4.3 Surface waters

4.3.1 Characterisation of surface water

The Danube River and the Kilia branch, where the DWNR goes, has a big depth and relatively small width of riverbed: near by Reni town the width of riverbed is 800-900 m, average depth reaches 10 m and maximal – 17-19 m, near Izmail town the width of the Kilia branch makes 500 m.

Riverbanks are very low, because of this dikes have been built practically at the whole length of the left bank of the river. By the data of the *Goswodhoz* the total length of the dikes is 212 km. Some parts of the dikes are located at the safe distance from the river, however some of them are subjected to river erosion.

The Bystre branch is branched off to the left from the Starostambylske branch 7.2 km below its beginning and flows between the Stambylsky and the Kubansky islands, flowing to the Black Sea. The total length of the Bystre branch is 9 km, the width is 100-200 m, the depth ranges from 6 to 13.1 m. Mean annual runoff of the Bystre branch is 36 km^3/year, and runoff share is 18% of the total Danube runoff.

4.3.2 Water quality of the Lower Danube

4.3.2.1 Suspended solids

Suspended solids (SS) are the key hydrologic element of the Lower Danube [19]. The first, it is due to great turbidity of the Danube water and, the second, due to high ability of SS to absorb the pollutants.

As a result of hydro-engineering construction in the Middle Danube the turbidity of water in the Danube delta gradually decreased for the last decades. For 20 years since 1959 to 1979 the decrease was from 325 to 200-205 g/m^3. Average annual turbidity for this period ranges within 93-242 g/m^3; monthly average – from 16,6 g/m^3 (XI.1969) to 801 g/m^3 (X. 1972), and daily average - from a few grams up to 2-3 kg/m^3. In 1995-1997 [37] average contents of SS was 93 g/m^3 and the range was 15 - 215 g/m^3. This affected growth of water transparency. Nevertheless in some years of floods the SS can be much higher. Thus in May of 2000 the maximal concentration of SS made 528 g/m^3.

In the delta branches in connection with decrease of the stream velocity the rate of deposition increases. At seaside in the zone of mixing river and seawaters at the saltiness range of 2 – 6 ‰ a coagulation of organic and mineral substances on the SS occurs. It facilitates further sedimentation of suspended matter in a so-called *avalanche sedimentation zone* spreading for a few kilometers from the Delta margin. In this zone up to 90% of suspended solids sediment. [38].

Suspended solids have a key role in ecology of the river and the coastal waters because SS restrict development of phyto- and bacteria plankton, on the other hand, they facilitate absorption of up to 80-90% of total pollutants (trace metals, oil products, surfactants and other) [39]. Suspended solids play role as a factor of concentration of toxic substances.

4.3.2.2 Sum of ions

One of the most important characteristics of fresh waters quality is their total mineralisation, which increased by 1.5 times for the last 50 years [40] (Table 4.3.1).

Such increase can have only anthropogenic nature: effluents from industrial enterprises, fields, collecting systems of towns.

By records of the DHMO the average mineralisation of the Danube water at the Reni – Vilkove site decreased from 403 to 362 mg/l for the period of 1995-2000. By ionic composition the water refers to a hydrocarbonate class of calcium group.

Table 4.3.1 –Total mineralisation of water on Ukrainian part of the Lower Danube

Years	Sum of ions, mg/l	
	Range	Mean
1948-1950	226-397	287
1958-1959	253-344	289
1963-1965	235-334	296
1976-1978	275-475	374
1985-1989	295-506	372
1990-1994	297-521	409

4.3.2.3 Nutrients and dissolved oxygen

The most important ecological factor for north-west part of the Black Sea, is nutrients load mainly from the Danube. Table 4.3.2 shows that in 70 – 80th of XX century the concentration of substances containing nitrogen and phosphorus sharply increased by a few times, and in 90th came back to the values of 50 – 60th. Starting from 90th, a noticeable decrease of concentration of mineral and increase of concentration of organic forms of nitrogen and phosphorus in the Danube water are observed as well as alteration of ratio between them, which existed prior to the beginning of anthropogenic eutrophication [41, 42, 43].

Table 4.3.2 – Changes of concentrations of nutrients in water of the Kilia delta

Years	Runoff, km³/year	NH_4	NO_2	NO_3	N inorg	N org.	N total.	PO_4	$P_{organ.}$	P total
		mg/l								
1958-1960	179.4	0.25	0.012	0.53	0.79	0.63	1.42	0.071	0.031	0.102
1977-1985	227.7	0.62	0.044	1.00	1.66	0.90	2.56	0.165	0.071	0.238
1986-1988	204.7	0.57	0.160	1.26	1.86	3.07	4.93	0.281	0.100	0.380
1989-1992	169.7	0.44	0.118	1.63	2.19	5.07	7.25	0.233	0.113	0.336
1993-1996	195.1	0.13	0.074	1.18	1.38	3.74	5.12	0.091	0.096	0.187
1997-1998	222.8	0.05	0.016	0.56	0.63	6.97	7.60	0.078	0.048	0.126

Change in ecological situation in the Danube delta is evidenced as well by retrospective analysis of dissolved oxygen. In middle of XX century its contents varied from 8 to 12 mg/l, a saturation was from 80 to 95%. In 90th a variability range sufficiently expanded, making 5.8 -12.8 mg/l and 60-120% of saturation, accordingly. Over-saturation was caused by a sharp (by 2-5 times) increase of plankton biomass due to decrease in the sediment run-off and increase in water transparency. Low levels of dissolved oxygen are connected with its consumption for oxidising of organic substances, being generated mainly when phytoplankton is dying off. Seasonal dynamics of the quality index of water connected with activity of biota are presented in graphs (fig. 4.14).

Water quality monitoring of the coastal zone, opened in 1977, and comparison with the literature data [42, 43] show that anthropogenic eutrophication of the Danube waters redounded also upon increase of contents of nutrients in a zone of influence of the Danube waters. At the seaside of the Danube in 90th it was marked a sharp increase of organic nitrogen against a background of a slight increase in concentrations of its mineral forms. Contents of mineral and organic forms of phosphorus - changed slightly since 80th.

It was established that a maximal transition of substances from water into bottom depositions occurs in a zone of avalanche sedimentation (saltiness 2-6‰) as a result of physical-chemical processes on adjusted coastal zone. Biological processes (vital activity of phitoplankton and zooplankton) at seaside also influences dynamics of nutrients. Mineral and organic compounds of nitrogen and phosphorus together with the suspended substance are accumulated in the bottom sediments of coastal zone.

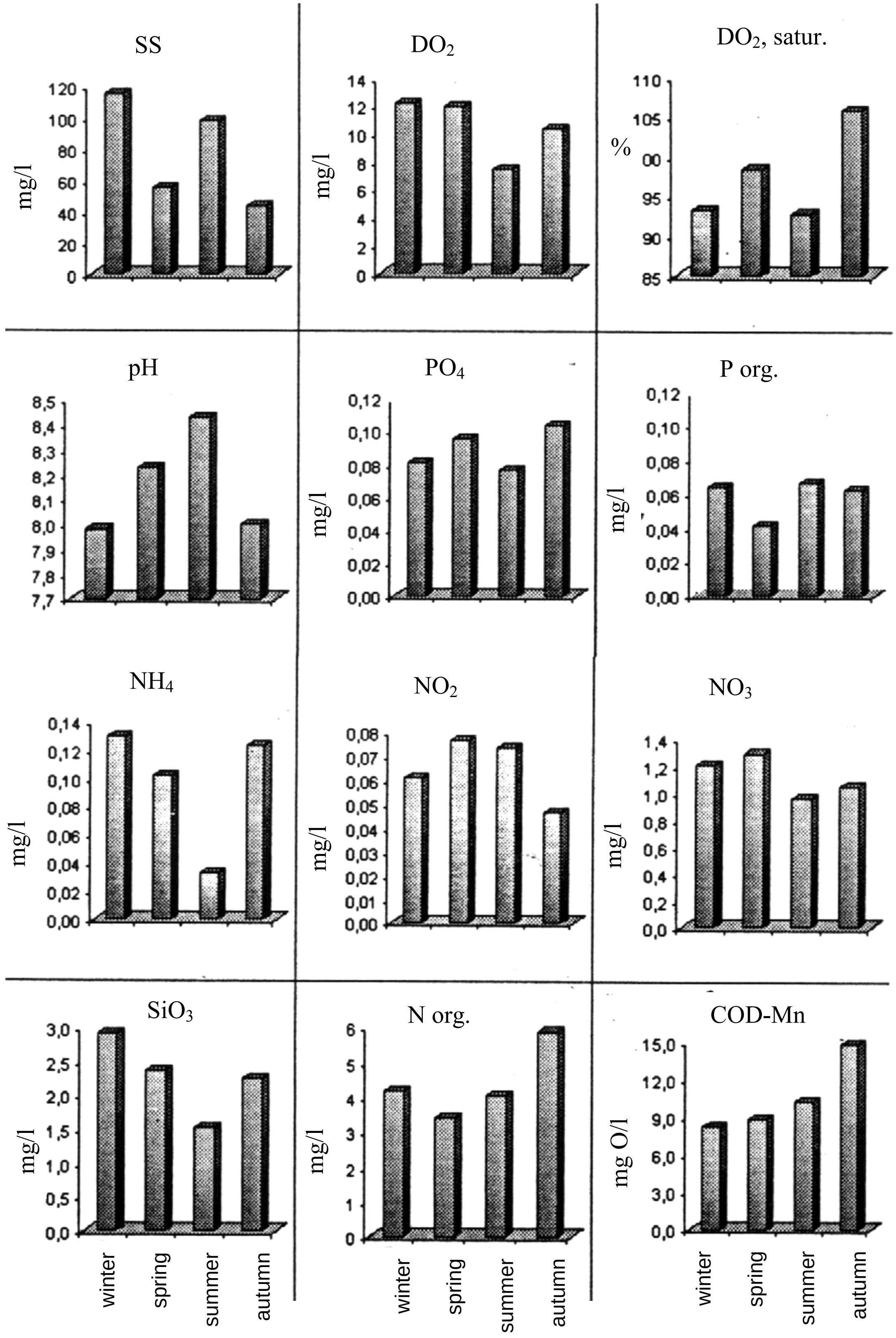

Fig. 4.14 – Seasonal dynamics of chemical indices in the Kilia delta during the period of 1993-1997

The bottom sediments of coastal zone at present in itself is a “depot” of nutrients. A specific character of hydrology on the coastal zone is such that in summer season the near-bottom stratum is isolated from the overlying strata of the sea by abrupt thermo-halocline. On absence of inflow of oxygen and destruction of organic substance the hypoxia and anoxia becomes usual phenomena on the coastal zone resulting in a rise of restoring conditions. The nutrients come to the near-bottom stratum of the sea from the bottom sediments, which is a secondary source of eutrophication in this case.

4.3.2.4 Toxic chemicals

Water of the Danube in Ukrainian sector is persistently polluted with heavy metals (HM), oil products (OP), phenol and other toxic chemicals (TC) due to industrial, communal and agricultural effluents [44]. Average contents of HM and OP by materials of *the Blue the Danube Second International Expedition* is presented in Table 4.3.3.

Table 4.3.3 – Average contents of OP and HM in water of Ukrainian part of the Danube (September-October 1990)

Forms	OP	Fe	Mn	Zn	Cu	Pb	Ni	Co	Cd
	μg/l	μg/l							
dissolved	75	76.0	8.0	55.0	15.0	4.1	5.2	1.5	1.0
suspended	-	394.0	25.4	20.8	2.9	100	10.6	3.1	

Nature of distribution of TC in the delta is connected with the particulars of hydrology regime and anthropogenic impact on the ecological system (economic activity, navigation, functioning of ports, etc.). The Danube delta can be attributed to the regions permanently contaminated with Cu, Zn and Cd (Table 4.3.4). Concentration of these metals in lower and middle current of the river is much lower than in the delta. This is connected with active application of plants protection means containing these metals in watershed area of the delta (in viticulture and horticulture) [45].

Table 4.3.4 –Pollutants in the Kilia delta water in 1993-1997

	OP	Cu	Zn	Ni	Cd	Cu	Zn	Ni	Cd
	mg/l	Dissolved forms(mg/l)				Suspended forms (mg/l)			
Surface stratum									
Min	0.01	0	0	0	0	0	0.004	0	0
Max	0.48	0.005	0.067	0.003	0.001	0.016	0.060	0.013	0.002
Average	0.09	0.003	0.011	0.001	0	0.005	0.021	0.004	0.001
Bottom stratum									
Min	0.01	0	0	0.001	0	0.001	0.008	0.001	0
Max	0.25	0.007	0.058	0.014	0.001	0.026	0.070	0.016	0.002
Average	0.07	0.003	0.014	0.003	0.001	0.008	0.027	0.005	0.001
MAC, mg/l	0.05	0.001	0.010	0.010	0.010	-	-	-	-

HM contents in water of the Delta, shown in Table 4.3.5.

For Kilia part of the Danube delta the high concentrations of phenol are specific: 0.013 – 0.120 mg/l (MAC = 0.001mg/l). Such concentrations are conditioned by incoming of products of natural destruction of air-water vegetation (reed, reed mace, etc.) into water.

Distribution of pollutants over the coastal zone of the Danube (Table 4.3.6) is defined by peculiarities of its hydrology. On the coastal zone there is enrichment of near-bottom stratum with HM and OP due to the active absorption processes on the suspended solids and sedimentation in a zone of interfusing of sea and fresh waters.

Table 4.3.5 – Contents of some trace metals (suspended and dissolved forms) in waters of the Kilia delta of the Danube [9]

Metal	MAC.fish, µg/l	Index	Total	Suspended forms µg/l	Suspended forms % of total	Dissolved forms µg/l	Dissolved forms % of total
Kilia delta of the Danube							
Mn	10	Min. Max. Average	32.8 720.0 117.3	13.4 660.0 92.0	40.7 99.2 76.4	4.5 168.0 25.3	0.8 59.3 23.6
Cu	1.0 (5.0)	Min. Max. Average	4.0 190.0 47.9	1.2 80.0 17.2	2.2 66.3 33.7	2.0 187.5 30.7	33.7 97.8 66.3
Zn	10.0	Min. Max. Average	10.2 173.0 59.8	3.9 100.7 29.5	6.0 88.7 46.9	3.5 160.0 30.3	11.3 94.0 53.1
Pb	100.0	Min. Max. Average	6.0 57.0 30.8	0.9 46.0 23.8	19.3 100 79.0	0.8 29.7 7.0	0.0 80.7 21.0
Cr	-	Min. Max. Average	14.0 168.0 86.0	2.4 137.0 52.0	5.7 87.7 56.2	8.0 81.5 34.0	12.3 94.3 43.8
Bystre branch							
Mn	10.0	Min. Max. Average	21.6 218.0 76.5	12.8 190.0 50.7	32.6 81.5 65.8	6.8 75.0 25.8	18.5 67.4 34.2
Cu	1.0 (5.0)	Min. Max. Average	4.5 86.5 37.6	2.7 58.7 14.3	7.5 79.2 37.6	2.3 80.0 23.3	20.8 92.5 62.4
Zn	10.0	Min. Max. Average	18.3 92.5 50.8	5.5 47.8 22.0	16.7 83.6 42.8	3.0 50.0 28.8	16.4 85.0 57.2
Pb	100.0	Min. Max. Average	10.3 130.0 35.8	7.5 80.0 22.3	48.5 100.0 72.0	0.0 50.0 13.5	0.0 65.6 28.0
Cr	-	Min. Max. Average	23.6 135.7 80.9	9.6 83.2 37.9	40.7 61.3 46.9	14.0 64.0 43.0	38.7 59.3 53.1

Table 4.3.6 –Pollutants in the water of the coastal zone of the Danube in 1993-1997

	OP	Cu	Zn	Ni	Cd	Cu	Zn	Ni	Cd
	mg/ l	Dissolved form (mg/l)				Suspended form (mg/l)			
Surface stratum									
Min	0.04	0.068	0	0.56	0	0	1.88	0	0
Max	0.34	3.62	50.13	2.65	1.22	4.45	63.37	3.08	0.93
Average	0.10	2.28	11.34	1.39	0.31	1.37	13.09	1.06	0.29
Near-bottom stratum									
Min	0.03	0.35	0	0.61	0	0	0.13	0	0
Max	0.39	6.12	65.12	11.44	12.37	12.83	40.67	10.44	0.91
Average	0.10	2.51	12.70	2.62	0.57	2.12	9.37	1.52	0.25
MAC, mg/l	0.05	0.005	0.050	0.010	0.005	-	-	-	-

Water of coastal zone of the Danube is characterized with increased contents of phenol: in surface stratum (0.012 - 0.018 mg/l) for the whole period of observations in 1994-1999 (MAC = 0.001 mg/l).

According to the approved procedures of ecological assessment of surface waters quality by corresponding categories the waters of Ukrainian sector of the Danube in the middle of XX century were referred to Class II and only in the worst cases to Class III. By the end of the century the usual condition of the water quality was Class III and the worst one was the Class IV. According to the verbal description Class II means good, quite clean, middle level eutrophic waters; III class means - at the best case - satisfactory, weakly polluted waters, and - at the worst case - mediocre, moderately polluted, eu-polytrophic waters; IV class means bad, polluted, polytrophic waters [40].

4.3.3 Bottom sediments

Bottom sediment is active component of the ecological system. This is because the hard core of pollutants are adsorbed by medium-sized silt particles (0,015-0,05 mm), as they have absorption capacity more than coarse ones and their share in SS predominates at all seasons of the year. On the other hand it is known that the particles of such size and less do not settle on a bottom at the flow velocity over 0,6 m/s. Formed during low-water temporary silt sediment are carried away during the floods. According to some data over 80% of bottoms of Ukrainian delta branches are covered with sand, which migrates and are of little use for the development of bottom organisms [39].

During construction of the DWNR the various kinds of bottoms polluted with heavy metals, oil products, phenols and other pollutants will be dredged.

HM contents in the bottom sediments of the Kilia-Reni section according to data of the Second International Expedition ‘Blue Danube’ [44] are shown in Table 4.3.7. A range concentration in bottom sediments of the Kilia delta and the coastal zone of the Danube [45] is presented in Table 4.3.8.

