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REPORT

ON SCIENTIFIC RESEARCH WORK

Environment Impact Assessment (EIA) within the framework of the project "Creation of the Danube – Black Sea Deep-Water Navigation Route in the Ukrainian part of the delta. Full development"

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ABSTRACT

This report consists of 187 pages, 70 tables, 30 figures, 11 annexes, 90 sources.

Subject of the research:

Development of the Danube–Black Sea Deep-Water Navigation Route

Purpose of the work:

Environmental Impact Assessment (EIA) of the DWNR

Characteristic of natural, antropogenic and social conditions of the territory of the DWNR development is provided. Here is given the assessment of environmental impact both during the creation process provided by the *Project for the full development of the Danube-Black Sea Deep-Water Navigation Route at the Ukrainian part of the delta* and during the period of operation of the DWNR.

DEEP-WATER NAVIGATION ROUTE, DELTA, DISTRIBUTARY, SAND-BAR, IMPACTS TO THE ENVIRONMENT, ENVIRONMENTAL IMPACT

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LIST OF ABBREVIATIONS

BOD – Biochemical oxygen demand

DBR – the Danube Biosphere Reserve

DWNR – the Deep-Water Navigation Route

DHMO – the Danube Hydrometeorology Observatory

ERL - the European Red List

g.s. – Gaging station

HM – Heavy metals

IHMNASU – the Institute of Hydromechanics of the NASU

IUCN - International Union for Conservation of Nature and Natural Resources.

MAC - maximum admissible concentration

MAC.fish - maximum admissible concentration for waters used for fishery

MSU – the Moscow State University

NASU – the National Academy Science of Ukraine

RBU - the Red Book of Ukraine

SAC – Sea approach channel

SMCS - Ship Movement Control Service

SNiP – (rus.) Regulations and Norms of Construction

SS – Suspended solids

SZhP - Stentsovsko-Zhebriyanski Plavni

TC – Toxic chemicals

TCA - Toxic chemical agents

TP - Total phosphorus

FS - Technical and Economic Substantiation for Construction of Facilities

UDS - the Ukrainian Danube Shipping Co.

USRIEP - Ukrainian Scientific and Research Institute of the Ecological Problems

INTRODUCTION

The present research work is fulfilled in compliance with the requirements of the States Building Code DBN A.2.2.2-1-2003 on the basis of the agreement between the Planning-Exploration and Engineering-Design Institute of River Transport *(Rechtransproject)*, Limited Liability Company, Kiev and the Ukrainian Scientific and Research Institute of Ecological Problems (USRIEP), Kharkiv and the additional agreement to the contract.

According to the requirements of the specification there was performed the environmental impact assessment of the Deep-Water Navigation Route (DWNR) with the length of 162.2 km for the 7.2 m draught ships in the work according to the working draft of the DWNR full development at the Ukrainian part of the Danube delta.

According to the item 1.1 of DBN A 2.2-1-2003, the purpose of this research work is to determine on advisability and admissibility of the activity projected and substantiation of economical, technical, organisational, sanitary, legal and other measures of providing of the environmental safety.

In accordance with the requirements of the mentioned States Building Code, this EIA contains:

- general characteristics of the territory under construction;
- analysis and assessment of ecological, social and man-caused factors;
- list of probable ecologically environmental impacts of the planned activity with the determination of their scales, and indication of the zones affected;
- estimation of changes of the environment according to the list of impacts;
- specification of complex measures provided by the project to prevent or restrict the impacts of the planned activity to the environment, necessary for meeting the demands of environmental and sanitary regulations and other legal acts related to the environment safety;
- assessment of admissibility of residual impacts to the environment which are likely to take place subject to the fulfilment of all measures provided.

As the development project of the first phase of construction of the DWNR through the Bystre branch has been approved, and dredging operations has been performed on the sand-bar part of the channel within the period of fulfilment of the present EIA, no examination of alternative variants has been performed.

The following materials have been used in this work:

- Feasibility study of Investments into the Construction of the DWNR “Danube - Black Sea” by the Rechtransproject Institute;
- Research reports of the Hydromechanic Institute of the NASU and the DHMO (conducted within the framework of the feasibility study and the development project of the DWNR);
- EIA of the pass variant along the Bystre branch, Odessa Branch of the Institute of the Southern Seas Biology of the NASU, 2001;
- EIA of variants of the Navigation Route ‘Danube River - Black Sea’ through the locked waterway the Solomonov branch – the Zhebriyanska Bay and through the Bystre branch, USRIEP, 2002;
- The collective monograph “*Biodiversity of the Danube Biosphere Reserve: Preservation and Control*”;
- Report “Evaluation of the Economic, Social, Legal, and International Perspectives of the Construction of the Deep-Water Navigation Route ‘Danube River – Black Sea’ in the Ukrainian Part of the Delta”, NASU’ Council of Studying the Productive Forces of Ukraine;
- “EIA of Design Variants (on the stage of the Feasibility Report) of Creation of the Deep-Water Passage ‘Danube – Black Sea’ in the Ukrainian Part of the Delta”. Institute of Hydrobiology of the NASU;
- Separate volumes of the development project by the *Rechtransproject* and the *Ukrrybproject,* Kiev, and *Noosfera Research Centre,* Odessa.

1. BACKGROUNDS

The reasons for the EIA is the requirements for the development of the section “Environmental Impact Assessment (EIA)” in structure of development projects “Creation of the Deep-Water Navigation Route ‘Danube – Black Sea’ in the Ukrainian Part of Delta”, given by the *Rechtransproject* Institute.

