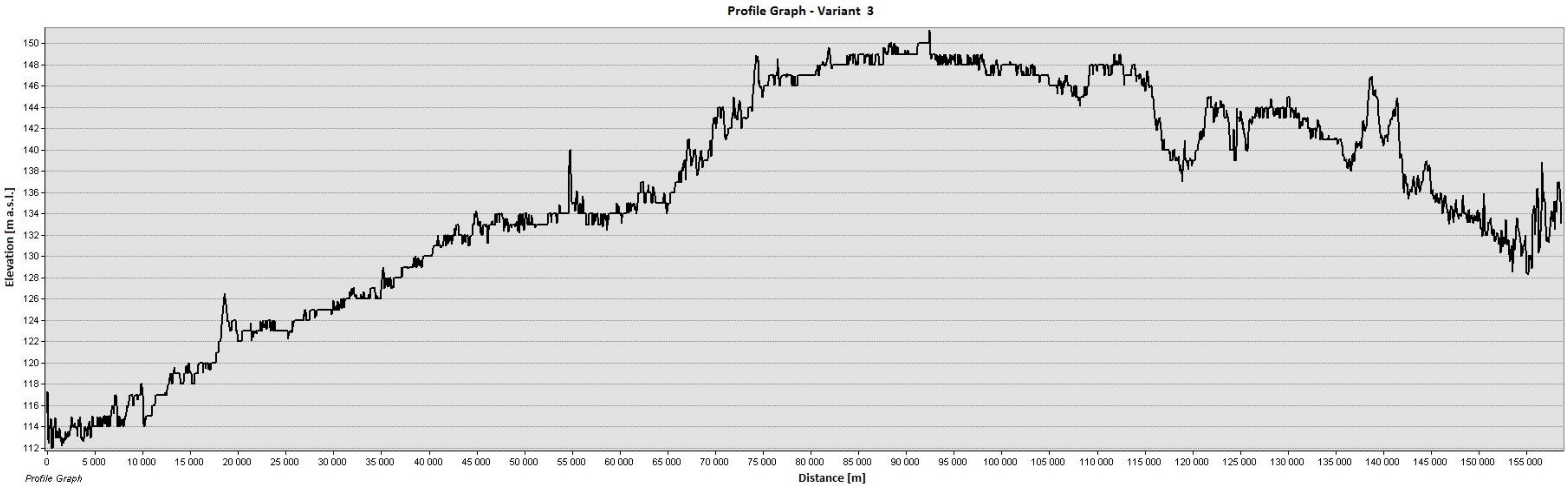
Appendix 1. Profile of the channel in Variant 1 provided on the basis of the designed DEM



Appendix 2. Profile of the channel in Variant 2 provided on the basis of the designed DEM

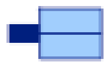
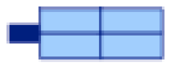
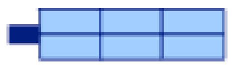
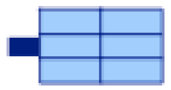
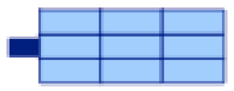


Appendix 3. Profile of the channel in Variant 3 provided on the basis of the designed DEM



Appendix 4. Classification of European Inland Waterways of international importance, according to the AGN agreement (https://www.unece.org/fileadmin/DAM/trans/doc/2014/sc3wp3/ECE-TRANS-120r3efr.pdf).

Classification of European Inland Waterways of international importance*

Type of inland waterway	Classes of navigable waterways	*Motor vessels and barges* — *Type of vessel: General characteristics* — Designation	Maximum length L (m)	Maximum beam B (m)	Draught d (m)	Tonnage T (t)	*Pushed convoys* — *Type of convoy: General characteristics*	Length L (m)	Beam B (m)	Draught[6] d (m)	Tonnage T (t)	Minimum height under bridges[2] H (m)	Graphical symbols on maps
1	2	3	4	5	6	7	8	9	10	11	12	13	14
of international importance	IV	Johann Welker	80–85	9.5	2.50	1 000–1 500		85	9.5[5]	2.50–2.80	1 250–1 450	5.25 or 7.00[4]	
	Va	Large Rhine vessels	95–110	11.4	2.50–2.80	1 500–3 000		95–110[1]	11.4	2.50–4.50	1 600–3 000	5.25 or 7.00 or 9.10[4]	
	Vb							172–185[1]	11.4	2.50–4.50	3 200–6 000		
	VIa							95–110[1]	22.8	2.50–4.50	3 200–6 000	7.00 or 9.10[4]	
	VIb	[3]	140	15.0	3.90			185–195[1]	22.8	2.50–4.50	6 400–12 000	7.00 or 9.10[4]	
	VIc							270–280[1]	22.8	2.50–4.50	9 600–18 000	9.10[4]	
								195–200[1]	33.0–34.2[1]	2.50–4.50	9 600–18 000		
	VII						 [7]	275–285	33.0–34.2[1]	2.50–4.50	14 500–27 000	9.10[4]	