Bottom sediments of the bar section of the DWNR are saturated with mineral and organic compounds of nitrogen, phosphorus, silicon. Concentration of these compounds in the sediments and interstitial waters exceeds by two orders the concentration in the near-bottom stratum.

Table 4.3.7 – Contents of TM in bottom sediments of the Danube in the section of Kilia-Rein (September-October 1990)

Site	pH	Mn	Zn	Cu	Pb	Ni	Co	Cd
	mg/g of dry weight							
Kilia, 32 km	33.20	0.92	0.188	0.110	0.066	0.062	0.022	0.002
Down Izmail, 90 km	50.03	1.20	0.120	0.034	0.050	0.088	0.026	0.002
Above Izmail, 103 km	25.00	0.80	0.160	0.028	0.034	0.046	0.016	0.001
Down Reni 182 km	7.6	0.44	0.060	0.018	0.012	0.042	0.022	0.001

Table 4.3.8 – Level of pollution in bottom sediments of the delta and the coastal zone of the Danube (1993-1997)

	OP mg/g of dry weight	Cu	Zn	Ni	Cd
		mg/g of dry weight			
Delta					
Min	0.1	2.0	25.2	23.0	0
Max	4.5	102.8	242.8	396.0	13.2
Average	0.9	46.2	129.6	62.8	6.6
Coastal zone					
Min	0.1	0	50.8	20.2	0
Max	5.2	201.6	516.2	144.4	17.0
Average	1.8	48.9	138.5	50.8	6.2

According to the results of microbiological research of bottom sediments in the branches of the Kilia delta (the Starostambulske, the Vostochne, the Bystre, the Prorva) and the coastal zone, which included qualitative and quantitative characteristics of saprophytic bacteria and quantitative characteristics of faecal coliforms (FC) [1], the highest index of saprophytic bacteria in bottom sediments was registered in the delta branches. At all stations there is evident tendency of increasing in the number of benthos bacteria from springtime to a summer-autumn period. In summer-autumn period the number both saprophytic bacteria and FC in bottom sediments in the seaside area was 1.5-2 times lower than in the delta branches. Spring period is exclusion when saprophytic bacteria in the branches bottom sediments were 2,7 times less than at the coastal zone. On average, the quantitative characteristics of benthos bacteria changed insignificantly on seasons, however, the changes in the number of benthos bacteria can be very big.

4.3.4 Analyses of the DWNR impact on surface waters

Factors of impact of construction and operation of the DWNR on the water are enumerated in section 3.4. This subsection discusses the processes caused by these factors and the possible consequences on distinct sections of the delta.

Reni – Vilkove Section

In this section where navigation is carried out during long time, the main factor of impact on the water ecological system is dredging, which periodically is made here. The main process of the impact of dredging is an increase of water turbidity, inflow of nutrients and toxic pollutants from bottom sediments in dissolved form and absorbed on the silt particles. Secondary pollution of this kind takes place regularly in the Danube delta in natural conditions at the periods of increased discharges going with increased content of suspended and drawn sediments.

Deterioration of water quality of a number of evaluative and normative indexes as a result of dredging, worsen of oxygen conditions and intensification of eutrophication processes only partially are synchronously connected with operation of dredging equipment. Deterioration of water quality is also conditioned by pollutants load from temporary coastal dumping grounds (mainly under heavy atmospheric precipitation) and direct destruction of benthos organisms in the areas of bottom dredging, that results in slowing down the processes of self-cleaning for a long period. More long impact is made by changes in morphometry and orthography of bottom surface, qualitative and grading structure of bottom, which, in turn, brings the change in hydrodynamic and lithodynamic conditions. All the described processes lead to the change of water life biotope, their partial destruction, worsen of fish reproduction conditions.

Comparison of the bottom areas under dredging in the section of Reni - Vilkove (**3,257 km^2**) and total area of the riverbed in this section (about **80 km^2**) shows that at the period of construction there will be totally about 4% of bottom biocenosis damaged and this cannot exert significant influence on the water ecology of this section. Hence, main impact on the water quality at the construction period will render the pollutants load from bottom sediments subject to a loss of ground during dredging, which according to the active norms make 2–5% of the ground extracted, depending on the type of a hydraulic dredge (Table 4.3.9.). Comparison of volumes of soil losses at that section of the DWNR during the whole period of construction and the value of annual load of suspended sediments along the Kilia branch shows that the man-made increase of the annual runoff of sediments can make about 1.5% and will not influence the hydrophysical conditions of the delta since it will be within the limits of inter-annual fluctuations of this factor.

The largest part in water quality deterioration from the soil losses is played by fine fractions, which make about 5% of bottom sediments on the average. They are the very factions that absorb maximal quantity of pollutants and form a stable suspension, spreading on considerable distances with the water current.

Table 4.3.9 – Predictable volumes of soil losses at dredging works

Sections	Construction		Cleaning during operation	
	Total losses, 10^3 m³	Losses of fine fractions, 10^3 m³	Total losses, 10^3 m³/year	Losses of fine fractions, 10^3 m³/year
Reni -Vilkove	139.35	6.97	16.0	0.8
Vilkove – the sea	29.80	1.49	7.5	0.38
Sand-bar	149.94	7.50	17.5	0.88

Possibility of chronic physical-chemical impact on water ecological system of the delta as a whole can be estimated by comparing predictable total mass of incoming pollutants per year of construction with yearly river loads and determining of mean annual value of increase in concentration of pollutants as it was done in a report of Institute of Hydrobiology of the NASU [9].

Not less important is to estimate maximal predictable contribution of pollutants at the section of executing dredging at the period of the hydraulic dredges work.

Such calculation was done for the work at one section of two dredges with capacity 1000 m³ of soil per hour. The volume of simultaneously extracted soil (**w**) was accepted 1200 m³/hour subject to their non-synchronous operation and wear-out. The density of preliminary loosened soil ρ assumed to be 1,6 g/cm³. Water discharge was assumed to be equal to: (1) 1350 m³/s - the minimal yearly discharge at the level of 95% provision in cross section of Kilia town, and (2) 850 m³/s - minimal discharge observed at this section of the branch. The content of calculated substances in extractive ground was accepted in accordance with the data of Institute of Hydrobiology [9]. The most pessimistic assumption is that all polluting and nutrients, which were in the mass of soil lost during loading, remain in the water column. The calculation of the SS increase in the water assumed that the silt fraction, that form a stable not sedimenting suspension, makes 5% of the soil loss mass.

Hourly average increment of SS concentration (**ΔC_{ave}**) in the water flow passed through the section line of the Kilia Branch, where the dredging are performed, was determined as a ratio of the mass of the stable suspension (**ΔM**), entering into the water during 1 hour work performance, to the hour discharge of the river water **Q**:

$$\Delta C_{ave} = \Delta M/Q,$$

$$\Delta M = w \cdot \rho \cdot 2\% \cdot 5\%;$$

For conditions of the minimal annual outflow 95 % provision in the section below Kilia town (1350 m^3/sec or 4860000 m^3/h)

$\Delta C_{ave} = 1200 \cdot 1.6 \cdot 0.02 \cdot 0.05/4860000 = 3{,}95 \cdot 10^{-7}$ t/m^3 = 0,395 mg/l.

At the minimal discharge of 800 m^3/s ΔC_{ave} will make 0,68 mg/l.

At that the requirements of the SPiN 4630-88 are fulfilled according to which at the points of community water consumption and background SS content up to 30 mg/l the increase of SS concentration should not exceed 0,75 mg/l. The standard established for fish-farm basins of the 1st category is not adhered to, demanding the SS concentration shall not increase more than by 0,25 mg/l.

Results of performed calculations of hourly average growth in concentration of chemical pollutants in the water of the branch are given in Tables 4.3.10–4.3.12

Regarding nutrients, the greatest relative growth in hours of intensive dredging works can be reached for total phosphorus (by 16,2% at discharge = 1350 m³/s). For time periods corresponding to the cycles of biological productive processes (24 hours and more), an average increase of phosphorus concentration in water is predicted a one order lower and cannot substantially influence the level of trophicity of the below sections of the delta. Increase in concentration of total nitrogen in water will make slightly over 0,1% and can’t influence the processes of eutrophication.

Table 4.3.10 – The influence of the channel dredging on nutrients content in the water of the Kilia delta

	Parameters	Units	NH_4	NO_2	NO_3	$N_{min.}$	$N_{org.}$	N_{total}	PO_4	$P_{org.}$	P_{total}
Back-ground	The average concentration during 1993-1996 [1]	mg/l	0.13	0.074	1.18	1.38	3.74	5.12	0.091	0.096	0.187
	during 1997-1998 [1]	mg/l	0.05	0.016	0.56	0.63	6.97	**7.6**	0.078	0.048	**0.126**
	The average concentration in the bottom sediment [1]	mg/g						1.2			2.6
	MAC.fish	mg/l	0.5	0.08	40				3.5		
Calculated	The entry to the water during the dredging	g/s						12.7			27.7
	The concentration increment in the water column due to the dredging										
	at discharge of 850 m^3/s	µg/l						15			32.5
	at discharge of 1350 $m^{3/}s$	µg/l						9.6			20.4
	at discharge of 1350 m^3/s	%						0.12			16.2

Table 4.3.11 – The influence of the channel dredging on the metal content in the water of the Kilia delta

	Parameters	Units	Fe	Mn	Zn	Cu	Pb	Ni	Co	Cd	Cr
Background	The average concentration during 09-10.1990 year dissolved *	µg/l	76.0	8.0	55.0	15.0	4.1	5.2	1.5	1.0	
	suspended*	µg/l	394.0	25.4	20.8	2.9	100	10.6	3.1	1.0	
	total	µg/l	470.0	33.4	75.8	17.9	104.1	15.8	4.6	**2.0**	
	The average concentration [9] dissolved	µg/l		25.3	30.3	30.7	7.0				34.0
	suspended	µg/l		92.0	29.5	17.2	23.8				52.0
	total	µg/l		**117.3**	**59.8**	**47.9**	**30.8**				**86.0**
	The average concentration in the bottom sediment [1]	µg/g		1770	225	128	108			3.3	176
	MAC.fish	µg/l		10	10	1	100	10	10	10	1.0
Calculated	The entry to the water during dredging	g/s		18.3	2.4	1.4	1.2			0.032	1.9
	The concentration increment in the water column due to the excavation										
	at discharge = 850 m^3/s	µg/l		21.7	27.4	1.6	1.38			0.04	2.2
	at discharge =1350 $m^{3/}s$	µg/l		13.5	17.1	1.0	0.84			0.02	1.4
	at discharge =1350 m^3/s	%		11.5	2.9	2.1	2.7			1.0	1.6

Notes: * under the materials of the Second International Expedition «Blue Danube».

Table 4.3.12 – The influence of the channel dredging on the organic matters content in the water of Kilia delta

		Units	Oil products	BOD_5	COD-Cr	C org.	Surfactants	DDT	Hexachloro-cyclohexane
Background	Kilia delta								
	The average concentration, 1988 [46]	µg/l	10						0.183
	The average concentration, March 1988 [47]	µg/l						**0.051**	**0.170**
	The average concentration, September 1990 [48]	µg/l						0.505	0.0075
	The average concentration, autumn 1989	µg/l					**0.37**		
	The average concentration, September-October1990*	µg/l	75						
	The average concentration, 1993-1997 [45]	µg/l	**80**						
	Bazarchyk backwater, 13-14.08.02 [9]	mg/l		10.0	20				
	Vilkovo (after Bazarchyk backwater),	mg/l							
	13-14.08.02 [9]	mg/l		**10.0**	40.0				
	Bystre branch, source, 13-14.08.02 [9]	mg/l		10.0	**20.0**				
	Bystre branch, mouth, 13-14.08.02 [9]	mg/l		10.0	40.0				
	The average concentration in the bottom sediment [1]	mg/g	0.92			23.9	$1\cdot10^{-3}$	$3.2\cdot10^{-5}$	$1.0\cdot10^{-5}$
	MAC.fish	mg/l	0.05	3-6			absence	absence	absence
Calculated	The entry to the water during the dredging	g/s	9.6			255	$1.08\cdot10^{-2}$	$3.42\cdot10^{-4}$	$1.08\cdot10^{-4}$
	The concentration increment in the water column due to the excavation								
	at discharge = 850 m^3/s	mg/l	0.0114	0.900**	1.8***	0.300			
		µg/l					$1.27\cdot10^{-2}$	$4.02\cdot10^{-4}$	$1.26\cdot10^{-4}$
	at discharge =1350 $m^{3/}s$	mg/l	0.0072	0.567**	1.134***	0.189			
		µg/l					$0.80\cdot10^{-2}$	$2.52\cdot10^{-4}$	$1.14\cdot10^{-4}$
	at discharge =1350 m^3/s	%	9	5.7	5.7		2.2	0.5	0.07

Notes. * Under the materials of the Second International Expedition «Blue Danube»

** Accounting of the ratio of $BOD_5 : C_{org} = 3$

*** Accounting of the ratio of COD: $C_{org} = 6$

Total content of organic substances during performing the dredging (by indexes of BOD_5 and COD-Cr) can increase for a short time by 5–6%, concentration of oil products - by 9%. The greatest growth among heavy metals predicted for manganese is up to 11.5%. Increases in concentration of other metals and toxic organic pollutants will not exceed 2.5%.

Therefore, the increase of the polluting concentration in water at the construction period can only result in short-time and local impacts on the water quality, not changing on the whole the existing sanitary-toxicological situation in the Kilia delta.

Incoming of pollutants into water will also take place during storing soil to channel dumping. Soil dumping by discrete portions to the dump “60.5 km” will result in pollution of water during the period of dumping in the form of secondary turbidity spots with the total volume of suspended substances of 21,200 m^3 [74].

During filling of the dammed anabranch at 36-37 km water coming to the river will already be clarified.

With the aim of decreasing water pollution, only natural clean, conditionally clean, and moderately polluted soils will be stored in underwater dumps.

The choice of the place for underwater dumps was carried out taking into account economic expediency, safety for navigation and minimal impact of the stored soil on water quality and on water bio-resources. The chosen areas are characterised by soils close by pollution degree to the dredged ones, by relative poor bottom and water biocenoses. Underwater dumps are located in the zone of a relatively weak dynamic impact of benthonic layers of the brunch current, that contributes to localisation of the dumps’ impact on the water environment, to quick stabilisation of the soil dumped and to prevention of its repeated roiling.

Besides direct load of pollutants from bottom sediments due to the losses during hydraulic dredges operations and during storing to underwater dumps, dredging is connected with the process of pollution of river waters by drainage waters and runoff from the coastal dumps. The most significant contribution to the man-caused pollution of the river water is expected with intense storms. According to the calculations, 10 mm atmospheric precipitation during an hour on the whole territory of dumps with 100% of filling the total runoff from this territory will not exceed 1 m^3/s, and a total transport of pollutants with this drainage water will be sufficiently less than at direct losses of the extracted soil.

To achieve a high degree of clarification of the discharged water, it is provided to divide the territory of each dumping grounds into sections with filling them in turn. The filling is supposed to be carried out together with forming of drain sump and providing the necessary path length of the pulp clarification by creating cross dikes.

So the impacts that occur during dredging are controllable and may be restricted to the acceptable level subject to proper organisation of the works and control of the water quality.

First of all it refers to determining of the conditions of the works performed, choice of the storage places and measures to avoid pollution of river waters with discharged waters from dumping grounds. In the project the termination of the works is provided during fish spawning and raying of young fish for one month. The restrictions can also be brought in on dredging at extremely low flow rate waters and on the basis of the water quality monitoring results.

In the areas of carrying out dredging, of dumping soil to channel dumps and in check cross-sections, control of water quality is provided for the following parameters: suspended solids, dissolved oxygen, sum of ions, pH, N-NH_4, NO_2, NO_3, P-PO_4, oil products, heavy metals. Regular monitoring of biomass and of biodiversity of bacterioplankton and bacteriobenthos, phytoplankton, zooplankton, and macrozoobenthos.

The mentioned restrictions on carrying out works and directions on monitoring refer both to the dredging during the period of construction and at to operational dredging, smaller

volumes of which as compared to the construction period enable to reduce the intensity of sediment extraction in conformity with ecological requirements.

<u>**Vilkove – Sea section**</u>

Impact of works performed

Riverbed deepening work in this section will be carried out in the Starostambulske branch and in the beginning of the Bystre branch. Suspended substances arisen from the performance of these works will be transported to the Bystre branch only partially. The volume of dredging works in the Bystre branch itself is insignificant (75,968 m^3) and concentrated mostly between 4-5 and 6-7 kilometres.

Besides dredging works, the working draft for the DWNR full development at this section provides for protection of dangerously erosive section of the bank and construction of a turning dam of 390 m long.

The impact of the bank stabilization upon the ecosystem of the Bystre branch lies in appearance solid substrates in the channel with benthos biocenoses not inherent for the branch under natural conditions. But together with bottom areas, damaged while carrying out dredging, these sections 500,700 m^2 in space make up about 3% of the section's total bottom area and in view of such proportion to the undamaged bottom sections cannot become the reason of a general reconstruction of bottom biocenoses of the Bystre branch.

A protection of this section from negative impacts of construction works is especially important, since downstream from the works site both the banks of the Bystre branch and the left bank of the Starostambulske branch are separated from the DBR hard core by narrow strips of anthropogenic landscapes zone. Performance of dredging operations with the '*Prorvin*' dredger provided for reducing of noise impact and emissions from the working mechanisms. The '*Prorvin*' dredger is a self-driven dredge hopper enabling to exclude intermediate soil reloading between the operations of its excavation and dumping.

Strict observation of all ecological restrictions provided for carrying out such works on the upstream sections is compulsory for this area. The additional restriction like the one on the carrying out the works in the section of a sand-bar is a suspension of the work during the birds nesting.

Impact of works performed upstream

Dredging performed in the Kilia branch in the Reni–Vikove section can have negative influence on the quality of water in the Bystre and other branches of the Kilia delta. For assessment of this impact calculations were made for incoming pollutants at dredging from the Kilia branch into the Ochakivske and the Bystre branches, because of these branches provide flooding of wetlands on the most part of the reserved area of the DBR. At that the existing distribution of the river flow by the branches (Table 4.3.13) were taken into account and the distribution of the suspension along the width of the river-bed, depending on the distance between the cross-section of the engineering of the rift and the check section line (CSL), on the hydraulic parameters of the flow and the location of the dredger with respect to the banks.