The EIA is performed out in compliance with the legal acts of Ukraine in force dealing with environmental safety and preservation of the environment. This work was performed under all the requirements of the States Building Code DBN A 2.2-1-2003.

An earlier EIA was performed within the framework of the FS of the investments by the Odessa Branch of the Institute of the Southern Seas Biology of the NASU, in which the basic variant of DWNR through the Bystre branch was examined, and the variants through the Starostambulske and Tsyganka branches were the alternative ones [1]. Limited list of variants was the principal cause of directing the materials of the FS for revision according to the decision of the complex investment examination. During the process of revision the USRIEP worked out a comparative assessment of the most perspective variants of the DWNR, *viz*. through the locked waterway ‘Solomoniv branch – Zhebriyanskaya bay’ and further through the Bystre branch [2].

The second complex investment examination recommended the variant through the Bystre branch for the further design as the most economical and ecologically safe. The conclusion of the State Ecological Commission, the major constituent part of the complex state examination, stated that the variant through the Bystre branch is the optimal one according to the EIA, disregarding the reserved status of the territory. At the same time it has been indicated that "Due to existing zoning of the Danube Biosphere Reserve, no environmental impact of either examined designs may be considered allowable". In connection with the existing situation the State Ecological Commission noted the possibility and urgent need of a scientifically reasonable zoning of the territory of the DBR with the obligatory accounting of the possibility of allocation of the DWNR ‘Danube - Black Sea’ in the zone of anthropogenic landscapes.

On the basis of the decision of the National Safety Council of Ukraine of 06.06.2003 "On the State of Realisation of the Decree of the President of Ukraine No. 861 of 10.08.1998, “On the Creation of the Danube Biosphere Reserve and the Perspectives of the Creation of the Deep-Water Navigation Route ‘River Danube – Black Sea’", by his Decree No. 502/2003 of June, 10 of 2003, the President of Ukraine obliged the Cabinet of Ukraine "with the participation of the National Academy of Sciences of Ukraine and interested executive authorities – during two month to develop propositions as to the optimisation of the boundaries of the Danube Biosphere Reserve, its reserved area and conducting of its territory zoning, taking into account the complex solving of the national, regional and local problems, with the consideration of international obligations of Ukraine, providing additional preservation of valuable natural complexes,…and to transfer the branches of the Danube River, which are needed for the development of water transport to the internal waterways”.

The same decree obliged the Cabinet "in accordance with the established procedure – to provide determination of the most effective variant of the DWNR “Danube – Black Sea” in three months on the basis of the complex public examination, taking into account ecological, economical, engineering and other points of view, and to establish an experimental Navigation Route, to provide additional scientific researches, targeted on minimisation of the negative environmental impacts of the construction of the DWNR, and to attract the capital, needed for realisation of this project”.

According to the recommendations of the Central Service of the *Ukrinvestexpertiza Ukrainian Invest Experts’ Commission* the FS for the investments in ‘Creation of the DWNR "Danube - Black Sea" in the Ukrainian part of delta’ through the Bystre branch, has been approved by the order of the Cabinet No. 598-p of 13.10.03 with determination of two stages of construction.

On the basis of the Decree of the President of Ukraine No. 117/2004 dated 02.02.04 with the purpose of improvement of preservation of the unique natural complexes of the Danube delta in natural condition, protection of wetlands of international significance, other valuable natural complexes of Ukrainian Lower Danube region, carrying out of zoning territory of the DBR and management optimisation of their control with the consideration of interests of regional development, transport and other national needs, as well as the activation of international co-operation, research studies and monitoring of the environment, at the same time with the extension of the DBR territory there was ratified the scheme of temporary zoning of its territory (Annex A). In accordance with this scheme and with the purpose of reconstruction of the navigation at the Ukrainian part of the Danube delta, the grounds of protective riverside and its branches – the Bystre branch and the Ochakivske branch – and adjacent part of the Black Sea coastal waters within the boundaries of the DBR were attributed to the zone of antropogenic landscapes (Annex B).

Thus, the Decree introduced the creation of the DWNR at the Ukrainian part of the Danube delta through the Bystre branch within the framework of legal area of Ukraine and eliminated the principle juridical impediments for the realisation of the complex state examination of the development project.

At the stage of the FS and development project of the first stage of creating of the DWNR, Declarations concerning ecological consequences activity was published in the central print press. Therefore it is unpractical to publish declarations of intents at this stage. Detailed declaration on ecological consequences concerning the project of DWNR in full development (Annex C) was also published.

The problems connected with the choice of variants of the DWNR and their potential influences to the environment and the DBR territory have being widely discussed in press [25-31].

Opinion of the community as to the creation of the DWNR at the Danube delta is ambiguous. Some articles both “pro” and “contra” were published in press.

Some representatives of the NASU, the owner of the reserve,, said ‘contra’. Emotional and ungrounded statements of the reserve employees prevail in its position as to inevitable destruction of the reserve in case of passing the DWNR through the Bystre branch. Some environmental organisations functioning as a rule in distant regions from the Danube (Pechenegi, Siberian Ecological Centre, Front, Novaya Volna, Zelenaya Dubna, MAMA-86, Ecopravo-Lviv, Socio-Ecological Alliance and others) did the same. As their statements contain no concrete and grounded objections and remarks, taking these opinions into consideration was found inexpedient.