Table.4.3.13 – Minimal annual discharges of the branches at 95% provision

Branches	Share of flow, %	Discharge, m^3/s
Kilia (near Kilia town)	100	1350.0
Solomoniv	50.9	687.2
Ochakivske	27.4	369.9
Bystre	33.2	448.2
Babina	16.9	228.2

The calculating was being performed in four variants, corresponding to the sediment excavation in the section line of each of four rifts of the Kilia branch, which are the nearest rifts to the territory of the reserve (Table 4.3.14). The place of sediment excavation for every rift were taken maximally approximated to the left bank of the Kilia branch (in accordance with the working project), since at such disposition of dredger, the Ochakivske and the Bystre branches will receive the maximal quantity of technogenic suspended solids.

Check cross-section lines (CSL), in which the SS distribution was calculated, were selected in the Kilia branch over the beginning of the Ochakivske branch (CSL 1) and the the Starostambulske branch over the head of the Bystre branch (CSL 2) (Fig. 4.15).

Table 4.3.14 – Location of calculated sections and dredgers

Name of the section	Distance from the mouth of the Bystre branch, km	Discharges, m^3/s	Distance of the dredger from the left bank, m
Rift, variant 1	20.5	1350	230
Rift, variant 2	24	662.8	50
Rift, variant 3	32	1121.8	200
Rift, variant 4	36	1121.8	250
CSL #1	17.1	1350	–
CSL #2	10.3	980.1	–

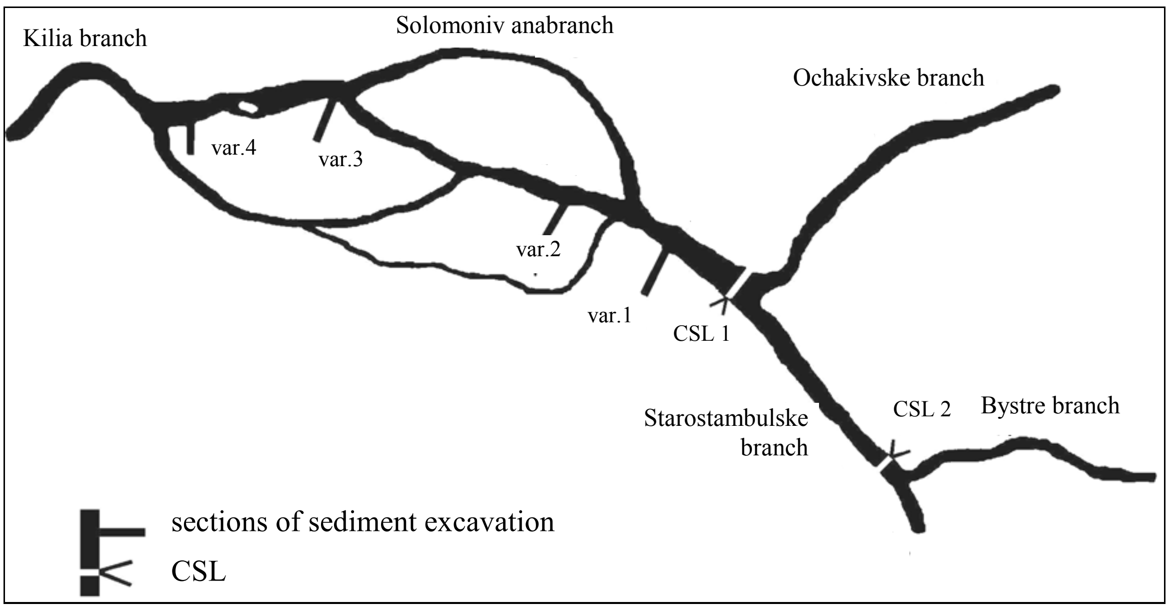

Fig. 4.15 – Scheme of the calculated section

In view of character of flow distribution it was assumed that below the CSL each of two branches receive the part of the total water flow, which is proportional to its proportion in total discharge and adjoined to the corresponding bank upstream CSL.

In determining the SS initial concentration at the cross-section of the sediment dredging it was assumed that the dredgers were at the same distance from the bank, the distance between them being 50 m, and short time moves of executive devices happen within 10 m. At such conditions the maximal mean one-hour concentration of SS below the section of dredging 50 mg/l with the background concentration including.

SS distribution in the flow at the section nearest to the section of dredging, where discharge of the contaminated part of the flow is much less of the total river discharge, was calculated according to [52] by *Tallinn Polytechnical Institute (TPI) method* [53]. This method is based on analytical solution of the equation of turbulent diffusion for the simplest case and assumes that the concentration distribution in the breadth of the flow at sufficient distance from the inflow is described with a normal distribution curve. The maximal concentration C_{max} of a substance at the check cross-section is

$$C_{\max} = C_{bg} + (C_{eff} - C_{bg}) \cdot \exp(-k_N \cdot l / v) / [H \sqrt{\pi \cdot v \cdot D \cdot l} \cdot erf(\xi \sqrt{2})]$$

where C_{eff} = concentration of the substance in effluent water (in our case – in the contaminated stream immediately below the rift dredging section, = 50 mg/l); C_{bg} = background concentration of the substance in the river (conditionally assumed to be 30 mg/l); l = distance form the effluent to the check cross-section; k_N = decay rate (assumed to be 1 according to calculated conditions); v, H – accordingly velocity and average depth of the stream, D – dispersion coefficient in the lateral direction; ξ – the value to be calculated by the formula $\xi = B\sqrt{v} / (2\sqrt{D \cdot l})$, where B – average width of the stream; probability integral $erf(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt$.

Further distribution of SS downstream along the branches sections, where the discharge of the contaminated part of the flow is proportionate to the total discharge of the river, calculation of concentration fields was performed by method of Karaushev, taking account of lateral circulation in the current and kinematics heterogeneity of the current [53]. This method is based on numerical solution of equation of turbulent diffusion for arbitrary case. In this method values of pollutant concentrations C(x,y) are calculated sequential for cross-sections with lateral interval Δx and lengthwise interval Δy.

The mass M of SS, entering the Ochakivske and Bystre branches with the corresponding water discharge Q, was determined by numerical integration of concentration C(x) by value $q_{CSL}(x)$, equal to the discharge of a part of the flow of x width:

$$M = \int_0^{Qp} C(x) \cdot q_{CLS}(x) dq_{SCL}(x)$$

Average SS concentration is

$$C = M / Q.$$

Results of calculation are presented in the form of a graphic chart of changing the maximal SS concentration in the flow along the Kilia branch (Fig. 4.16) and SS concentration at CSL (Fig. 4.17-4.20), where the X-axis shows percentage of water discharge in CSL from the left bank to the right one, and vertical lines divides the stream into two part in accordance with their further distribution by two branches.

Values of increment to the background SS content in the water, entering the Ochakivske and the Bystre branches ($\Delta C = C - C_{bg}$) are given in Table 4.3.15.

Table 4.3.15 – Results of calculation of dredging work impact on the SS content in the Ochakivske and Bystre branches

	Increment of SS content ΔC, mg/l		In norm for increment unit = 0.25 mg/l, times
Variant	Ochakivske branch	Bystre branch	
1	1.5	–	6.0 (in Ochakivske)
2	–	–	–
3	–	0.03	–
4	0.01	1.0	4.0 (in Bystre)

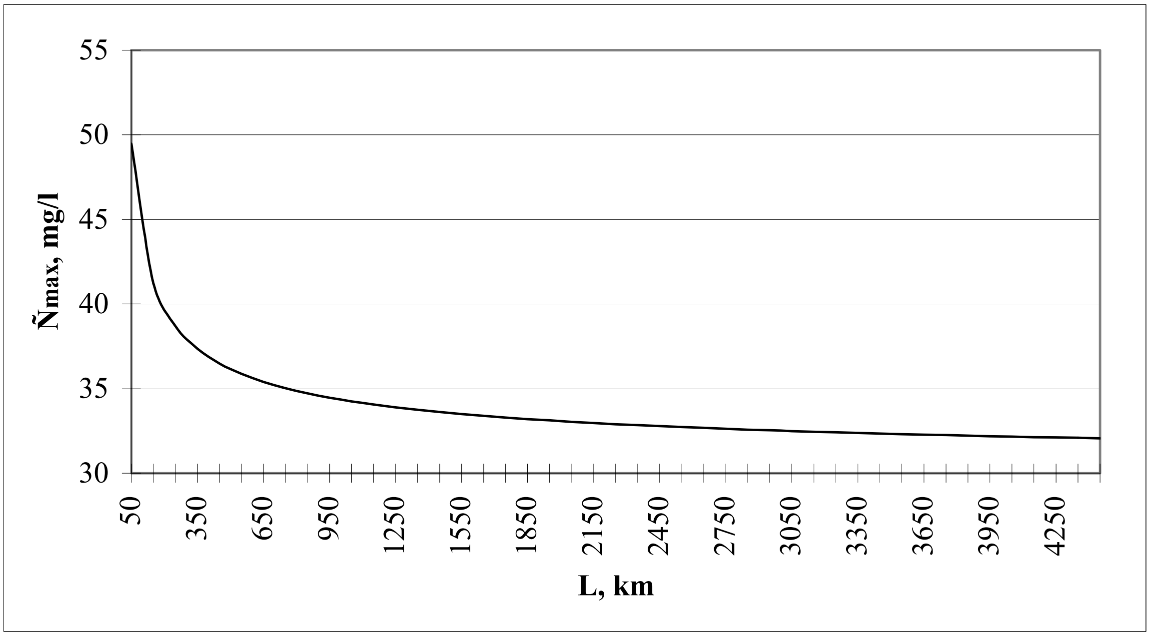

Fig. 4.16 Decreasing of the maximal SS concentration in contaminated stream as distancing from the section line of the rift dredging

The results of the calculation show that at distance of several dozens of meters below the site of dredging the increment of SS concentration may reach 20 mg/l at breadth of contaminated stream about 10 meters. As a result of turbulent diffusion and sedimentation processes, the maximal SS concentration rapidly falls, and even at 600 m downstream its increment makes 5 mg/l (Fig. 4.16).

At large distance from the rift this process slows, and at a distance of 4 km the maximal increment of SS concentration makes up about 2 mg/l. The breadth of the contaminated stream, where the SS concentration increment exceeds the limit admitted by MAC.fish (+ 0,25 mg/l to background), at such distance increases up to 150 m, which makes about 1/3 of all breadth of the river-bed. This can make slight impact on passively floating inhabitants of the water column (incl. fish larvae rolling back from spawning).

Depending upon dredgers positions, the main mass of the technogenic SS can reach the Ochakivske branch (in variant 1), the Bystre branch (in variant 4) or remain in the Starostambulske branch (in variants 2 and 3). At that the increment of the average SS concentration in the Ochakivske branch will make 1,5 mg/l, and the Bystre –1,0 mg/l, which exceed the increment (0,25 mg/l), admitted by MAC.fish, and requires taking appropriate restricting measures. In particular, **in low-flow periods they should restrict the intensity of dredging operations on rifts of the Kilia branch with the consideration of monitoring data and the place of dredging.**

For the calculation of contamination of the Ochakivske and Bystre branches with the substances, washed out from bottom sediments at dredging the Kilia branch, background contaminants concentrations in the Danube water and concentrations in bottom sediments were assumed in accordance with Tables 4.3.10 – 4.3.12. As well as in section 4.3.4.1, there was assumed conservatively that all pollutants and nutrients, contained in the lost bottom sediment, remain in the water column. Besides that, similar calculations were performed simultaneously using empirically determined coefficients of pollutant desorbing at dredging in accordance with *Annex 3* to *DBN B.1.1.31-96* [76] (mass of contaminants in the whole volume of dredged sediments was considered). Results of calculation are given in Table 4.3.16, results received using the desorbing coefficients, are placed in denominator.