People of the Ukrainian Lower Danube region declares ‘pro’. That testifies the resolution that adopted at the public hearing with the participation of delegates of local communities at Vilkove, 03.03.2004 (Annex D and E).

In particular, the resolution contains the decision to apply to the President of Ukraine and to the Cabinet with the request to push on the solution of the questions which concern approval of the development project of construction of the first stage of the DWNR ‘Danube – Black Sea’ through the variant developed by the Ministry of Transport of Ukraine, and its immediate realisation.

The development project of the first stage of construction of the DWNR was approved by Decree No. 283-p of 12.05.04 of the Cabinet of Ukraine, taking into account the opinion of local communities and positive conclusion of the complex examination. After that the channel dredging works were started with the simultaneous implementation of a complex monitoring of natural environment.

2. Physical and climatic characteristics of the Ukrainian part of the Danube delta and area of the DWNR

2.1 Basics of the Danube delta and dynamics of the Kilia delta formation

The estuary area of the Danube belongs to the river-delta type and consists of sub-delta parts (length about 85 km), delta (one of the largest in Europe) with area of 5640 km^2, and estuary shore about 1360 km^2 [3]. The length of the delta on its main branch is 116 km, its top is at the place where Danube branches into the Kilia branch (left) and the Tulcea branch (right) (Annex F). The length of delta's sea edge is about 180 km, the average breadth of the sea-bank is 6-10 km. The total area of estuary is about 7000 km^2 [4].

The Kilia branch serves as an extension of the Danube River and it is the main branch of the Danube delta. On its extent the Kilia branch forms two internal and one external (marine or Kilia) deltas. Internal deltas were formed as a result of inwashes by suspended sediments of huge ancient Danube bay. To the present day the most of branches of two internal deltas died off. The largest of remaining branches are Seredne, Tataru, Kislitsky (the first internal delta), Solomoniv, Pryamyy, Babina (the second internal delta). In the Kilia delta the basic branches are the Ochakivske (left) and the Starostambulske branches (right). Ankudinov, Poludenny, Prorva, Potapovskiy, Gneushev branches are detached from the Ochakivske branch, and the Bystre, Vostochne, Tsyganske, Limba and other are detached from the Starostambulske branch. All these branches run directly into the sea.

The length of the Tulcea branch is 17 km. Further it branches into the Sulina branch (69 km) and the St. George (Sf. Gheorghe) branches (109 km). There is a small delta in the estuary of the St. George branch.

Northern border of the delta adjoins to the native margin of Budzhakske plateau and goes on the tops of Yalpug, Katlabuch, and Kitay lakes and on the systems of the Kilia branch. The south-west border of estuary area coincides to the western shore of Razelm – Sinoye lake-lagoon complex. Numerous water bodies (lakes, lagoons), with the total area about 1400 km^2 are placed in the delta.

22 percent of the delta area (1240 km^2) belongs to Ukraine; the remaining part belongs to Romania. The state border between Ukraine and Romania passes on a navigable waterway of the Danube, the Kilia branch and its branches – the Seredne, the Pryame, the Starostambulske and the Limba branches.

The present-day delta of the Danube began forming approximately 5000 years ago in the extensive marine bay, which has arisen as a result of postglacial transgression, when the level of the Black Sea was some meters higher than the modern one. Thousand years ago the bay was partly blocked from the sea by the long marine foreland and was transformed into a huge lagoon. Nowadays the series of sand waves, dragged inside the modern delta from the northeast to the southwest (Zhebryanska, Letya, Karaorman patches), reminds about this foreland. Inside the Danube bay - lagoon, under the foreland protection, a fast forming of delta replacement took place. At first the most southern branch of the delta (nowadays the St. George branch come over the line of foreland [4]. Later the foreland had been broken through in the middle part by the central branch of the delta (by the Sulina branch). In the estuary of this branch the extensive delta of foregrounding had been formed, nowadays it is partly degraded by marine heaving.

It is believed [3], that fast extension of the Sulina branch in the sea had happened in V - I centuries BC, that was promoted, probably, by lowering of the sea level on 2-4 m about the modern one. Then the St. George branch became more active again, which had formed the small delta in the sea. And only approximately in the 16th century the northern branch of the Danube delta (nowadays the Kilia branch) became more active. It had gradually increased its discharge and formed two consecutive internal deltas in a shallow-water bay soon. In the middle of the 18th century, after sediments filling of the almost all the northern part of the bays - lagoon, the Kilia branch had left the line of forelands and began to form a delta of extension called nowadays *marine* or *Kilia*.

According to I.V.Samoylov [5] there was no island in the sea on the Bauer's map (1770) in a place of outlet of the Kilia branch. One island is shown on the map of Pustoshkin (1775), and on the map of Kushelev (1800) seven small islands had been marked already. The further history of the Kilia delta development can be recovered by the analysis of more authentic maps from 1830 to 1980 (Fig. 2.1) [4].

In its development the Kilia delta had passed four consecutive phases: one-branched (1740-1800), mild-branched, when the amount of branches did not exceed 20 (1800-1856), multi-branched, when the quantity of estuary branches amounted to 40-60 (1856-1956) and again the mild-branched one (since 1957), when the quantity of estuary branches had been decreased (from 19 in 1957 up to 16 in 1980, 15 in 1989 and 14 in 1993) (Table 2.1).