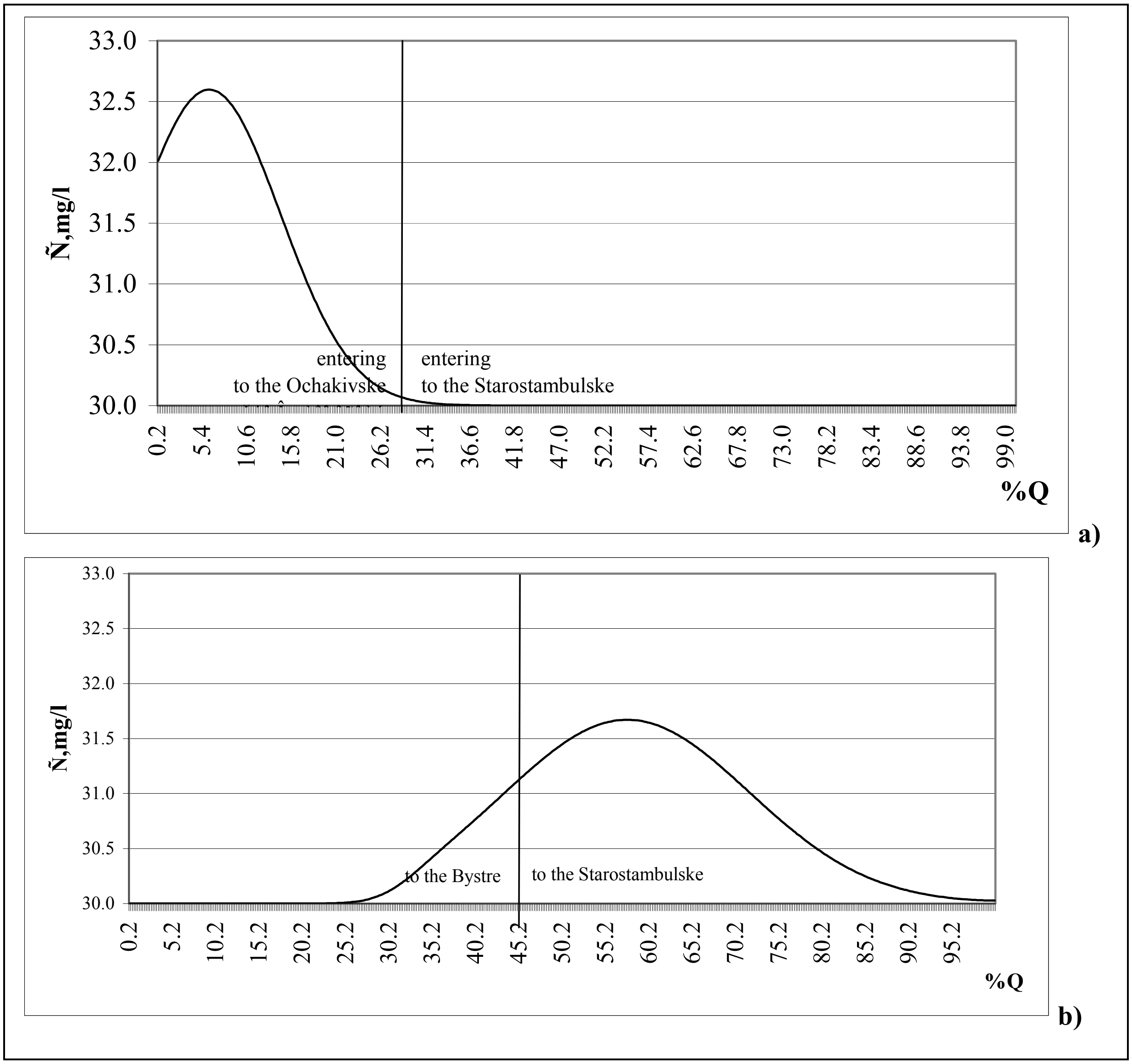

Fig.4.17 – Concentrations of SS for CSL 1 (a) and CSL 2 (b). Variant 1

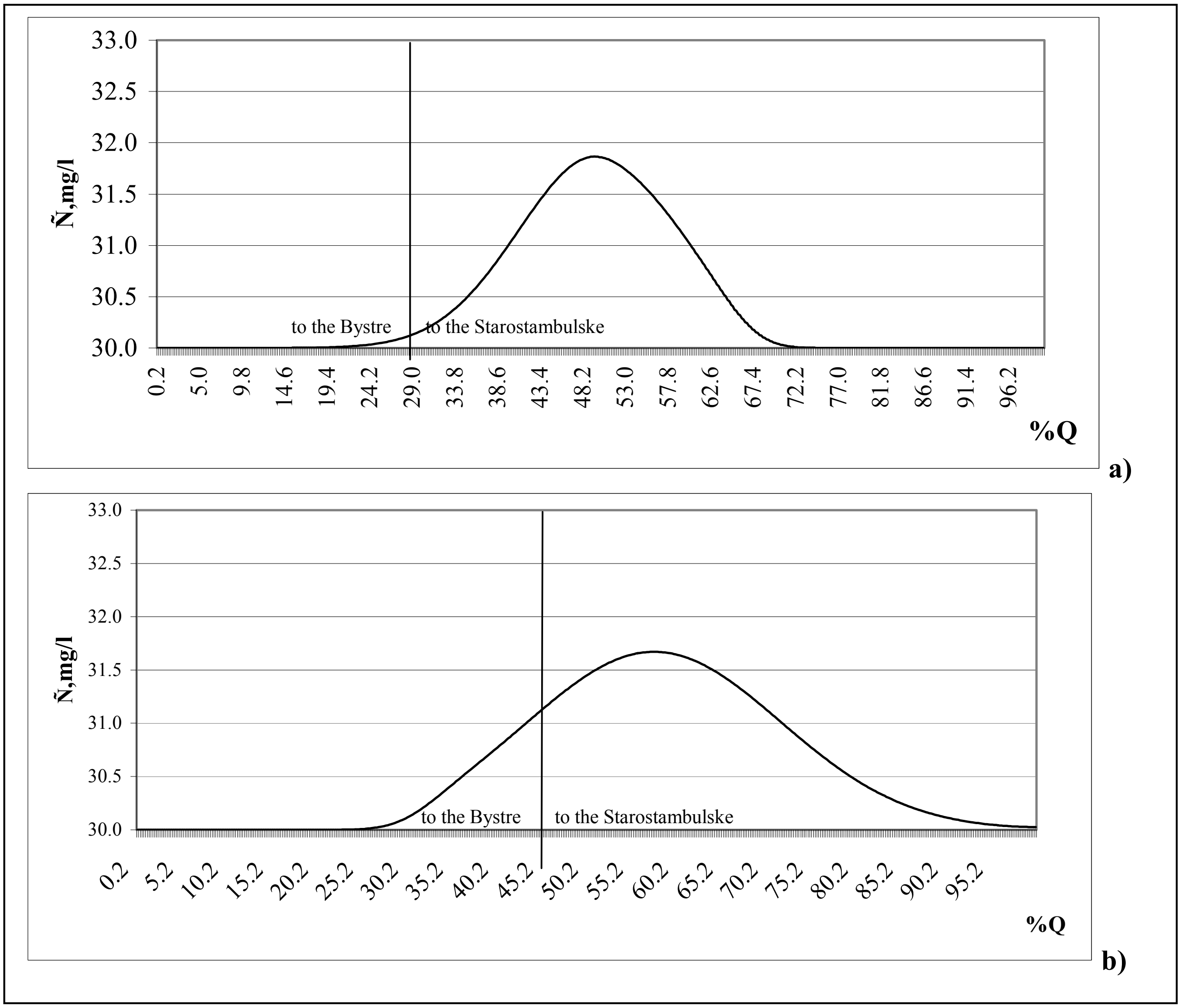

Fig.4.18 – Concentrations of SS for CSL 1 (a) and CSL 2 (b). Variant 2

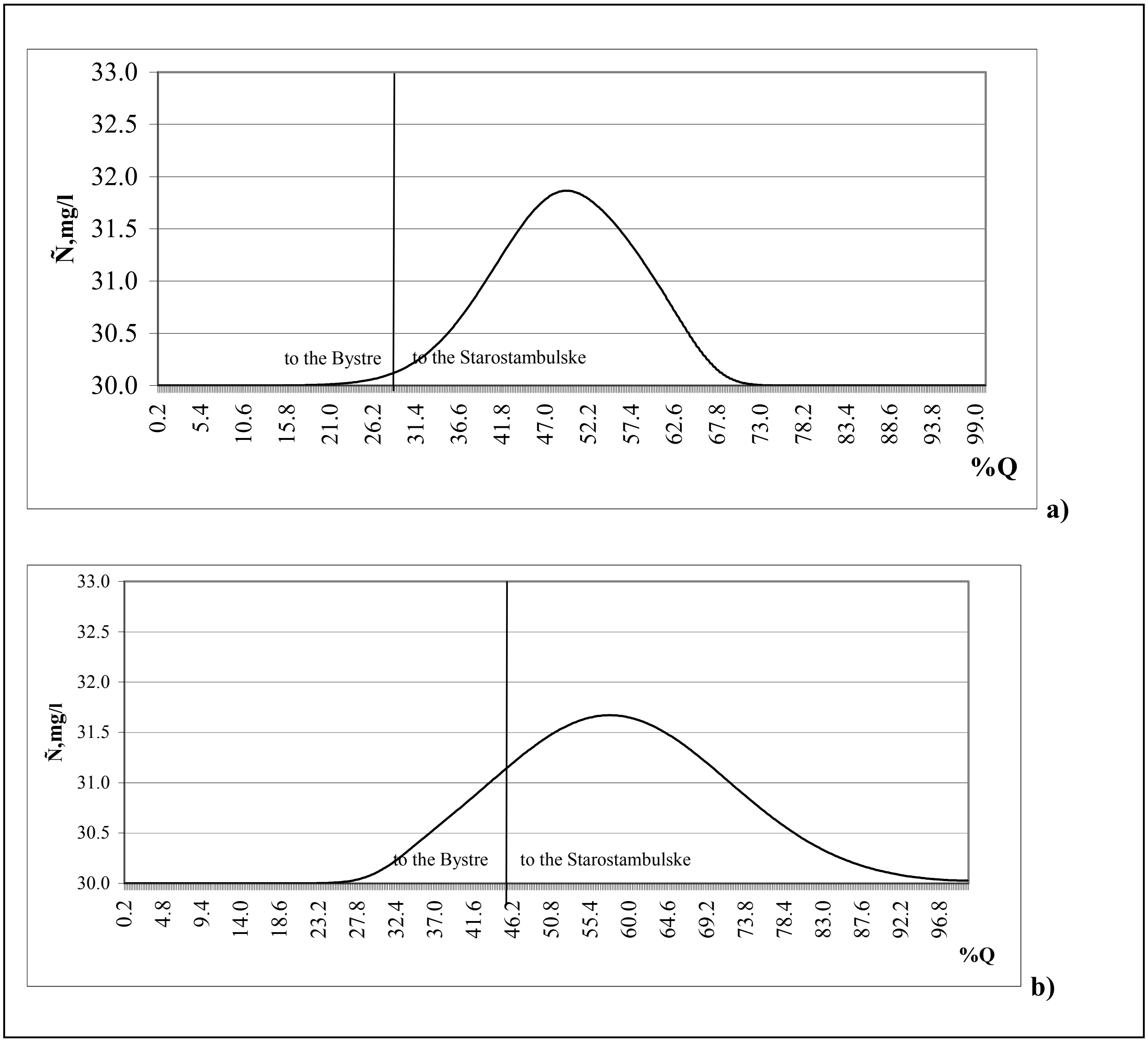

Fig.4.19 – Concentrations of SS for CSL 1 (a) and CSL 2 (b). Variant 3

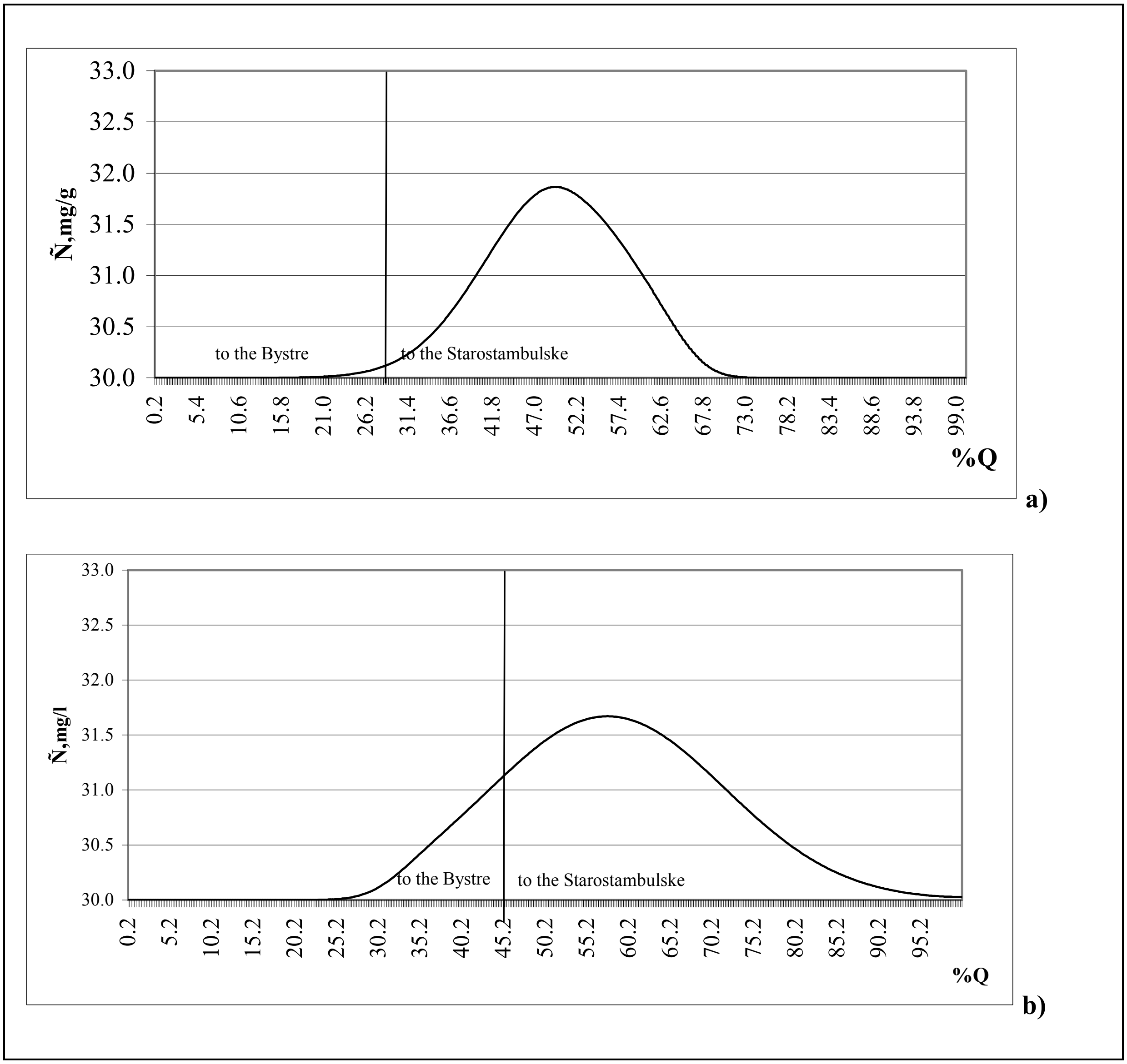

Fig.4.20 – Concentrations of SS for CSL 1 (a) and CSL 2 (b). Variant 4

These tables show that under the worst conditions the excesses of background concentrations of contaminants in the branches for most indices are predicted to be less than 7%, excluding total phosphorus (background excess by 21,3 %), Mn (excess by 16,5 %) and oil products (excess by 13,4 % and 71,8 % according to different methods of calculations). **So impact upon the water quality of the branches may be recognized acceptable with the consideration of limited period of action of factors and introducing restrictions on dredging operations in the low-flow periods on the criterion of standard acceptable increment of SS concentration.**

Ecosystem of the Bystre branch can also be subject of certain negative impacts ***in connection with laying the Sea Approach Channel (SAC) through the bar area***.

Table 4.3.16 – Results of calculations of the water quality in the Ochakivske and the Bystre branches at performing dredging operations in the Kilia branch

No.	Index	Back-ground concentra-tion, mg/l	Average content in bottom sediment, µg/g	Volume concentration in bottom sediment, mg/	transitional coefficient, % (under DBN B.1.1.31-96)	MAC.fish, mg/l	Variant No. 1, Ochakivske branch			Variant No. 4, Bystre branch		
							Average concentra-tion, mg/l	absolute background excess, mg/l	Relative background excess, %	Average concentra-tion, mg/l	absolute background excess, mg/l	Relative background excess, %
1.	Total Nitrogen	7.6	1200	1920.0	–	–	7.88	0.28	3.7	7.76	0.16	2.1
2.	Total Phosphorus	0.126	2600	4160.0	–	–	0.153	0.027	21.3	0.150	0.024	19.4
3.	Mn	0.1173	1770	2832.0	–	0.01	0.1367	0.0194	16.5	0.1345	0.0172	14.7
4.	Zn	0.0598	225	360.0	1.87	0.01	0.0639 0.0637	0.0041 0.0039	6.8 6.4	0.0628 0.0626	0.0030 0.0028	5.1 4.8
5.	Cu	0.0479	128	204.8	1.31	BG + 0.001	0.0507 0.0503	0.0028 0.0024	5.9 5.0	0.0499 0.0495	0.0020 0.0016	4.2 3.3
6.	Pb	0.0308	108	172.8	2.50	0.1	0.0328 0.0330	0.0020 0.0022	6.6 7.2	0.0323 0.0325	0.0015 0.0017	4.9 5.5
7.	Cd	0.0020	3.3	5.3	0.95	0.0033	0.00210 0.00208	0.00010 0.00008	5.0 4.2	0.00207 0.00205	0.00007 0.00005	3.3 2.6
8.	Cr	0.0860	176	281.6	–	0.001	0.0906	0.0046	5.3	0.0891	0.0031	3.7
9.	Oil products	0.080	920	1472.0	14.5	0.05	0.091 0.137	0.011 0.057	13.4 71.8	0.089 0.135	0.009 0.055	11.6 69.1
10.	PAC	0.00037	1	1.6	–	–	0.000392	0.000022	5.9	0.000386	0.000016	4.2
11.	DDT	0.000051	0.032	0.051	–	–	0.000053	0.000002	4.1	0.000052	0.000001	2.5
12.	HCH	0.00017	0.01	0.016	–	–	0.000176	0.000006	3.6	0.000173	0.000003	2.0

Magnification of the phenomena of rise-fall of water level because of wind influence is predictable after opening the sand-bar. It can facilitate water exchange in wetlands to some extent.

Results of numerical simulations of the surge phenomena carried out by Institute of Hydromechanics of the NASU [9], show that the influence of changing parameters of the onset wave will be insignificant and spreads within the limits of a few tens of meters upward to the Bystre branch.

Process of penetration of salt sea water to the branch mouth zone was researched for the Ochakivske branch and artificially deepened Prorva branch. Critical discharges impeding this process in the absence of storm surge was calculated [89,90]:

Depth of the fairway on bar, m	2	3	4	5	6	7	8
Ave. sectional depth of the bed, m	1.3	2.0	2.7	3.3	4.0	4.7	5.3
Critical discharge, m^3/s	83	152	235	328	431	543	664

On conditions of storm surge, the penetration of salt water into the mouth of the Prorva branch after its deepening up to 8 m along the fairway was noted at discharges over 700 m^3/s, and the maximal distance of their penetration into the Prorva and the Ochakivske branches in bottom water layer reached 16 km upstream.

It is reported [9] that the salt waters could penetratein the near-bottom stratum up to very beginning of the Bystre branch on conditions of storm surge.

Preliminary calculations for penetrating of salt wedge during organisation of the SAC, carried out by Institute of hydromechanics of NASU shows that creation of the opening will exceed the saltiness at the inlet into branch and result in increase by about 1,5-2 times the length of salt wedge. However, at all values of salinity gradientthe salt wedge will not penetrate into branch at the discharges over 800 - 900 m^3/s.

According to the results of calculations, performed by the DHMO [89], the values of critical water flow of the Bystre branch are:

Depth of the fairway on bar, m	5	6	7	8	9	10
Average sectional depth of the bed, m	3.3	4.0	4.7	5.3	6	6.7
Critical discharge, m^3/s	390	520	660	790	960	1130

It is calculated that at the designed deepening of the SAC even at absence of storm surge the penetration of seawater into the branch will happen during the most part of the year, and maximal length of the wedge of salted waters can reach 5 km. Therefore about half of the length of the branch will be constantly influenced by the seawater. At extreme storm surges the wedge of salted waters can reach the length of 18 km, being spread onto the adjacent section of the Starostambulske branch.

Impact of waves from the passing ships at the period of operation of the DWNR is considered in the present **EIA** Report in the section 4.1.2 in the aspect of possible erosion of banks of the Bystre branch, i.e. the direct impact on the processes of relief forming of the delta. However in case of extensive wash-outs the consequences of such impact are predicted in the form of disrupt of water and hydro-chemical conditions of large massifs of wetlands, separated by riverbed banks from the river, degradation of vegetation and animal life of banks and adjacent territories. Therefore returning to the earlier produced analysis of the given impact we shall once more notice that according to the preliminary calculations carried out by the Institute of Hydromechanics the limitation of a ship 7 knots speed while passing the Bystre branch accepted in the project is sufficient to preserve riverbed banks in steady state. Additional restriction of speed may be accepted on necessity on the basis of the results of monitoring at the period of experimental operation of the DWNR.

As a whole, the results of calculations and modelling enable to estimate a possible change of the level, wave and water quality conditions in the Bystre branch while building and operation of the DWNR as local and allowable subject to preservation of the protection function of the channel banks. This function is ensured by operational restrictions of speed for the passing ships provided in the project.

The final conclusions and prognosis will be made on the results of hydrologic and hydro-chemical monitoring during the DWNR experimental operation.

4.3.5 Analysis of impact of the DWNR on coastal areas of the sea

Section of the sand-bar of the Bystre branch

The main negative impacts on water quality of the seaside at construction period are effected by making sea approach channel through sand- bar of the Bystre branch and creation of protective dam. . The main damage will be inflicted to benthos organisms due to worsening of water quality as well as damaging of considerable areas of bottom. However benthos in this area is accommodated to the active processes of reforming of the bottom relief, permanent carrying away of pollutants and sediments due to it being capable to restore quickly after termination of man-caused factors, which in this case are similar to the impact of natural factors.

The source of pollution in the area of the bar will exist only at the period of dredging and then will quickly be dispersed by the current of the Bystre branch and the sea currents. To estimate the impact of soil extraction during construction of the SAC on the SS content in sea water and their carrying over towards the border with Romania, numerical modelling has been performed of SS carrying over by along-shore sea currents from the place of sediments extraction by a chain-bucket dredge taking into account non-reactive processes of advection, dispersion and gravitational sedimentation. Modelling parameters were accounted so that SS carrying over towards the state border will be maximized.

The model took account of the main processes of the simulated phenomenon and conditions of dredging, namely:

1) SS losing of into marine environment during dredging;

2) SS transport by the sea current (advection);

3) SS dispersion in marine environment by turbulent vortexes and by the current velocity gradients (dispersion);

4) SS removal from marine environment due to gravitational settling of solid particles.

According to characteristics of the dredging process, of the extracted sediments and of the area of dredging, the most negative design conditions are:

For process 1):

- point character of the SS source;
- continuous action of the source;
- maximum daily volume of sediment extraction = 11,714 m³/day (0.136 m³/s);
- all losses of the extracted sediments are solid dispersed fraction, which = 5% or 0.0068 m³/s;
- maximum percent (23.2%) of fine-dispersed ($d < 0.005$ mm) sludgy fraction content in losses, which gives $q =$=0.00158 m³/s for given fine-dispersed fraction source;
- maximum concentration ($C_{\max} = 75$ mg/l) of fine-dispersed fraction in the water thickness in the place of sediment extraction (taking into account the initial dilution).

For process 2):

- northern direction of wind of the speed ($W = 5$ m/s) specific for the area where operations are carried out, to which corresponds the shortest direction of sea current towards the marine state border;

- time-constant speed of the sea current.

For process 3):

- exclusion of longitudinal (along the current direction) dispersion from the consideration and preserving the influence of lateral dispersion on suspended fine-dispersed fraction transport.