Table 2.1 - Morphometrical characteristics of the Kilia delta [6]

Year	Length, km		Area, km^2	Volume of alluvial talus train, km^3	Length of seashore, km	Quantity of branches
	Starostambulske branch	Average				
1830	9..3	8.4	80	2.26	36.2	17
1856	13.6	11.5	111	2.89	47.0	20
1871	13.5	11.9	122	3.45	49.5	23
1883	15.5	13.6	174	4.05	55.6	56
1894	15.6	14.2	214	4.64	47.6	36
1922	19.0	16.3	285	5.66	55.2	47
1930	19.3	16.7	291	6.02	53.6	39
1943	21.3	17.4	308	6.55	56.0	25
1948	22.3	17.7	309	7.01	63.0	23
1957	22.3	18.4	328	7.54	70.0	19
1980	23.3	19.3	348	8.26	59.0	16

The Kilia delta was extending into the sea, always preserving its asymmetry. In the process of deceleration of delta extending to the sea and the reduction of the quantity of estuary branches the indented marine margin of the delta was levelled little by little. After 1930 the line of delta sand beaches became to form along seashore. Their total length increased: from 4 km in 1930 up to 12 km in 1943, 17 km in 1957 and 20 km in 1980. Simultaneously the general length of the marine margin of delta reduced a bit, because the forelands had crossruffed small bays – 'kuty' [4].

The most active growth of the Kilia delta is marked in 1871 – 1922, which were abounding in water. The delta area for this time had increased for 163 km^2 at the average annual rate of 3,1 km^2. In the last decades the growth of the area of the delta slowed down (in 1943-1980 it was only 1,1 km^2/yr) in connection with an outlet of delta on deep waters, raise of the level of the Black Sea and reduction of sediment load of the Danube. For the period of 1955-1979 (Fig. 2.2) the shore extended in the areas of the Ochakivske and the Starostambulske branches, in a smaller measure - at the Bystre branch [7]. By 1980 the area of delta made up 348 km^2, volume of alluvial talus train - 8.26 km^3.

In some parts of marine margin of the delta in the last 30 years erosion became more active and deviation of a shore took place. Areas of bank erosion are located between the estuaries of the Bystre and Vostochne branches (the Kilia delta) where washout in some years achieves 10-15 m/yr and on the big extent of a shore to the south from the estuary of the Sulina branch. For 1962-1992 the general loss of lands had made 2,200 ha (77 ha/yr); washout of a shore in the most cases was about 200 m (in some places up to 340 m) [8].

The amount of runoff of the Kilia branch increased up to the end of 19th - the beginnings of 20th centuries, and then began to reduce, having been decreased to the present day up to 53% (Table 2.2). Apparently, this redistribution of an runoff in favor of the Tulcea and the Sulina branches was stimulated by deepening and cut-off of the Sulina branch in 1880-1902, and also due to extending of the Kilia delta to the sea. For the last 140 years the runoff of the Sulina branch has constantly increased (especially since the beginning of the century) from 7-8% up to 17% of Danube runoff.

The runoff of the dying St. George branch was decreased approximately from 30% up to 20%. In 1984 a line of bends on the St. George branch has been straightened. At present the runoff of the St. George branch makes up 27% of the Danube runoff [4, 9].

Table 2.2 - Water flow distribution by the main branches of the Danube delta

Year	Proportion of the Danube runoff, %			
	The Kilia	The Tulcea	The Sulina	The St. George
1872	63	37	8	29
1895	70	30	7	23
1921	68	32	12	20
1928	66	34	14	20
1943	64	36	16	20
1960	63	37	17	20
1970	61	39	18	21
1980	59	41	20	21
1990	56	44	20	24
2000	53	47	20	27

Channel network of the Kilia branch is very dynamic. There were large lateral branches, *viz*. Potorocha, Kartenko, Rydvan, Dibab, Kislitsky, Stepovoy (to the north of the basic channel), Popadya, Tataru, Dzhetkovo-Saha, Repedeya (to the south from the basic channel) in the first internal delta of this branch in the 18-19 centuries. Nowadays the majority of them died off. The Kislitsky branch still exists, but decreases the amount of runoff (from 10% of Danube runoff in 1940s up to 5% in 1970s). The Stepovyi branch practically died off in 1950s and had been covered. The Tataru branch bears no more than 1% of Danube runoff. The principal runoff goes through Sredne branch with about 90% of the runoff of the Kilia branch (more than 50% of the Danube runoff).

In the second internal delta the Kilia branch branches into Solomoniv (27% of the Danube runoff), Pryamyy (19%) and Babin (about 10%). A set of anabranches died off: Laptysh, Murza, Chat, Zolotoy, Dyra, Stepovoy (Dunayets), Abraimok (to the north from the basic branches), Chernovka, Sulimanka, Khamdzhyyev, Bretushka, Potakova (to the south of the basic branches).

Evidently, process of concentration of runoff in the limited amount of the largest branches takes place (Table. 2.3). Thus, such large branches as Polunochnyy, Shabash, Sredne, Zavodninskiy has already died off; rather large branches such as Potapovskiy, Starostambulske, and as well as small branches such as Belgorodskiy and Limba reduced in the share of the runoff. At the same time some branches became more active – in the direction of the Starostambulske – the Bystre branches. It is evident that redistribution of the runoff from the Ochakivske system to the Starostambulske system takes place. Branches of the Ochakivske system would die off in the middle of XX century [4, 9] but for the constant deepening of an inlet in the Belgorodske branch and deepening of a bar of Prorva channel.

Table 2.3 –Flow distribution by branches of the Kilia delta (% from the runoff of the Danube)

Branch	1894-1895	1942-1943	1958-1960
Ochakivske			25.3
Belgorodske	1.4		0.1
Polunochnyy	1.0	0.4	0
Prorva	10.0	4.6	6.1
Potapovske	5.7	20.0	15.0
Starostambulske			37.2
Sredne	10.5	1.7	0.7
Bystre		6.6	10.2
Vostochne		1.0	1.5

Table 2.3 (continued)

Branch	1966-1970	1976-1980	1986-1990	2000
Ochakivske	20.7	18.0	16.9	14.5
Belgorodske	0.1	0.1	0.1	0.1
Polunochnyy				
Prorva	7.7	7.6	7.6	7.1
Potapovske	8.2	4.3	3.1	2.7
Starostambulske	40.5	40.7		38.5
Seredne	0.2	0.1	0	
Bystre	12.4	14.3	16.5	17.6
Vostochne	1.7	2.3		2.3

The Bystre is a most perspective branches of the Kilia delta; it existed in the Kilia delta even in the beginning of 19th century. In connection with degradation of the other minor branches in the southeast part of Kilia delta the share of the runoff of the Bystre branch steadily increased. In the end of 19th - the beginning of 20th century it made up ≤5% of the Danube runoff. Since the 1940s, this share has increased from 6.6 up to 17.6%.

The most dynamic areas of the branch network of the Delta are the bars. Their natural depth does not exceed 2-2.5 m even in the most active branches (Potapovske, Bystre, Starostambulske, St. George) [10].

The basic morphological elements of the delta bar (Fig. 2.3) are the left and the right estuary forelands (1, 2) and their underwater parts (3, 4), the central sea bar or the bar part (5), the bar hollows (6). The line, perpendicular to the axis of the stream passing through the extremity of the shortest surface estuary foreland, is considered to be the estuary range (7). The delta bar has a crest (7) – this is a line connecting estuary forelands and passing through the most shallow parts of bar [11].

Morphological and morphometrical characteristics of delta bars depend on the water discharge and sediment load of the branch and the characteristics of the coastal zone (depth and fall of the bottom, heaving, rising tides, rise and fall of water level in branches and reedbeds caused by wind-generated rise and fall of coastal waters), as well as ice processes and artificial measures conducted on the estuary part of the river and the shore.

In the non-tidal rivers estuaries the sediment discharge and energy of marine heaving have a basic influence on forming of bars and their dynamics. The role of the sediment load in a bar morphodynamics increases in a snowmelt flood, and a role of marine heaving - in a lower river water. Depending on combination of these two factors in non-tidal estuaries - riverine (I) and river-marine (II) types of bar are formed [12, 13]. The second type of bars, typical for the branches of the Danube delta, consists of four subtypes.

For subtype IIa extension of a bar is typical at high water and partial wave breaking down – in a mean-water. The delta bars of the large branches having well expressed estuary forelands, bar part and 1-2 bar hollows relate to the bars of this subtype.

Extension in high water and practically complete wave breaking down in low water is peculiar to the bars of subtype IIb. Such bars are formed in the medium-sized branches. They are poorly extended to the sea, their estuary forelands are very short, bar part are not expressed and frequently have only one bar hollow.

The basic features of the bars of the subtype IIc are negligible extension in high water and exceeding wave breaking down in low water. Such bars can be formed in the estuary of the small branches. The bars of this subtype are split along the seacoast, their estuary forelands are very short, usually the bar hollows are curved aside a prevailing alongshore sediment transport.

The blocked bars of subtype IId are formed in the estuaries of the dying off branches. In low water the sea wave can shut off the channel flow by foreland completely.

Characteristics of the bars are changed during the natural or anthropogenic redistribution of the water flow by branches. The bars are extended when the runoff of branches are increased, and their depth is normally increased [12, 14]. In particular the bar length in the estuary of the Bystre branch has been increased from 500 up to 1400 m from 1940 to 1973, and then - up to 2500 m by 1994 (Fig. 2.4). The bar was appreciably extended into the sea, and its subtype IIb was replaced by subtype IIa for the last 30-40 years [11].

The area of the Danube delta relates to the depression areas with the speeds of land lowering ~1 mm / year. According to [11] the intensity of land subsidence makes up 1.8 (Primorskoe, 8 cm for 40 years) – 0.2 mm / year (Reni, 0.8 cm for 40 years). This phenomenon can be explained by a deflection of the earth under the bulk of delta sedimentation and their gradual rise of denseness [15].

2.2. Geomorphology and Relief

The territory of Kilia delta is within Dunaysko-Dnestrovskiy sub-region of geomorphological area of Prichernomorskaya lowland and flat Crimea. The surface of the delta is almost horizontal, with small rise in the northern part where its crossing to loess steppe; it is raising above level of the sea not more than 5-7 m.

Its highest parts are near-river-bed ridges and seaside foreland of the islands, the average relative height of which is 0.5-1.0 m. The central parts of islands have the flat lowered relief with lakes and channels.