For process 4):

- density of fine-dispersed fraction material $\rho_m = 1{,}900$ kg/m³; at that the power of stationary point source makes $Z = \rho_m q = 1{,}900$ kg/m³ $\times$ 0.00158 m³/s $\times$ 1000 g/kg=3000 g/s;
- maximum density of sea water in the area the works are carried out, $\rho_w = 1{,}013$ kg/m³;
- maximum viscosity ratio of sea water $\nu = 1.8\times10^{-6}$ m^2/s;
- characteristic diameter of fine-dispersed fraction particles $d = 5\times10^{-6}$ m;
- absence of "collective" interference effects of solid particles during their gravitational settling.

Taking into account that a characteristic feature of spread (influence) zones of dissolved or suspended substances, coming from point sources, is their significant oblongness in the current direction (length to width ratio is about 10:1), a stationary transport model in curvilinear orthogonal coordinate axes [71] was used, related to the current direction:

$$\frac{\partial C}{\partial \varphi} = hD\frac{\partial^2 C}{\partial \psi^2} - \frac{\omega}{J}C$$

where: C = concentration of fine-dispersed fraction in sea water, related to activity of point steady source, mg/l; φ = integral potential of a steady sea current speed, m³/s; ψ - integral function of the sea current flow, m³/s; $h = h(\varphi)$ - the current depth along the line of flow $\psi = \psi_0$, passing through the point source, m; $D = D(\varphi)$ - dispersion coefficient, m^2/s; ω - hydraulic size of fine-dispersed fraction, m/s; $J = J(\varphi)$ - Jacobian of conversion of the rectangular system of coordinates (x, y) into the curvilinear one (φ, ψ), m^4/s^2.

Dispersion coefficient, according to full-scale experimental researches [72], is calculated by empirical formula

$$D = 0.032 + 21.8\frac{J}{h^2}.$$

Hydraulic size of fine-dispersed suspension is determined using Stokes law by formula

$$\omega = \frac{g(\rho_m - \rho_w)d^2}{18\nu\rho_w} = 6.6\times10^{-6} \text{ m/s}.$$

Calculated dependencies of the indicated model for a steady point source have the following form

$$C(\varphi,\psi) = \frac{Z}{\sqrt{2\pi\, a(\varphi)}}\exp\left[\frac{(\psi-\psi_0)^2}{4a(\varphi)} - b(\varphi,\omega)\right],$$

$$a(\varphi) = \int_{\varphi_0}^{\varphi+\varphi^*} h(\varphi)D(\varphi)\,d\varphi, \qquad b(\varphi) = \int_{\varphi_0}^{\varphi+\varphi^*} \frac{\omega}{J(\varphi)}\,d\varphi,$$

where: φ_0 and ψ_0 are co-ordinates of the steady point source in the curvilinear system of coordinates; φ^* - is the conjugation parameter that ensures fulfilling the condition by the amount of concentration in the place of the source location:

$$C(\varphi_0,\psi_0) = C_{\max}.$$

Modelling the process of carrying over fine-dispersed fraction of sediment from the steady point source in the littoral zone of the sea in the dredging area was carried out in the following order:

- Numerical calculation of the current integrated function distribution $\psi = \psi(x, y)$ in a rectangular area with the dimensions by latitude and longitude of 32 km$\times$70 km, including estuary coastal waters of the Bystre branch, with the steps of grid $\Delta x = \Delta y = 250$ m. This calculation is carried out using the model [73] adapted to the conditions of shallow littoral zones of the Black Sea.
- Calculations of carrying over fine-dispersed fraction of sediments into the sea from the steady point source are carried out for a littoral section from the place of dredging to the state border with the dimensions by latitude and longitude of 6,000 m$\times$18,000 m. For this section distribution of the current speed integrated potential was calculated in accordance with dependences

$$\frac{\partial \varphi}{\partial x} = -\frac{\partial \psi}{\partial y}, \quad \frac{\partial \varphi}{\partial y} = \frac{\partial \psi}{\partial x} \quad ,$$

after which these functions values were interpolated into nodes of net domain that covers the indicated area with the steps $\Delta x = \Delta y = 31.25$ m, which enabled as a result to visually reflect graphically the structure of the tail area fine-dispersed fraction of soil coming from the point source into the sea.

- At the final stage, distribution of fine-dispersed fraction concentration $C(\varphi,\psi)$ was calculated as well as distribution of suspended substances concentration $C(x, y) = C(\varphi(x, y),\psi(x, y))$ corresponding to it from the point source in the angles of the rectangular grid.

The main calculations results are presented in the graphic form on Fig. 4.21.

As it follows from the mentioned distribution of concentrations, under the most unfavourable design conditions that deliberately worsen the conditions of coming, dilutions and settlings of soil particles coming to the marine environment during dredging and are virtually impossible to happen, **concentration of the suspended particles on the frontier with the bordering state will not exceed characteristic background values ($\approx$5 mg/l) that correspond to suspension-carrying capacity of sea currents.** In the near-shore sections of the sea where the natural suspension-carrying capacity of currents corresponds to background concentrations of 25 – 30 mg/l, hypothetical impact of dredging will not become apparent outside 5 – 6 kilometre zone limit from the work site.

This conclusion agrees with the data of field observations carried out in the context of integrated monitoring of the environment in the DWNR zone of impact by the *Noosfera Research Centre* during the period of carrying out dredging of the first stage of the DWNR construction (see Annex I).

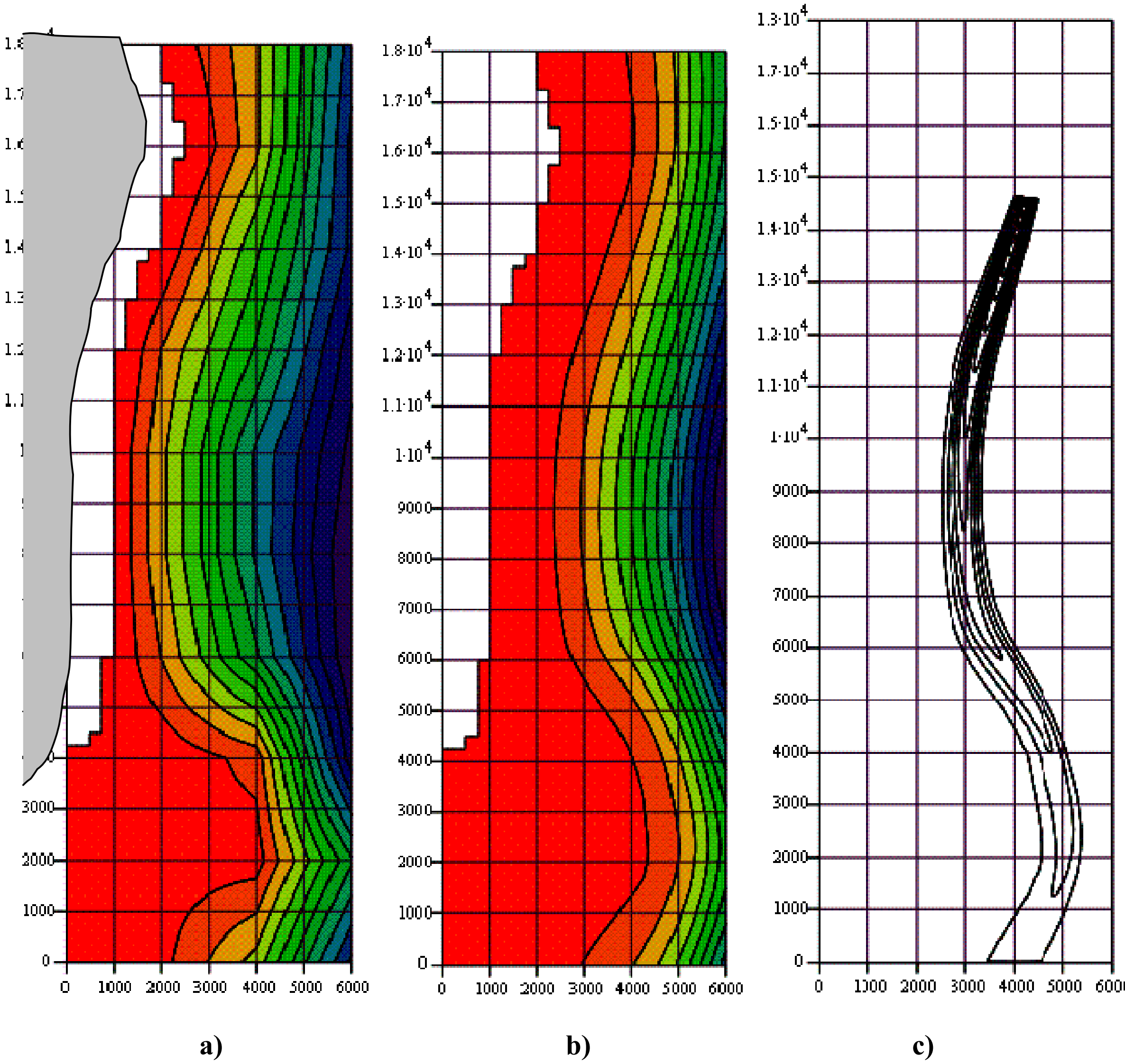

Fig. 4.21 – Model characteristics of carrying over fine-dispersed fraction of soil, coming to the littoral sea zone in the process of dredging
a) distribution (isobaths after 1 m, coastal line is on the left) of depths $\mathrm{h} = \mathrm{h}(x, y)$ in the area where dredging is carried out to the state border (the lower margin of the figure); b) distribution of the flow integral function $\psi = \psi(x, y)$ (isolines are drawn with the interval of 37 m³/s, on the coastal boundary $\psi = 0$); c) distribution (isolines) of concentration $\mathrm{C} = \mathrm{C}(x, y)$ of fine-dispersed fraction of soil in the tail area of suspended substances coming to the marine environment during dredging (isolines are drawn with the interval of 5 mg/l; concentration of 5 mg/l corresponds to the external isoline). Distances by system axes are drawn in meters.

Section of the sea dump of ground

Main volume of the sediments extracted is subject to a dumping in the sea dump. The area of this dump is approved by the decision of Odessa region authorities and coordinated with the organs of sanitary supervision and inspection of the Black Sea protection.

The grounds to be extracted at the first stage of construction by status on October 2003 refer mainly to the class A and I, not needing special precautions while shifting and dumping.

The planned capacity of the dump while filling the ground of 3 m thickness is determined as 5 361 000 m^3. In the area of dumping a local long-term pollution of the bottom and water mass is predicted. The consequences of the dumping are predicted by way of destruction of the bottom biocenosis, worsening of oxygen conditions, increase in trophic and toxic action on hydrobiotones.

As a result of complex hydro-ecological examination of the water area of the Danube seaside, adjacent to the mouth of the Bystre branch, the area has been chosen to organize the sea underwater dump with the centre co-ordinates 45˚19′13″ N, 29˚51′58″ E and depths of 22 – 23 m. The ground dumping is located south from the entry to the sea approach channel at the axis of fresh water runoff and at the period of flooding it gets into a zone of maximal removal of the suspended substance. It is extremely important for the process of natural burial of the storing ground and prevention of the pollutants outflow from the stored grounds into the water thickness. At the same time the discharged ground does not get onto the zone of driven sediments formed by general along-shore transporting and so will not shift to the zone of channel. Territory of the dump is over 5 km away from the seashore excluding spreading of tail area of contaminated water into coastal zone.

This area is also characterised for the grounds close by the degree of pollution to the grounds in the area of the opening, relative scarcity of the bottom and deep-sea biocenosis. Judging by temperature characteristics and oxygen conditions in near-bottom stratum, the recommended place of the ground dump subject to short-time spring – summer hypoxia (no longer than 2 - 3 weeks). This means that during the last 30 years as a result of oxygen shortage in near-bottom stratum there was a definite depression of benthos. According to the results of research of the Danube seaside for many years it was determined that the recommended place of ground dumping has not to do with permanent and long hypoxia. So the hydrologic conditions and hydro-biologic characteristics of the selected place of underwater dump of the ground provide minimisation of impact of the dumping on biota.

According to the project the area intended for the dumping of grounds presents in itself a circle of 1 sea mile in diameter. A segmentation and subsequent filling of the parts of the dumping area is provided for the purpose of its even use. Such organisation of the works on the dump will enable to observe restoration of the bottom fauna in the filled sections.

Calculation made during the working out the Report of Impact on Environment of the sea dump by the method of *ChernomorNIIproject* and *State Oceanographic Institute* showed that beyond the check section lines the concentration of turbidity will remain within the limits of its natural variability [50].

The working draft at the DWNR full development foresees during carrying out dredging and soil dumping in the coastal waters area observing the same environmental restrictions and carrying out water quality monitoring as while carrying out dredging in the river-bed part of the DWNR.

4.3.6 Ships passage impact on quality of the water. Emergency situation

Impact of the passing ships on quality of the water in normal operation conditions is predicted as insignificant. Ballast and sewage waters according to the shipping rules are to be delivered to special ships. Heated waters of the engine cooling systems relates to the category of "conditional clean" and in the existing discharged volumes can't sufficiently influence the river water quality.

The most serious negative impacts at all sections of the DWNR can be caused by the accidents with the passing ships. According to the available estimates the probability of the emergency situations in the navigation route, which meets international requirements for navigation, is extremely low. It's important that the riverbed of the Bystre Branch is separated from the adjacent territories of wetlands with near-riverbed banks acting as barriers s. So a source of pollution arisen as a result of a shipwreck firstly would have affected the coastal area of the seaside and only from there the pollutants can spread in the wetlands.

At the same time, even in case of failure of building navigation route in Ukrainian section of the Danube delta, the dangerous consequences of the shipwrecks in the above navigable sections of the Danube will be able to appear in full on the territory of the DBR, because the pollution if occurred as a result of a shipwreck will inevitably spread to the boundaries of the reserve.

4.3.7 Conclusions on impact of the navigation route on the water environment

Analysis of impact of the DWNR on the water environment indicated that the main factor of impact is dredging, which is provided in the area of the bar of the Bystre branch and in the sections of the Kilia and the Starostambulske branches used for navigation earlier.

Impact on the water quality can be considered allowable subject to limited period of action of the polluting factors and introducing restrictions on performance of dredging operations in the period of low waters and on the criterion on normative admissible growth of suspended substances concentration.

The most negative impact is effected by opening of the bar of the Bystre branch. At that the negative consequences arise for the processes of forming the quality of water in the branch itself (due to spreading of the salt water wedge) and in the area of the bar. Under conditions of great flowage of the branch and unconfined water exchange in the adjacent water area of the seaside the changes of water quality will be short-run.

Results of the modelling research allows to estimate possible changes of the level, wave and salt conditions in the Bystre branch during construction and operation of the DWNR as local and allowable subject to ship passage speed operational restrictions provided by the project**.**

Opening of the bar can result in insignificant redistribution of water outflow along the Kilia delta. In this connection the working project for full development provides construction of a turning dam at the begining of the Bystre branch, which is capable to make this process controlled and not to allow negative consequences for the water conditions of the delta. Its configuration will be specified by the results of physical modelling and integrated monitoring.

4.4 Soils

Conditions of soil forming in the delta are conditioned mainly, by hydrologic conditions and the relief pattern. Depending on the Danube water level and its duration the various areas of delta are subjected to flooding for short or long time.

Very changeable conditions of surface and ground water give rise to the change in the soil forming processes. So, along with well-developed soil cover there are young and undeveloped soils. Vast areas in the delta are constantly covered with water so practically there are no soils there. Luxuriant vegetation of the delta serves a source of enriching the soils with humus and organic substance.

The most favourable conditions to form the soils are on the riverside ridges so the soil cover there is most developed.

By a degree of spreading and forming the soils in the delta one can mark out 5 classes of soils: juncaceous water-meadows and Lucopodiales, lake-marsh, sand, alluvial, saline chestnut chernozems.

Taking into consideration the kind of construction and operation of the DWNR, the impact on the soil cover in the area from Reni to the Bystre branch will be limited by separate areas along the channel route where alluvial soils are predominant. These soils are formed on the near-riverbed ridges and from economic viewpoint present the greatest value. They are rich in mineral salts (in river alluvions) and humus, very fertile, they are weakly saline in high-level places. Alluvial soils are distinguished in structure and the degree of development. Alluvial-turf soils are exposed to short-term flooding, the depth of ground waters is 1 - 1.8 m, oxidising processes are predominant. These soils have grey tints with rusty inclusions, lumpy and laminated structure.

The main impact on soil is caused by the dredging at Vilkove – Reni section connected with transporting of the sediments extracted by hydraulic dredges to specially equipped coastal dumps. The total need in the grounds to be allotted for dumps is about 125 ha. The sites for dumps are allotted in accordance with documents (for each site separately). All allotted grounds border on stop banks of the Danube River and are in the state of seasonal ground water rise with the depth of water table from 0.0 to 1.0 m. The allotted grounds were used mainly for growing forage grasses, for vegetable gardens, pastures and meadows (Table 4.4.1). With the exception of drying out and partially cut down plum plantation, the sites do not have perennial plantings. At present in view of swamping the allotted grounds, as a rule, are not cultivated, they are being overgrown with shrubs and reed.

Table 4.4.1 – Register of grounds by sludge ponds

Sludge ponds,	Meadows, ha	Sparse shrubs, ha	Hygrophilous grass, sedge, ha	Reed and sedge, ha	Arable land, ha	Plum (grubbing), ha	Willow, ha	Tall-grass vegetation, ha	Tall-grass vegetation with reed, ha	Total, ha
No. 3					11.0					11.0
No. 6					4.0	21.0 10.0				35
No. 9									13.0	13.0
No. 11 b			8.0				1.0	1.0		10.0
No. 12 b	15.0									15.0
No. 13 a				2.0						2.0
No. 13 b	3.6									3.6
No. 14				2.8			1.7			4.55
No. 15	5.0	4.0	0.66							9.66
No. 16	7.0	9.4		4.81						21.21

Creation of dumps on the bank, whenever possible, is assigned to the places of the river dikes in need of repair. The main bulk of the soil from dumps will be used for operations to restore these sections of the protective dams. In the presence of sandy soils it is possible to achieve fractionation of the inwashed soils, i.e. separation of sand for its further use for construction purposes at minor installations.