Sub channel patches are formed along the branches and *eriks*. The asymmetric structure caused by washing away activity of streams is peculiar to them. The highest areas are located near watercourses. They are lowered in the direction of the center of islands, which defines the general relief as a hypocrateriform. Forming of the ridges directly depends on the magnitude of sedimentation, especially during snowmelt flood, owing to their increase at the expense of sedimentation of silt and sand. Thus the height of the ridges in the crown of islands (1.0-1.5 m) is considerably large in comparison with the bottom (0.5 m) where the snowmelt flood is much weaker. The ridges are interrupted by lowerings of the miscellaneous area, which have been formed in the places of former inter-island watercourses. Near-river-bed ridges are the places of the basic forestry and, partially, meadows.

On the territory of Kilia delta of the Danube there are artificial raises - dikes, banks (formed owing to deepening of the rover reaches) - except natural ones.

The seaside forelands are the positive ground features besides the near-river-bed ridges. They are formed on some distance from the islands being a result of the interactions of the watercourses and the sea. At the first stage (Vostochna foreland, for example) they have no appreciable rises of the relief, negligible as for the length (up to 1.5 km). Seaside forelands play an important role in the desalted bays forming. Increasing in the sizes, they fence off a part of the beach shallows from the seawater influence. Further on the upper plots of forelands incorporate with the near-river-bed ridges of islands, forming the bay, which is transformed to a half-closed basin gradually. Depending on the character of alluvial process the seaside forelands incorporate to the land geo-complexes of delta further and function altogether as a structure of geo-complexes either of the island.

Stentsovsko-Zhebriyanski Plavni (SZhP), which are the internal basin of initial delta of the Danube, may serve as an example. These *plavni* (reedbeds, reed marshes) were formed after the ancient marine firth silting, which had been separated from the sea by Zhebriyanski dunes. In the central and eastern parts of reedbeds on depth of 4-7 m the plastic silts of *liman* origin with incorporation s of numerous seashells have been found out, that proves the existence of the marine superficial *liman* here in the past. Reedbeds are located in the northern part of the Delta between the inhabited locality of Kilia and Vilkove. The *plavni* are separated from the Solomoniv branch by banks and a native margin, and in the southeast part from the Black Sea – by Vilkove's sandy formation composed of silting sands predominantly of marine origin.

2.3 Climate

The climate of the Kilia delta is moderately continental with rather short and warm winter and long hot summer. Among the flat areas the Black Sea coast is characterized by the warmest winter (the average temperature of January is 2,0 ^{0}C). The frost-free period continues up to 200 days, vegetative - 235-245 days, the sum of active temperatures is 3500-3600 ^{0}C. The –mean annual amount of precipitations achieves 400 mm/yr, and evaporation - 800 mm/yr. According to the general climatic zoning of Ukraine the territory relates to the continental area of the climatic zone of moderate latitudes, and according to the agroclimatic zoning of the territory of Ukraine - to the very arid moderately hot zone with mild winter.

Duration of solar radiation in the Danube regions exceeds 2300. The highest month values are in July - till 350 hours, the lowest - in December - within 60 hours. The total solar radiation makes up to 4800 MJ/m^2, minimum is in December (about 110 MJ/m^2) and a maximum - in June (up to 800 MJ/m^2). The radiation balance during one year is positive and for a year is about 2100 MJ/m^2. The large part of heat of radiation balance is spent for turbulent heat interchange of the earth's surface with the atmosphere, the rest - for moisture evaporation from the earth's surface.

The atmospheric circulation has a well-defined seasonal character. During a year about 48 revolving storms and 36 anti-cyclones pass on in the south of Ukraine at an average. Anti-cyclones are less mobile, therefore anti-cyclonic weather lasts about 230 days, and cyclonic - up to 135 days in the course of a year. Cyclonic activity is more intense in the cold periods of a year, the amount and duration of anti-cyclones increases in summer and in autumn.

Short and rather warm winter proceeds from the middle of December till the second decade of February. The beginning of spring falls on the last decade of February and the first decade of March. The long and hot summer begins in the first decade of May and lasts till the third decade of September. Autumn begins at the end of September - the beginning of October.

The average temperature of July is 22.4-23.7°C. The greatest raise of monthly average temperature is overseen within the period from April to May (on 10°C), and the decrease gradually on 5-6°C takes place every month since August till December. The annual amplitude of temperature between the coldest and the warmest months is 24.4°C. The amplitude of daily average temperatures makes up 41.5 °C. The absolute annual amplitude of temperatures is 70°C. The frost-free period proceeds within 200 days.

The least relative humidity is fixed in May when the air temperature (up to 70%) is increased rapidly, the greatest - in January (up to 90%).

The mean annual temperature of water of the Danube delta is 12,7°C. Waters of the estuary part are getting warm mostly in July - August (at an average up to 24.1°C). The maximum in this period reaches 27.6°C. The duration of the period with the temperature of water up to 5°C makes up 265 days (16.03-06.12) at an average, up to 10°C - 213 (10.04-09.11), up to 15°C - 16 (04.05-13.10), up to 20°C - 108 (31.05-16.09).

Abundance of heat, water and high fertility of soils promote the development of dense vegetation, including moisture-loving, which occupies *plavni*, shores of water-currents and basins. The most spread is reed, which occupies more than 2300 km^2 (about 1850 km^2 – in the territory of Romania). Reedbeds in the Danube delta are the most compact in the world. There are afloat and fixed thick carpets of died and alive greenery - "*plaura*s", formed from the residuals of reeds and reedmaces .