The results of chemical analysis of bottom sediment samples of the Kilia delta show that they are substantially saturated with oil products and heavy metals (Tables 4.4.2 and 4.4.3).

This is especially relevant to Pb and Cu compounds. Thus, for instance, the amount of Pb in bottom sediments in section lines of the Bystre branch - beginning, rifts 24-25 km, rift 73-74, 2-3 MAC.soil = 32.0 μg/g. Exceeding of allowable content of Cu takes place in bottom sediments in section lines: 18 km of Kilia branch, the Bystre branch - beginning, on all rifts from 24 to 74 km.

The inwashed territory is allotted for temporary use (for 5 years) and in future, after rehabilitation, will be returned for agricultural use, moreover, the water regime of the sites will improve considerably and their fertility will increase. The damage to landowners and land users, caused by temporary allotment of sites for dumps, will be fully repaired in accordance with the procedure determined by Regulation of the Cabinet of Ministers of Ukraine of 19.04.1993.

The project provides for the works on reclamation and restoration of bank dumps to be allocated financial means in the amount of 3,562,700 UAH.

Table 4.4.2 – Results of chemical analysis of bottom sediment samples from May 25 – May 28, 2004

No.	Indices	Units	Samples numbers							Class
			1	**2**	**3**	**4**	**5**	**6**	**7**	
1.	Oil products	mg/kg	195	150	202	228	124	182	266	I – II
2.	Hg	mg/kg	0.38	0.23	0.16	0.18	0.16	0.17	0.35	A – II
3.	Cd	mg/kg	0.66	0.29	0.39	0.52	0.41	0.33	1.36	A
4.	Pb	mg/kg	23.8	28.8	19.8	21.6	22.4	35.4	38.9	I – II
5.	Cu	mg/kg	50.8	32.5	31.1	38.0	34.4	31.3	62.0	A – II
6.	Zn	mg/kg	119	99.7	98.8	106	90.7	86.8	155	A – II
Samples numbers			**8**	**9**	**10**	**11**	**12**	**13**	**14**	
1.	Oil products	mg/kg	91	306	169	202	150	84	72	A–III
2.	Hg	mg/kg	0.13	0.44	0.083	0.19	0.14	0.26	0.22	A
3.	Cd	mg/kg	0.25	0.94	0.39	0.47	0.37	0.26	0.26	A
4.	Pb	mg/kg	14.0	63.0	29.5	27.3	33.8	18.5	21.2	I – II
5.	Cu	mg/kg	14.2	54.8	17.2	48.4	40.7	25.5	29.2	A – II
6.	Zn	mg/kg	52.9	198	64.6	114	116	130	76.0	A–III
Samples numbers			**15**	**16**	**17**	**18**	**19**	**20**	**21**	
1.	Oil products	mg/kg	110	344	201	247	104	280	240	I–III
2.	Hg	mg/kg	0.12	0.55	0.21	0.48	0.10	0.29	0.17	I – IV
3.	Cd	mg/kg	0.21	1.14	0.61	1.22	0.33	0.59	0.64	A – I
4.	Pb	mg/kg	17.6	66.1	29.8	93.1	35.8	43.5	108	I–III
5.	Cu	mg/kg	25.8	84.9	41.8	67.8	43.0	78.2	56.0	A – II
6.	Zn	mg/kg	72.4	207	109	229	127	180	140	I–III
Samples numbers			**22**	**23**	**24**	**25**	**26**			
1.	Oil products	mg/kg	182	214	182	234	247			I–II
2.	Hg	mg/kg	0.19	0.19	0.27	0.29	0.29			I – II
3.	Cd	mg/kg	0.54	0.41	0.49	0.54	0.57			A
4.	Pb	mg/kg	36.7	26.3	28.8	46.9	48.9			II
5.	Cu	mg/kg	58.4	38.0	46.2	59.7	73.2			I – II
6.	Zn	mg/kg	135	94.2	105	198	166			II–III

Table 4.4.3 – Places of sampling on May 25 – 28, 2004

Sample No.	Sites	Depth, m
Delta of the Kilia branch		
1.	18 km of the Kilia branch	1
2.	Bystre branch, beginning	3
3.	Bystre branch, mouth	7
4.	Vostochne branch, mouth	4
5.	Starostambulske branch near the Limba island	3.5
6.	Potapovske branch, mouth	4
7.	Prorva branch, 3 km	4
8	Connecting channel, port of Ust-Dunaysk	1
The Kilia branch (Kilia-Izmail section)		
9.	Rift 24-25 km	3
10.	Rift 29-30 km	3.5
11.	Rift 35-38 km	4
12.	Island of Katenka, bank dumping ground	
13.	Rift 47-49 km	7
14.	Rift 51-52 km	7
15.	Rift 61-63 km	7
16.	Rift 64-66 km	4
17.	Rift 67-68 km	4
18.	Rift 73-74 km	5
19.	Island of Yermakov, bank dumping ground	
Zhebriyanska Bay		
20.	Section line 65-7	11
21.	Section line 65-B	4
22.	Section line 65-3	4.5
Coastal waters		
23.	Section line B-1 (the place of sediment sampling on the sand-bar of the Bystre branch)	9.6
24	Section line D-1 (the DWNR point of sea dumping)	22.5
25.	Section line DF (background station of sediment dumping)	22.5
26.	Section line coastal waters of the Starostambulske branch	20.5

Main amounts of rehabilitation work include surfacing of dumping ground after the consolidation in them of dredged soils and seeding grass on the layer of topsoil. Preparation work for further recuperation partly includes the work on creating dumps and recovery of storing dredged sediments.

In whole, the typical complex of measures on recuperation of the territories, temporarily allocated for the dumping grounds, includes

In the period of creating of coastal dumping sites:

- stubbing of brush wood and shriveling garden;
- removal of the layer of generous soil and its stowage in ledges.

In the period of soil flush and consolidation:

- use of a part of the soil for repairing the protection along-bank dams and road construction, which allows to optimize the final height of dumping grounds and fractional composition of the soil, reasoning from criteria of their further agricultural use (to lower the height to optimal 1,5 –2,5 m and decrease its sand content).

In the period of recuperation proper:

- Surfacing, leveling, flattening and averaging of the remained soil;

- covering the surface with a layer of generous soil from the ledges and by seeding grass, which, being used as green manure crops, will additionally improve the composition of the topsoil;
- conducting the agrochemical and sanitary-toxicological monitoring of the topsoil composition and, if necessary, taking additional agrotechnical measures.

Thanks to high fertility of river bottom sediments and optimal rising of the surface layer of the plots, temporarily allocated for the recuperation and presently being water-logged, their agricultural value will increase in comparison with the initial state, and in that way a possibility of causing damage to the fertility of the ground will be excluded.

Taking into account increased content of oil products and heavy metals in the deposited sediment, it is recommended to use reclaimed territories mainly for growing forage and meadow grasses. Production of food grain is possible after receiving the corresponding permission of sanitary supervision bodies.

With purpose to prevent negative impact on the soils and plant formations of the near-riverbed banks along the Bystre branch a decision in the work project was accepted to reject the arrangement of permanent and temporary signs of navigation on the banks of the branch limiting it to the installation of floating signs.

4.5 Flora and Fauna, the nature reserve objects

As the navigation in the Kilia branch and above section of the Starostambulske branch was effected earlier and for storing of the bottom sediments the territories are provided to be used which have been already exposed to the man-caused heavy duty and this territories do not represent botanic and zoological value then the description of biota and estimation of the DWNR impact mainly have to do with the sections of the DBR adjacent to the Bystre branch. The presented below description of vegetation and animal life on the territories, located in the area of the DWNR is based on the report of Institute of Hydrobiology [9], which is the main part of Technical Economic Ground and the data of the directors board of the DBR, placed in the materials of the institutes which participated in working up Technical Economic Ground materials on investments and working draft on construction of the DWNR [1; 46].

4.5.1 The Danube Biosphere Reserve

The route of the DWNR below Vilkove town crosses territory of the Danube Biosphere Reserve, which biota is the most valuable and at the same time most sensitive. Just this case attracts attention of ecology experts of various specialisations to the analysis of expected impact of construction and operation of the DWNR on the vegetation and animal life.

The President of Ukraine in a Decree No 861/98 founded the DBR of NASU on August 10, 1998 on the basis of natural reserve "Danube Plavni" of the NASU, which existed as unaffiliated organisation since 1981. Before this (since 1976) the territory was a branch of Chernomorski reserve. Area of the DBR was fixed at the rate of 46,402.90 ha together with watercourses, interior ponds and 2 km of coastal water strip of the Black Sea adjacent to the delta. At that 23,740.9 ha were included to its makeup without taking away from the landusers.

By decision of UNESCO of 02.02.99 the reserve has received the appropriate international certificate of biosphere reservation. By the same decision of UNESCO an integrated Rumania-Ukraine ambilateral *The Biosphere of the Danube Delta reservation* was created that is one of the five ambilateral reservations in the world. Wetlands of the Danube Delta are included in 200 of most valuable territory in the world because of their high biodiversity , which constitutes the planetary network known as Global 200 (WWW International).

At present DBR territory has the following structure:

- Core area – territory of the former natural reserve "Danube Plavni" of 14,851 ha (Fig. 4.2), where it is *prohibited*: presence of the persons without respective permits, hunting, catching of animals, cattle pasturing on the seaside spits; *allowed are*: normalized pasturing of cattle along riverbeds, extraction of water nuts, provision of reed, cleaning of channels to restore fish yield and conservation of the lakes productivity, traditional burning–out of juncaceous bush, regulation of number of separate kinds of animals, forest recreation, scientific and ecology-educational tourism, strictly controlled traditional commercial fishing, which can be temporary limited during nesting and forming of big aggregation of birds.

- **Regulated management zone** – territory of Stentsovsky-Zhebriyanski Plavni of total area 7,811 ha, where *it is allowed*: limited pasturing of cattle, commercial and sports fishing, prey of musk-rats, green frogs, sports fishing, provision of reed, organisation of tourist activity.

- **Buffer zone** – a territory of 19,687 ha in total (south section of Yermakov island and water-meadow lands between Zhebriyanska ridge and western boundary of the reserve zone of 13,000.8 ha as well as a strip of the Black Sea coastal waters and its Zhebriyanskiy bay of 6,686.2 ha), on which in order to avoid negative effect on the reserve area the economic activity is realized mainly within the framework of its traditional way; *it is prohibited* to change the type and features of the natural landscapes.

- **Zone of anthropogenic landscapes** is the territory of total area 4,053.9 ha (north section of Yermakov island, Zhebriyanski dunes, vegetable gardens and pastures near Vilkove along Belgorodske, Ochakivske, Ankudinov, and Starostambulske branches), which economic use is realised with restricted application of harmful technologies, use of biological resources, type and volumes of insecticides, pesticides and herbicides are co-ordinated with administration of the DBR.

By the Decree of the President of Ukraine No. 117/2004 dated of 02.02.2004 in order to make better the natural state of unique natural complexes in the Danube delta , protect wetlands of international value, other valuable natural complexes of Ukrainian near-the Danube lands, execution of zoning of the territory of the DBR and optimisation of its control subject to the interests of the region development, transport and other national needs, as well as activation of international co-operation, scientific research and monitoring of the environment the scheme of temporary zoning of the DBR territory was approved concurrently with expansion of its territory (Annex B). In accordance with this scheme in order to restore navigation in Ukrainian section of the Danube delta the lands of coastal protective strip of the Danube branches i.e. the Bystre and the Ochakivske branches and adjacent section of the Black Sea defined water area within the limits of the DBR territory are referred to the zone of anthropogenic landscapes (Annex A).

So the decree introduced a creation of deep-water navigation route in Ukrainian section of the Danube delta according to a version of route through-passing the Bystre branch into the legal sphere of Ukraine and eliminated fundamental legal barriers for implementing the working draft of the first stage of its construction and for working out of the working draft at full development of the DWNR.

Assignment of the DBR is to achieve long-term ecological purposes in everyday activities, which in the report [9] are determined in the following way.

The most general purposes:

- Provision of maximal naturally running processes in the delta and conservation of the biodiversity at the ecological, organism and genetic levels under the conditions of steady development of the region;

- Execution and provision of long-term regular observations (ecology monitoring) with up-to-date methods (including remote sensing) processes of succession (self-development and deformation of structural-functional organisation) of water and terrestrial systems of the Danube delta on impact of natural factors of regional and planet scales under conditions of minimisation of anthropogenic activity.

Purposes for separate territories:

Secondary delta of the Kilia branch of the Danube:

- Conservation of the biologic variety, maximal naturalness of delta forming processes, ecological and economic potential of the grounds under conditions of partial and rational use of natural resources.

Stentsevsko-Zhebriyanski Plavni (SZhP):

- Renewal and maintenance of *SZhP* as a stable and mosaic flood-plain ground with shallow water grounds and currents relying as much as possible on the natural processes of the wetlands functioning, preserving their natural and economic potential at the same time.

Zhebriyanski dunes:

- Provision of stable functioning of natural and anthropogenic systems of the ridge while preserving and renewing their biologic variety under conditions of running forestry and rational use of natural resources.

Yermakov Island:

- Provision of stable functioning of the island ecological system with maximal preservation of biologic variety, ecologic capacity and economic potential of the territory under conditions of partially regulated water conditions and rational use of natural resources.

Ecological systems of the DBR make in aggregate very diverse and peculiar complex due to variety of its landscapes and transient (ecotone) location between large river and the Black Sea.

Main part of the Kilia delta, the Stentsevsko-Zhebriyanski Plavni and partially the Yermakov island are occupied by wetland ecological systems represented mainly with weak mosaic grounds with slight flowage. Vegetation groups of reed, cat-tail, lake tule, sharp sedge are predominant here. Small spots of ash-grey willow bushes are distinguished.

Forest and bush ecological systems of wetland landscapes are represented both by natural groupings and man-made planting. Along the currents there are strips of 5 to 200 meters bushes of white three-staminal willows stretching and along the seashore there are loeaster, amorpha, tamarisk, sea-buckthorn.

Grass ecological systems in the Kilia delta are located on elevation areas, near-riverbed ridges as well as in outlying areas of reed marsh, adjacent to the seaside ridges. They are formed on the marsh and coastal water groupings, which disappear in the relief elevations caused by yearly accumulation of alluvium. Mainly spread are large-cereal and small cereal, large cane, juncaceous as well as motley grass salty grasslands. There are appreciable areas of grasslands on Yermakov island.

By natural-geological reasons and due to anthropogenic interference the ecological system of Zhebriyanski dunes formed on sands between the leavings of sand steppe and man-made forest of Crimean pines distinguishes itself with great diversity. Ecological system of Zhebriyanski spit can be characterised as sand-littoral.

There is great diversity in water ecological systems of the DBR. There are fresh water systems and in foredelta of the Kilia branch there are salt-water ecological systems, which develop in the water flows, estuaries and numerous lakes. Specific ecological system of the seaside is a contact zone of the Danube and the Black Sea. Along with great water masses of the Danube the suspended substances and dissolved nutrients, 100-200 thousand tons of fresh water plankton and other organisms are carried away here yearly to the sea and settle on the bottom forming a store of organic substance. This phenomenon is vital for the processes of forming biological productivity in northwest part of the Black Sea and the Danube itself with spawning reproduction of population (in particularly sturgeons and the Danube herring).

The DWNR in the Ukrainian part of the Danube delta, no matter along which of the potentially possible tracks it were created, to a certain extent infringes upon the DBR interests, crossing some or other zones of its territory and resulting in occurrence of disturbance factors.

Dredging in the area of the bar can affect as a long-term outlook the natural development of the delta while the long-run task of building the reserve is to provide at the most the natural course of the processes in the delta.

Implementing the project decisions to construct the DWNR by the Bystre variant foresees maximum possible consideration of the aims of the DBR and of restrictions on economic activity imposed for its various zones.

4.5.2 Vegetation and analyses of impact on the project activities

Vegetation cover of the reserve as well as the whole Kilia delta differs from the deltas of other rivers of the northwest regions near the Black Sea with more wetland communities by composition, which occupies about 80% of the area. 10% of the territory is occupied with near-riverbed wetland woods and seaside bushy association. Fewer areas are occupied with psammophyton, halophyton and grassy land association, which share is about 10%.

Flora of the DBR numbers 950 species of higher plants, which belongs to 379 kinds and 100 classes. 134 species of plants refers to the different categories of rare and disappearing ones (14,1%), out of which the 16 are put into the Red book of Ukraine and 3 put into the European Red List.

In the area of building the navigable channel about a half of the reserve flora grows in the Bystre branch. However here the alien acclimatised species practically do not occur except for cosmopolite species (bush amorpha, Canadian fleabane, flagroot common and others.)

Marsh vegetation in the area of the DWNR as well as all the secondary delta of the Kilia mouth of the Danube, distinguishes with great share of association: cuspate sedge, sedge-pseudogalingale, reed-cuspatesedge, narrow-leaved reed-mace, reed-mace-large sedge class. Diagnostic species of the class are common reed, buckhome plantain celandine, narrow-leaved reed mace, broad-leaved reed mace, river equisetum, bog bedstraw, European Lycopus, amphibiotic knotweed, coastal dock, bell-like Scutellaria, broad-leaved Sium, bog woundwort, bog iris and others. This vegetation develops under conditions of fluctuation of water level during vegetation period that influences morphology of community. The most valuable because of the biodeversity and number of rare species is a cuspate sedge association (altogether 48, 15 of them are rare), the following is reed-cuspatesedge one (altogether 87, 6 of them are rare).

In the considered area of pure community there is practically no common reed. This is conditioned by natural hydrologic conditions (spring floods carrying considerable amount of alluvium on one part and not so large water level fall on the other hand).

Water vegetation is presented with duckweeds and pondweeds integrating community of free-floating and bottom-fixed plants with the leaves immersed in water. Diagnostic species are: frogbit, small duckweed, three-lobate duckweed, common multiply root, Canadian Elodea, dark-green Ceratophyllum, eared Muriophyllum, whorled Muriophyllum, flattened pondweed, shiny pondweed, perfoliate pondweed, compact pondweed, straight bur-reed and others. Among them there are species put into the Red book of Ukraine, – floating water nut, floating Salvinia, floating heart, white spatterdock, yellow spatterdock. Vegetation of these species develops in not stagnant ponds and gullies of fore delta under conditions of insignificant fluctuation of water level during vegetation period, conditioned by hydrologic peculiarities of the Danube. Only in the delta of the Danube among the rivers of northwest territories near the Black Sea there are cenosis of duckweed-azole, grass-azole, as well as the community of water nut, floating heart types, spatterdogs, put into the Green book of Ukraine.

Communities of pilot vegetation of the seaside integrate Cakile maritime forming on upper boundary of land wash. Diagnostic species are Black sea Sinapis, sea knotweed, spurge water-purslain-like, spear-shaped orache, Russian thistle soda-bearing, perforated camomile, which the succession families of littoral vegetation start with. They are followed with species of Khonkenio class (water-purslain-like) - sand leumus integrating community of seaside bank. Its diagnostic species are represented by Black sea leumus, sand leumus, seaside fever-weed, Siberian Tourneforcia, sand sagebrush, Russian thistle soda-bearing, Colchis sedge, white melilot.

Tree vegetation is represented with willow and integrates flood-lands wood and bush community of white willow, ashy willow, fragile willow, black poplar, white poplar, high ash-tree and others, timed to the near-riverbed ridges of estuary-adjoining row of geocomplexes as well as narrow-leaved loeaste, silver loeaste, sea buckthorn, scattered tamarisk entering in frutescent community of low-salt sand soils of estuary geocomplexes.

Meadow vegetation of large-grass marshes class is represented with shoot forming bent, giant bent, Azov bent, meadow foxtail, reed foxtail, couch-grass, Azov couch-grass and others. It is typical mainly for estuary-adjoining and partially formed estuary geocomplexes. Halophytic vegetation of statice of Meyer, South-Bug statice, cauline galimione, spread puccinellia is typical for the same geocomplexes like the preceding group, however for the areas of the secondary salinity. This type of vegetation has the least popularity in the area of the DWNR.

According to skeleton maps there are 2 types from the Red book noticed in the area of the Bystre Branch (Fig 4.22) and two grouping of the Green book (Fig 4.23), moreover the places of their growing are widely spread throughout the territory of the reserve main core.

The impacts of the DWNR on biocenoses, populations and individual plant species will be of a double character: on the one hand, wave-breaking effects during ships' movement may result in changes of vegetative cover in the riverside of the Bystre branch and falling out of many species and communities, including rare ones, and on the other hand, navigation will contribute to saturation of flora with newly arrived species, including quarantine ones.

Of rare communities of marsh type vegetation the most sensitive to man-caused influence are the Carex acutiformis and Phragmites australis, species-poor reed communities will be formed, in the place of their possible falling out.

Possible reduction of tree and bush vegetation areas of channel banks under the influence of wave activity is fraught with serious consequences, which will require artificial reforestation for coast protection.

Fig. 4.22 – Map of the main places of vegetation of vascular plants put into the Red book of Ukraine on the territory of the DBR [35]

Fig. 4.23 – Map of the main places of vegetation groups put into the Green book of Ukraine on the territory of the DBR.

In consequence of dredging and hydraulic engineering operations in the sand-bar of the Bystre branch and passage of ships along the approach channel, it is possible to damage coastal sand ecosystems of the Ptychiya spit and the adjacent area of the Kubanskiy island, as well as communities of the Red Book species of floating water-chestnut and floating-moss, that began to develop in the newly-formed freshwater internal reservoir – the Bystre (kut).

It is necessary to take into consideration the impact of runoff redistribution, that may occur as a result of dredging operations, on the flora and vegetation of ecosystems of the whole reserve, not just the area of the ships' navigation. In case of reduction of discharges of the other branches overgrowth of internal reservoirs (kuts) will quicken, as well as withering away of small narrow straits, general prairification of grass vegetative cover.

At the same time, the danger of damaging even the most vulnerable and valuable vegetative groupings growing on channel and coastal banks in the zone of ships' navigation is not imminent. When installing navigation equipment in a floating version direct intrusion into these territories is eliminated. Wave impact on channel banks under speed restriction of the ships' movement along the branch is reduced effectively. It is also considered workable to restrict the use of mosquito-fleet during the ships' navigation operating period at the level close to the modern one.

If these conditions are met and the existing water discharges of the Bystre branch are maintained by means of engineering structures, creation of ships' navigation on vegetation of the adjacent areas will not threaten to preservation of biodiversity of plant kingdom and the places where valuable plant associations grow.

To detect possible negative consequences of creating a navigation channel along the Bystre Branch, additional research and constant ecosystem monitoring, first of all in the channel affected zone, are necessary.

All this permits to consider the probability of preserving vegetation of the Bystre branch area high enough to regard the impact on the DBR plant kingdom acceptable.

4.5.3 Characteristic of fauna and analysis of impacts on it

4.5.3.1 Insects

According to the data [9], insects (about 3,500 species) that belong to 23 kinds predominate among terrestrial and amphibia invertebrates in the DWNR construction and operation zone of impact. Most of them (90%) belong to 6 kinds: hymenoptera, diptera, beetles, Lepidoptera, homoptera and bugs. Of 8 types of the DBR entomocomplexes 7 occur in zone of impact (the steppe one is missing). Of them 5 are represented very well – juncaceous, grass, psammophytic, fruticose and forest flood-plain ones. The fruticose entomocomplex occupies the largest area. The grass and fruticose complexes are notable for the greatest specific diversity. Brackish and anthropogenic ethnomocomplexes occupy a very small area and are characterized by the lowest specific diversity. Of insects found in the zone of impact, 23 species (56% of all protected species, found in the DBR) are inserted in protection lists; they belong to 7 classes: butterflies (8 species), hymenoptera (7), beetles (3), dragonflies (2), day-flies (1), orthopterans (1), and diptera (1). Of 23 species of protected insects found in the zone of impact, the species entered into the Red Book of Ukraine constitute the biggest number (15). One specimen each is entered into the European Red List and the Bern Convention list, two species are included simultaneously into the RBU and the ERL, another two – into the ERL and the Bern Convention list, 1 specimen is entered into the RBU, the ERL and the IUCN list, one more – into the ERL, the Bern Convention list and the IUCN list.

Hence, by insects composition, the areas that are included in zone of impact **belong to highly valuable in ecological and scientific respects. The scale of the DWNR impact on insects is determined by impact on vegetation and landscapes that are a habitat of insects and, therefore, will be insignificant.**

4.5.3.2 Hydrofauna

The DBR hydrofauna is represented by fish and water invertebrates.

Ichthyofauna is a very important component of the Danube biodiversity. Fish play a key role in trophic chains. Besides, no other group of wild animals has such an important economic significance as fish.

A great diversity and considerable sizes of natural habitats of fish, from fresh to sea water areas, as well as a specific geographical location, cause a great biodiversity and density of the Danube ichthyofauna.

In the Ukrainian delta of the Danube according to the data [9], there are 95 species of fish that belong to 31 families, of freshwater species representatives of the families of carp, perch and goby predominate.

This number includes all fishes from the European Red List. Of sturgeons, these are spiny sturgeon and Atlantic sturgeon; of salmons, these are Black Sea salmon and Danube salmon, of perches these are big chop and little chop. (In the DBR 15 fish species out of the 32, entered into the Red Book of Ukraine, are found. Besides the mentioned ones, these are beluga, sterlet, *Rutilus frisii*, light weakfish, red goby, Danube shemaya, striped ruff, yellow gurnard.)

The annual catches of fish in the river range between 500 up to 1,500 tons. The base of the catch in the Danube is made of Danube shad and crucian carp that make up on average 49.2% and 32.6% respectively. The share of bream in the total take makes up on average 10.3%, of sazan – 8.0%, of pike perch – 2.7%. During last years the share of herbivorous fish in the catches and, first of all, silver carp + bighead – 2.5%, has increased significantly. The share of sturgeons in the catches during last years makes up about 5%. Catfish, vimba, pike and other commercial fish are also caught in the river. Altogether 43 fishing organisations do fishery in the Danube.

Of food species the most interesting are sturgeons, but the most important in the economic aspect is Danube shad.

At present one of the main ecological factors that affect the size of the main fish species are the conditions of their reproduction. As a result of a large-scale diking of the floodplains carried out in 1960-1970, about 30,000 hectares of most valuable spawning habitats were cut off. The main factor affecting reproduction conditions of the fish directly in the lower part of the river is the water level regime (height, terms and duration of the flood period).

It is a sharp decrease of the number of sturgeon species that not only were of great industrial importance, but also played a significant role in the Black Sea ecosystem that gives maximum concern. It should be noted that spiny sturgeon (*Acipenser nudiventris*) and Baltic sturgeon (*Acipenser sturio*) have always been rare species here. At the same time sterlet (*Acipenser ruthenus*) was a usual food fish formerly, but in 1964 already it ceased to be noted by fishing statistics, though the number of its migratory young fish is sometimes the greatest among all sturgeon species.

The number of three other species of migratory food species of sturgeons – Great sturgeon, *Huso huso*), Russian sturgeon (*Acipenser guldenstadti colchicus*) and Starred sturgeon (*Acipenser stellatus*) has decreased sharply. In 1994, as Great sturgeon was included in the Red list of Ukraine, its catch was forbidden. That same year Ukraine unilaterally imposed a ban on catching sturgeons; and from 1995 only its scientific and experimental catch is carried out. The Danube is the last Black Sea basin river where natural spawning of migratory sturgeons still takes place.

A small number of spawning grounds are located in the lower course of the river, their bulk is outside Ukraine. Accordingly, the Ukrainian section of the river is mainly a spawning route of the sires and migratory route for the fry, the fore-delta also serves as foraging area for sturgeon whitebait.

According to the data [49], the total foraging area of migratory sturgeons of the Ukrainian delta of the Danube within 5 km coastal zone makes up 16,250 ha. The mean annual concentrations of sturgeon whitebait makes up: Great sturgeon – 0.05 sp./ha, sturgeon – 0.35 sp./ha, Starred sturgeon – 0.75 sp./ha, Spawning migrations of sturgeons and downstream migration of the whitebait down the Danube are extended in time. The main run of sires takes place in March – June and the first whitebait are found in the Starostambulske estuary and in the adjacent seashore sections in the beginning of May.

Average fry sizes are 6-9 mm; the downstream migration takes place during 3-4 month from the end of April till the beginning of August. The main downstream migration takes place mostly along the main riverbed 4-10 m beneath the surface. The whitebait downstream migration from the late spawning sires may be delayed.

After turning to active feeding, the predominating part of sturgeon, Great sturgeon, Starred sturgeon whitebait migrates to estuary part of the river where they feed till September-October. 95% of sturgeon whitebait migrates downstream to the sea not gaining the mass of 2 g, while specimens with the mass not less than 1 g make up 72%.

Great sturgeon whitebait, having reached 3-6 cm in length, moves to coastal shallows where it is kept throughout summer. Till September Great sturgeon young-of-the-year reach 26-30 cm in length and 40-65 g in weight. Great sturgeon whitebait grows 2 times faster, thus it passes to predatory way of living in the first decade of active feeding already.

The second subject in significance and the first one in catches is Danube shad. Annual catches in the 80s reached as high as 350-400 t. In 1994-1997 – 210-290 t. Since 1990 an abrupt decrease of catch (18.0 t in 1999, 78.9 in 2000) is observed. (Table 4.5.1).

Table 4.5.1 – Dynamics of fish catch in 1991-2000 within delta of the Danube (within the DBR borders) according to the DBR data (tons)

Species	Years										Average	%
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000		
Great sturgeon	2.4	1.7	0.1	-	-	-	-	-	-	-	0.42	0.1
Sturgeon	4.1	3.2	1.7	-	0.4	0.5	1.5	0.9	0.1	0.38	1.28	0.3
Starred sturgeon	0.2	0.4	-	-	-	-	-	0.1	0.3	0.35	0.13	-
Shed	323.2	308.3	169.7	293.1	218.5	266.4	272.6	159.4	16.9	71.4	209.95	56.1
Clupeid shad	-	0.2	0.1	0.9	0.2	1.3	1.6	-	1	-	0.44	0.1
Sazan	54.8	44.8	32.7	32.4	39.0	21.4	4.0	5.9	3.85	3.19	24.2	6.4
Pike perch	16.6	5.6	4.1	8.4	1.5	1.4	-	0.7	0.3	0.61	3.92	1
Cat-fish	0.1	-	0.2	0.4	0.4	0.1	-	0.1	0.1	0.43	0.18	-
Vimba	2.6	5.5	5.8	2.7	4.6	1.8	0.5	1.9	0.7	1.3	2.74	0.7
Bream	73.4	17.9	6.6	17.1	17.8	13.1	12.2	15.9	7.2	2.4	18.36	4.9
Crucian carp	175.1	99.2	76.9	42.0	104.7	93.8	66.2	55.5	54.7	40.15	80.82	21.6
Pike	-	-	0.1	-	0.1	0.6	0.1	-	-	0.2	0.11	-
Cuprinid	5.0	2.9	4.2	3.3	5.1	6.7	3.9	2.7	1.7	1.35	3.68	0.9
Silver carp + bighead	2.8	18.9	48.5	67.7	50.0	29.9	7.4	5.5	2.5	-	23.32	6.2
White amur	0.2	0.3	-	-	-	-	-	-	-	-	0.05	-
Rudd	10.6	0.9	3.0	-	-	-	-	2.3	2.8	1.73	2.13	0.5
Roach	1.2	1.0	0.2	0.5	-	-	-	1.6	0.2	0.27	0.49	0.1
Silver bream	-	0.9	4.8	2.0	0.6	-	-	0.7	0.6	1.44	1.1	0.3
Sicklefish	-	-	-	0.1	-	-	-	-	-	-	0.01	-
Perch	7.3	0.4	0.5	0.1	0.3	-	-	-	0.2	0.4	0.92	0.2
Mullets	-	-	-	-	-	0.3	-	0.2	0.1	0.5	0.11	-
Total	679.6	512.1	359.2	470.7	443.2	437.3	370.0	253.4	92.4	126.1	374.4	100

Danube shad is a typical migratory fish that spawns outside the Ukrainian part of the river. Because of pelagic spawn it proved less sensitive to an abrupt decrease of spawning ground area. The mean annual shad number is relatively stable and natural annual number variations are a characteristic peculiar feature of the family. The catch decrease in recent years is explained, first of all, by lesser quantity of shad delivered to fish receiving centres. Besides, for reasons unknown, spawning migration of shad in 1999 was 12.4 times less the average rate of ten years.

Spawning migration of shad sires takes place from the end of March till the first half of June, depending on hydro-meteorological and other conditions. The majority of shad migrates very early now, and its main catch takes place in March-April, before the ban to catch it takes effect. Downstream migration of sires after spawning begins in May.

The main spawning grounds are located outside the borders of Ukraine, 500-600 km from the Danube estuary. Because of pelagic spawn, the decrease of spawning ground areas during the river diking did not affect the shad reproduction.

Shad spawn and its fry migrate downstream passively with the average speed of about 80 km a day. Intensive downstream migration of whitebait is observed from the end of May till the beginning of June. The drift takes place only in the upper two-meter water layer (most of them drifts in the water layer from the surface to the depth of 1 m – 90%). Shad fry are found any deeper sporadically. The degree of water transparency determines the fry distribution in the water mass: the increased suspended matter content in water keeps the fry closer to the surface of 0 – 50 cm, more transparent water allows to keep deeper 50-150 cm.

The whitebait downstream migration is at its most intensive in daytime. In the riverside the whitebait is usually found during the morning or evening hours. In case food is available the fry start to feed during the downstream migration, which affects their development and survival on approaching the feeding areas. Most fry migrate downstream to desalinated sections of the sea where their further development takes place, but a certain part of them is detained in the river and is brought in the lakes. The downstream migration period of Danube shad whitebait in the Danube lower course may take as long as 4 months, the mean annual downstream migration of whitebait in the Ukrainian section makes up 200-250 million specimens. [49]

Rare endemic fish species, such as little chop (*Zinger streber*), big chop (*Z. zingel*), striped ruffe (*Gymnocephalus schraectcer*) and some other small fish species almost never get caught into fishing instruments. That is why no special measures are necessary to preserve these and other species of small fish, other than preservation of the existing biotopes.

During the last decades the golden carp that occupied the vacated econiche of valuable fish species sharply predominates among freshwater/semi-migratory fish species. As an active detritophage, the crucian carp avoids food competition; it is undemanding to the spawning substratum, matures early and has an extended spawning period.

Sea fish (grey mullets, silverside, flounder (*Platichthys flesus luscus*) and others) under favourable conditions enter estuary sections of the Kilia delta, they are constantly found in shallow waters of estuarine seashore of the river delta.

The distinctive feature of the Bystre branch with its increased current velocity is that reophilic rare fish species, such as little and big chops, striped ruff, gudgeons, madder, sturgeons, etc. are found here more often than elsewhere. Here a significant downstream migration of sturgeons' whitebait – Starred sturgeon, Russian sturgeon, Great sturgeon and sterlet takes place. Because of the greater discharge, it is one of the main ones along which passively drifting Danube shad fry migrate downstream.

Great water masses carried by this branch attract Danube shad there during its spawning migration. Wide river banks in the narrow strait and a greater depth are favourable for its successful catching. That is why in the 90th the average annual catches of Danube shad in the Bystre branch made up 16.7% to 51.1% [49] (according to the DBR data – up to 21.1%) of all shad catches in the Kilia delta.

Because of considerable depths, cat-fish and sazan are successfully caught there, in winter time wintering gatherings of many fish species are observed there. In that season sterlet is caught there more often than in other narrow straits.

An interesting distinctive feature is that the greatest concentration of river crayfish, as compared to other branches, is observed there.

During the last five years, big catches of red-finned mullet have been registered in the area of the sand-bar of the Bystre branch. Shallow waters of this narrow strait are traditionally noted for good catches of vimba. Because of spacious shallow waters the sand-bar zone, blocking the entrance to the Kilia bay in the form of a reef, is of great significance for all hydrobionts. These are excellent feeding grounds both for whitebait and mature fish of many food species.

In other fishery aspects the Bystre branch is similar to other Kilia branches.