The fauna of delta is very rich and diverse. 150 species of birds, inhering to 18 groups inhabit and hibernate here [3]. White, grey, red and yellow herons, big cormorant, pink and curly pelicans, grey goose, the mute swan, grey duck, bald-coot and other are the most spread. Among the mammal such as wild boar, mink, otter, muskrat, hare, wildcat etc. live in the delta.

Delta – is the place of spawning and growing of valuable species of fishes; ways of migration of migratory and semi-migratory species of fish pass through it. Ecological effect of delta is felt far outside of it. In delta natural reserves, including the Danube Biosphere Reserve, are located.

2.4 Hydrophysical conditions of delta formation

The average annual runoff of the Danube for the period from 1921 till 1993 made up 203 km^3 per year (6460 m^3/s) (Table 2.4). Mean annual discharge of the Kilia branch of the Danube is 3990 m^3/s, mean annual runoff of the Kilia branch is about 126 km^3.

A share of the Kilia branch makes up 61-62% from the total amount of a flow for the long-term period. In turn, at bifurcation of the Kilia branch in a marine part of delta in the Starostambulske branch passes about 67% of flow, in the Ochakivske branch it makes up 30%, in Ankudinov is 2-3%, in Belgorod and Sredniy up to 1%. For the period since 1884 till now the length of the Starostambulske branch has been increased for about 9 km, the Ochakivske for 6 km, the Belgorodske for 2 km, that has changed a share of runoff which passes through them (Table 2.2, 2.3).

Table 2.4 - Characteristics of water and sediment discharge of the Danube

Years	Mean water discharges, m^3/s	Maximal water discharges, m^3/s		Average sediment discharge, kg/s	Average SS, g/m^3
		Mean annual	Maximal		
1921-1960	6320	10100	15300 (1941)	2150	340
1961-1993	6630	11700	16000 (1970)	1340	202
1921-1993	6460	10800	16000 (1970)	1790	277

The most abounding in water months in a year are April, May and June the share of which makes up 10-12% of the annual runoff (Table 2.5). The least discharge is observed on September - October (about 5.5-6% of an annual runoff). Maximum discharge in a high water reaches 15000-16000 m^3/s. Discharges are dropped up to 1300-1500 m^3/s in a low water [4].

Table 2.5 - Mean month discharges for the period of 1921-1997, m^3/s

Month											
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
3700	3960	4660	5400	5690	5190	4370	3330	2800	2630	3030	3570

Note: discharges since 1950 were measured at top of the upper internal delta - at the Izmail gaging station (50 km above the city of Kilia on Kilia narrow strait), for the period till 1950 discharges have been estimated.

In the last decade the extensive variations of an annual runoff of the Danube from 132 up to 236 km^3 per year (Table 2.6) has been marked.

Table 2.6 - Dynamics of annual runoff of the Danube, km^3*

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Runoff	213	207	177	132	198	172	154	181	230	236	224

* According to the data of the DHMO

Average non-reversible consumption in the Ukrainian part of the delta is 0.9 km^3/yr. Economic activity has not caused the reduction of a runoff of water of the river, moreover, the period of 1961-1993 (when the water storage basins on the Danube and its runs were built and irrigation diversion had been increased) appeared to be more abounding in water, than the period of 1921-1960.

At the same time for the last decades the average discharge for October (approximately by 500 m^3/s) have appreciably increased, and the average discharge for May, on the contrary, were lowered (approximately by 800 m^3/s) as a result of a runoff control [15].

In the Kilia branch the mean annual discharge were lowered from 4250 up to 3680 m^3/s at an average, mean discharge for October have increased approximately by 70 m^3/s (with 2740 up to 2810 m^3/s), and for May were decreased approximately by 470 m^3/s.

The greatest discharges are fixed, as a rule, in May, within the period of a spring snowmelt flood, and the minimal ones - during summer-autumnal low water. Extreme discharges in the Danube delta are shown in Table 2.7.

Changes of the Kilia branch runoff are caused by two reasons: "external" (change of the Danube runoff) and "internal" (discharge redistribution by branches). For the period of 1958-1997 the share of the Kilia branch runoff in the Danube runoff was decreased from 62% up to 58% on an average and from 65 up to 59% at a low water [15]. Therefore in a branch reduction of mean annual discharge has been increased, and ascending of the mean water rates was slowed down to some extend.

Table 2.7 - Maximum and minimal mean daily discharges in the Kilia delta for the period of 1921-1997

Gaging station	Daily mean discharges, m^3/s	
	Max	Min
Kilia branch – Kilia	8380	1410
Kilia branch – Vilkove	9290	1360

The slopes of a water level in the Kilia delta are changed within the limits of 1-7 cm/km (disregarding the events of wind-caused rise-fall events).

The Danube delta water level regime is characterised by sharp and continuous fluctuatings during the year. In its annual course the high spring-and-summer snowmelt flood, autumn and winter high waters - snowmelt floods, the summer and winter low water is outlined. Spring snowmelt flood is characterised by the highest levels, and takes place almost every year (from March till July) and passes with the several waves, superimposed on each other. The summer-autumnal low-water (that takes place in the period from July till November) is characterised by the lowest stages. Low-level summer-autumnal high waters, which peaks exceeded peaks of a spring snowmelt flood in shallow years (1972, 1974), were sometimes observed. In the period from December till March winter high waters, the peaks of which in some years (1942,1985, etc.) was observed also could exceed the peaks of spring snowmelt flood. Largely it is linked to formation of ice gorges, the reason of which were the exclusively high levels on the marine delta part (1925, 1946, 1967, 1998).