Qualitative composition of **water invertebrates** in the water areas of the DBR is notable for species affluence of the so-called Punto-Caspian relict fauna. These hydrobionts came into existence and evolutionary formed 1.5 million years ago in the ancient Sarmatian saltish lake-sea, on the place of which the Aral Sea, the Caspian Sea, the Azov Sea, and the Black Sea appeared later. In the Caspian Sea, as well as in certain sections of the Azov Sea and the Black Sea, this ancient unique fauna complex of hydrobionts stands out for its specific affluence, singularity and an important significance in forming a nutritive base for the fish.

In the Ukrainian part ot the Danube delta, in particular in the DBR, Caspian relict species of water invertebrates are mass forms. They form the base of plankton and benthos biotic communities. 96 species of Punto-Caspian relics are present within water faunistical complexes of the reserve. Among them there are 3 hydroids' species, 9 *Oligochaetes* species, 1 leech species, 22 mollusks' (shellfish) species, 2 *Cladocera Crustacea* species, 9 *Ostracoda* species, 4 copepods species, 1 *Isopoda* species, 33 *amphipoda* species, 9 cumacean species, 8 opossum shrimps species, 1 *Decapoda* species, 1 tick species.

Three mollusk species, 4 *Rotifera* species and 1 infusoria species, as well as some species of amphipoda, two *Decapoda* crayfish subspecies belong to endemics of the Danube delta.

Along with freshwater hydrobionts, saltish water ecosystems occur in the Kilia delta front.

The Danube and the Black Sea contact area is a specific seashore ecosystem. Aside from suspended substances and dissolved biogenic elements, 100 to 200 thousand tons of fresh water plankton and other organisms that die there and sink to the bottom, forming stocks of organic substance, get to sea each year with the river discharge. This phenomenon is of great importance for the processes of forming biological productivity in the North-western part of the Black Sea.

Because of its physico-geographical and ecologo-hydrological conditions, the Bystre branch plays a significant role in the Kilia delta in whole and is of great importance for the territory and water area. That applies to biological diversity of water and land plants and animals, as well as to important ecological processes, in particular to passing of spawning migrations, feeding and wintering of water organisms. Under normal weather conditions, water in the Bystre branch remains fresh from surface to bottom. On the one hand, this results from a constant current towards the sea, and on the other hand, by existence of a sand-bar in the sea in front of the mouth. That is why zooplankton and zoobenthos in the Bystre branch are mainly of freshwater nature from surface to bottom.

Negative impact on hydrobionts at the DWNR creation results first of all from carrying out construction work to remove bottom sediments that result in changing ecological situation in the river.

The work of dredging equipment results in upsetting ecological situation in the river: the density of suspended mineral substances in the water mass increases, colour and transparency change.

During the work of dredging and dumping the solid suspension solid concentration can increase in times. It results in decrease of feed organisms' quantity and biomass, death of spawn, fry and whitebait; besides, death of plankton organisms happens in the volume of water-soil compound.

The increased content of suspended particles has a negative effect on **phytoplankton**: its quantitative indicators decrease, the change of dominant types takes place. Suspension particles break large cells and colonies of water-plants, increase the speed of plankton forms settling, cover **the submerged macrophytes**. Due to the small-sized particles, the rivers' self-cleaning happens too slowly, phytoplankton partial renovation takes place at a considerable distance from the work site and in the work sections with the increased content of suspended particles it is much poorer in a quantitative and qualitative sense.

The decrease of quantity, biomass and the depletion of **zooplankton and benthos** specific composition results from direct influence of suspension on search functions and breathing conditions of the organisms in the work zone. Removal of top layer of bottom sediment or sediment dumping results in biocenoses reformation, disrupts the benthos structure, and makes organisms unstable to survival.

The impact of carrying out construction work on **ichthyofauna** may be expressed in death of fish whitebait, feed organisms, disruption of spawning grounds, crossing of fish migration and downstream migration routes. In the first place, the increase of suspended particles negatively affects the fry and the whitebait, whose organisms are weaker as compared to the grown up fish. In the increased turbidity area mature fish undergo morphometric changes in the organism, in particular, body weight and size, fertility, which affect the quantity and the quality of the progeny.

While carrying out construction work, the water areas lose their fishery significance, which results from the absence of feed organisms, the increased noise during the mechanisms' work, the increased turbidity. Adverse factors scare away fish, block the routes of spawning migrations and the whitebait downstream migration.

During the construction period the food reserve in the places of dredging will be terminated temporarily. Also, the water area in the zone of the sea protective dam construction is forever withdrawn from fishery use. Besides, the change of environment state as a result of deepening the bar part will result in the loss of these areas for feeding conditions of whitebait of the most valuable ichthyofauna representatives – sturgeons.

Carrying out works during nonspawning period cuts out the impact on spawning migrations and downstream migration of migratory fish whitebait.

For the purpose of reducing the negative impact of construction work on biocenoses of the ponds, it is necessary to carry them out only in accordance with the project and only in coordination with fishery protection bodies.

Due to intensification of processes of salt sea water wedge penetration into the Bystre branch, shifting of transitional zone of freshwater/saltish water biocenoses of bentos upstream and dominance of ev-halobionts in the middle part of the branch is predicted. Such local transformation will not lead to significant failure of biocenoses of the Kilia delta branches and marine marge of the delta in whole, and it will not affect reproductive conditions of fish stock.

4.5.3.3 Amphibious and terrestrial vertebrates

According to the [9], in the zone of projected construction of the DWNR along the Bystre branch live 10 species of amphibious, 2 species of reptiles, 29 species of mammals, that makes up 91%, 40% and 74% of species composition of the corresponding groups of vertebrates in the DBR fauna. Of them, 10 species of mammals are entered into *the Red Book of Ukraine*; 3 species of amphibious, 1 species of reptiles, 5 species of mammals are entered into the IUCN Red list; 3 species of mammals are entered into *the European Red List*; 9 species of amphibious, 2 species of reptiles and 19 species of mammals are entered into t*he Bern Convention List*.

Such species as the Danube triton (*Triturus dobrogicus*), red-bellied toad (*Bombina bombina*), common tree-frog (*Hyla arborea*), common spade-footed toad (*Pelobates fuscus*), swamp tortoise (*Emus orbicularis*), ermine (*Mustela erminea*), European mink (*M. lutreola*), European otter (*Lutra lutra*) have in the DBR, including the area of the Bystre branch, a very high or a considerable population size, while in many countries of Europe they are threatened with extermination. The importance of the DBR for preservation of these species on an all-European scale is very great. *T. dobrogicus* triton lives only in the lower course of the Danube, i.e. it is a narrow endemic; and the species itself is an endemic of the Danube basin. *Rana lessonae* frog in the DBR is known for certain for three points only; two of them are located in the Bystre branch zone. The wood cat (*Felis sylvestris*) and the monk seal (*Monachus monachus*) are very rare animals; the territory and the water area of the DBR, and, in particular, the Bystre branch zone, are extremely important for their preservation.

The zone wetlands have considerable resources of fishing and game-preserve species – green frogs (first of all, lake frog *Rana ridibunda*), musk-rat (*Ondatra zibethicus*), common fox (*Vulpes vulpes*), raccoon dog (*Nyctereutes procyonoides*), boar (*Sus scrofa*). The predominant majority of amphibious', reptiles' and mammals' species that live in the Bystre branch zone give preference to channel banks, littoral ridges and internal lakes (*kuts*). These natural elevated territories and water stretches act as centers of biodiversity under conditions of large areas of continuous undergrowth of reeds, reed maces, and sedges in the Danube delta.

Creation of the DWNR will not cause direct damage to amphibious and land vertebrates, as it will not disturb their habitat territories. At the same time, to a greater or lesser extent, scare effect caused by construction machinery and ships passing will be revealed, despite the measures taken in the project to decrease such effects. This will result in a certain decrease in the size of the vertebrates' fauna in the riverside of the Bystre branch, and in migration of a certain number of animals to similar biotopes of other branches. An impact like that in the zone of anthropogenic landscapes should be considered acceptable.

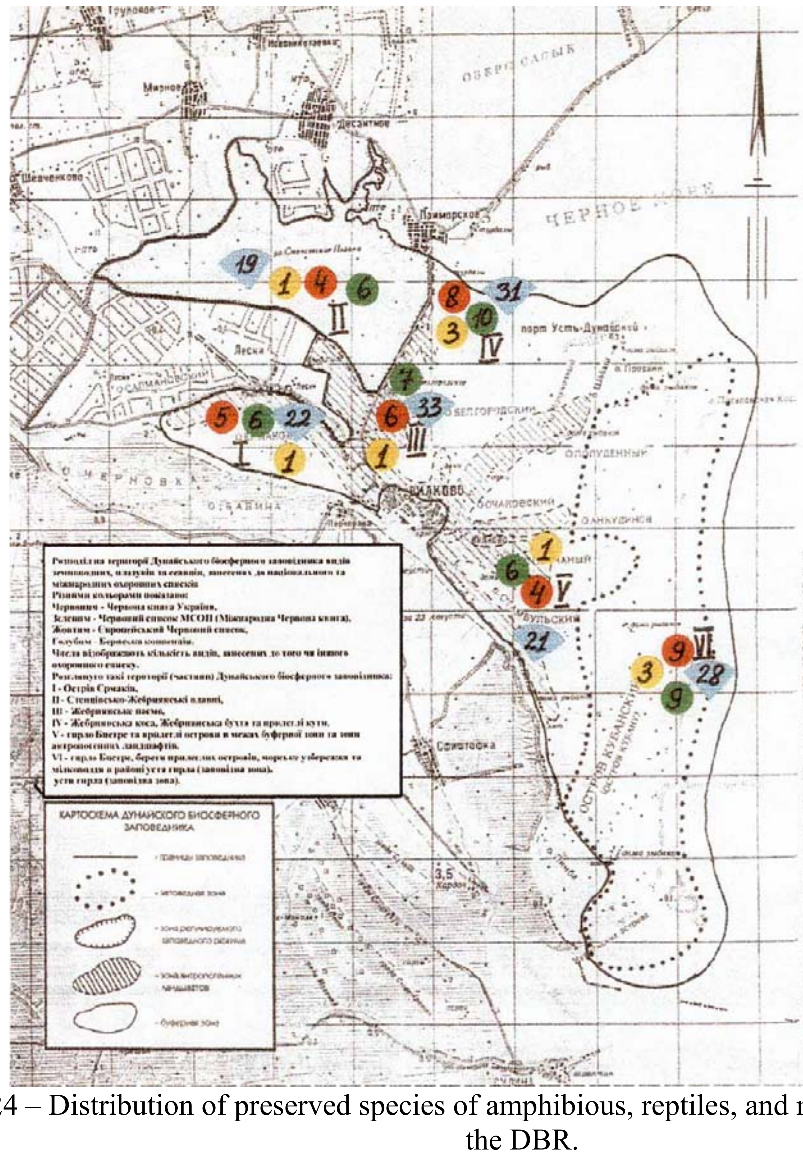

Fig. 4.24 – Distribution of preserved species of amphibious, reptiles, and mammals within the DBR.

4.5.3.4 Birds

Wetlands of the Kilia delta are of international importance, mainly as places of water birds reproduction and mass gatherings. About 257 species of birds (that makes up about 62% of ornithofauna of Ukraine) can be found here, of them 124 species nest in the Danube delta. Migratory birds make up the most numerous group – 196 species. A significant number is known hibernating – 129 species. 41 species are recorded as summering, 3 – as migrant, 8 – as straying. 42 species are entered into the Red Book of Ukraine and into the European Red List [9]. Wetland grounds of the Kilia Delta of the Danube were entered into the List of wetland grounds of international significance as early as 1975. This high status of wetland grounds of the Kilia Delta of the Danube was confirmed in 1996 by the Convention on wetland grounds of international significance on the basis of Ramsar Convention of 1971. The uniqueness and nature-conservative value of many Danube delta ornithocomplexes on a European or a global scale, as well as key importance of the Danube delta for preservation and reproduction of a number of globally vulnerable bird species, are generally known.

An absolute majority of ornithocomplexes known for the DBR have one or another nature-conservative status, they fall under the force of some or other international nature-conservative conventions and agreements. 42 species (about 16%) among which 11 are known as nesting, 31 – as flying past, 22 – as wintering, 16 – as summering, 2 – as straying, are entered into the Red Book of Ukraine (1994) and into the European Red List (1991). Dalmatian pelican (*Pelecanus crispus*), Pygmy cormorant (*Phalacrocorax pygmaeus*), Red-breasted goose (*Rufibrenta ruficollis*), erne and others are entered into the IUCN Red book.

Waterbirds and wetlands birds, especially *anseriformes* (swans, geese, ducks), totipalmate birds (pelicans and gannets), *Ciconiiformes* (herons and guaras), charadriiformes (sandpipers and seagulls) have a leading place in the reserve ornithofauna. Among them are Great white pelican (*Pelecanus onocrotalus*), spoon-bill (*Platalea leucorodia*), glory ibis (*Plegadis falcinellus*), yellow heron *(Ardeola ralloides*), white-eyed pochard (*Aythya nyroca*), big and medium sandpiper and others, entered into the Red Book of Ukraine [9].

For some of them, such as pygmy cormorant, the Danube delta is a key area on a global scale, for Dalmatian pelican – on a European scale.

Of four main reserve sections, the greatest diversity of birds' species is typical of the secondary delta of the Kilia branch. Next in this line are the Stentsovsko-Zhebriyanski Plavni (, the Zhebriyanski dunes and the Yermakov Island.

In the secondary delta of the Kilia branch the main colonies of cormorants, herons and ibis are located. The vast shallow waters of the Kilia delta coastal zone, where the birds' seasonal gatherings boast as many as 50,000 specimens, are of special significance for water and circum-water birds. Here the majority of migratory ducks amass. In certain seasons the number of wild duck alone reaches 16-20 thousand specimens, there are as many bald-coots. Other species are less numerous. Almost annually from 500 to 5,000 mute swans mew in the southern sludgy section of the delta front.

Almost all birds' species of the reserve meet in the area of construction of the DWNR along the Bystre branch with one or another degree of regularity.

Along the channel within the DBR the following main ornithocomplexes are allotted:

- of littoral low islands and spits;
- of desalinated littoral shallow waters;
- of bush undergrowth on littoral on sand-sludgy dunes;
- of reed-sedge undergrowth;
- of flood-plain willow woods.

The most valuable of them – ornithocomplexes of littoral low islands and spits and of desalinated littoral shallow waters are located in the sand-bar part of the DWNR. One of the two most important colonies of charadriiformes birds in the reserve is located there at present. Oyster catcher (RBU), snowy plover (RBU), common tern and sandwich tern, herring gull, avocet nest here.

At present time man-made impact on birds populations in the DBR reserved zone is quite insignificant. Among man-made factors two main groups stand out: direct action factors (commercial fishing, partial recreation burden, pyrogenic (fire) factor, regulated pasturing) and indirect action factors (man-made changes of the river and delta hydrological regime, the impact on delta formation processes, deterioration of water quality, general deterioration of air basin quality and global environment pollution). According to ornithologists [9], all of them are not a determining factor for birds populations functioning on this territory.

Ornithologists consider one of the most essential negative consequences of construction work on the Bystre branch sand-bar to be a prospective merger of the Ptichya spit with the sea boundary of the delta, that will result in loss of safe places for wintering and nesting of protected birds species [9]. The spit washing away, they believe, will lead to even greater negative consequences.

A general assessment of possible consequences of the construction for ornithofauna, made by experts of NASU, is presented in Table 4.5.1.

Table 4.5.1 – Characteristic of impact of the DWNR construction and operation on birds

Indices	Values
Total number of birds' species in zone of direct impact of construction	245
Number of species from ERL	5
Number of species from RBU	36
Size of nesting complex in the direct risk zone, couples	up to 5600
Total number of birds from RBU on nesting in the direct risk zone, specimens	up to 10
Number of autumn gatherings in the direct risk zone, specimens	up to 3200
Total number of birds from ERLt in autumn gatherings, couples	45
Total number of birds from RBU in autumn gatherings in the direct risk zone, specimens	up to 450
Size of wintering complex in the direct risk zone, specimens	up to 750
Total number of birds from ERL on wintering in the direct risk zone, specimens	up to 25
Total number of birds from RBU on wintering in the direct risk zone, specimens	up to 270
Probability of violation of aboriginal ornithocomplexes structure	High
Probability of violations ecosystemic character	Very high
Practical possibility of compensating the predicted losses	Very low

Such assessment corresponds to the most pessimistic predictions of the impact of the DWNR creation on the landscape of the zone of its impact and, besides, it does not take into account high mobility and adaptability of birds. Assessments of man-caused wave factor, made by Hydromechanics Institute of NASU does not give reasons to forecast significant changes in configuration of the Ptichya spit in connection with the DWNR creation. At the same time, natural instability of the delta sea boundary does not give reasons to count on long-term existence of the Ptichya spit and other temporary formations of the bar zone of the Bystre branch with or without the navigable channel. On the other hand, further designing protective engineering structures in the sand-bar zone taking into account the tendencies of the spit configuration changes, revealed during the experimental operating period, permits to increase stability of its state.

Under such conditions, a sufficiently slow evolution of the existing habitats, close to normal one, may be forecast, and on the strength of this assess the navigable channel impact on ornithofauna as acceptable, provided that ecological restrictions on carrying out construction work, stipulated by the project, are observed. ***Particularly important for***

preserving ornithofauna is the ban to carry out work in the bar zone during the period of birds' nesting.

4.5.3.5. Conclusions on flora and fauna

The assessment of the DWNR creation on separate environment components shows that, taking into account the measures to ensure normative condition of environment and ecological safety, stipulated by the project, residual effects are limited in scale to the territories, directly adjacent to the route, which are attributed to the zone of man-made landscapes. This is acceptable according to the current environmental legislation.

Construction and operation of the DWNR will not lead to changes in number and species composition of the DBR biota.

Biotic groupings of the Bystre branch area, including rare species and aggregations, are not unique for the DBR, they are widespread within its territory. That is why certain local successions of vegetative associations and partial migration of animals from the branch itself and its riverside, that may happen in connection with the DWNR creation, do not pose a threat to preservation of the reserve biodiversity, particularly to existence of rare and especially valuable representatives of plant and animal kingdoms on its territory.