Long-term amplitude of water stage fluctuatings at the Reni gaging station (the distance is 136 km from the delta-sea margin) makes up to 6.26 m (the maximum level is 5.83 m, the minimal is 0.43 m), at the Kilia gaging station (distance from delta margin is 47 km) - 3.04 m, at Vilkove gaging station (distance from the delta margin is 18 km) connecting the lower internal and marine deltas - 2.39 m, and 2.09 m in coastal water.

Characteristic water stages in various cross sections are shown in Table 2.8.

Table 2.8 - Daily water levels (mBS) in years of various provision within the period of 1990-2002

Provision, %	Name of gaging station							
	Prut mouth	Reni	Izmail Chatal	Izmail	Kilia	Vilkove	Bystre, 10 km	Coastal waters
1	5.41	5.18	3.85	3.22	1.71	0.83	0.61	-
10	4.60	4.33	3.11	2.53	1.31	0.63	0.46	-
50	2.81	2.66	1.87	1.50	0.71	0.29	0.19	-
99	**0.49**	**0.41**	**0.17**	**0.05**	**-0.18**	**-0.24**	**-0.26**	**-0.48**

According to SNiP 2.06.01-86 the lowest shipping water-level by provision of 99%, defined on the daily data for the long-term period is accepted for imputed for a shipping industry.

The Delta water bodies and reedbeds are the natural flow regulators, collecting a part of water on the snowmelt flood rise and returning it in the branch on the snowmelt flood recession and in the low water. The flooded areas of delta on open spaces depend on the discharge of the river. Earlier all delta territory except for the high patches, was flooded at the discharge about 16,000 m^3/s. Owing to branches and islands bordering at the discharge 16,000 m^3/s in the Ukrainian part of the delta no more than 1/4 of the territory is flooded, that has also resulted in raise of maximum water levels in the snow-melt flood on 0.2-0.3 m. Complete double-ended delta branches bordering can increase maximum levels of water for 0.5-1 m [4].

Wind-caused rise-fall phenomena have the defined effect on the water level regime of the Kilia delta. Rise of water level are formed by the action of eastern winds, fall - by the action of western ones. From the winds of wave-dangerous directions, the activity of which is the factor of shores processing intensity, the winds of N, NE, E, SE and S points, creating heavy sea and along-shore transport of sediments to the north from the Bystre branch, are the most important. The closer to delta margin, the wind-caused rise-fall effect is stronger. Rises, caused by severe north-eastern, eastern and south-eastern winds, sometimes makes up to 1 m on the Danube beach. The greatest rise has been fixed on December 5-9 1945, when the magnitude of water-level was 78 cm at the Vilkove gaging station, 59 cm – at the Kilia g.s., and 4 cm – at the Reni g.s.. Thus a number of islands had been flooded in the marine delta part. At the wind change the rise can vary on fall as it was observed on 20.11.1960, when the rise of the level up to 45 cm was followed by fall up to 75 cm. Thus, this phenomena considerably influence on forming of the delta water level regime.

The propagation length of wind-caused rise of water level in delta is the bigger, the more is their magnitude in the beach and less is the river discharge. The wind-caused rise of level in the sea of 1 m can be spread 350 km upstream at the Danube discharge about 3000 m^3/s. So, the rise magnitude on January, 30 - on February, 2, 1962 has made: up the beach - 88 cm, in Prorva (3.6 km from the sea) - 56 cm, in Vilkove (18 km) - 50 cm, in Izmail (93.6 km) - 30 cm, in Reni (163 km) - 10 cm, in Brail (206 km) - 8 cm. The ordinary wind-caused rises (with height of 0.4-0.5 m) do not spread further than 200 km from the sea.

Even the strongest wind-caused falls of water level on the estuary beach makes up no more than 0.6 m. Such effect are spread in the delta branches to the distance up to 100 km. So, wind-caused fall in September, 28-30, 1959 has made: on the beach of 56 cm, in Prorva - 36 cm, in Vilkove - 40 cm, in Kilia - 24 cm, in Kislitsy (68 km from the sea) - 6 cm. Fall effect was not spread up to Izmail (94 km) [4].

In Table 2.9 the meanings of the Danube monthly average levels in the Kilia delta for the periods of observations are indicated: 1921-1998 - at the Kilia g.s. (1) and at the Vilkove g.s. (2), 1945-1998 - according to Primorskiy g.s in Zhebriyansky bay of the Black Sea (3), actually on the marine delta margin.

Table 2.9 – Mean monthly water levels of the Kilia delta for the period of observations, m

#	Months												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I-XII
1	0.56	0.65	0.84	1.07	1.13	1.02	0.77	0.44	0.26	0.20	0.34	0.53	0.65
2	-0.04	0.09	0.15	0.25	0.28	0.23	0.13	-0.03	-0.13	-0.16	-0.09	0.01	0.06
3	-0.14	-0.13	-0.10	-0.06	-0.06	-0.06	-0.10	-0.13	-0.18	-0.20	-0.20	-0.17	-0.13

The statistical analysis of the data concerning the actual long-term mean water levels for the most shallow month (October) and the most water abounding month (May) water levels on gaging station in the Kilia branch of the Danube delta (Izmail, Kilia, Vilkove) and on the estuary beach (Primorskiy) for 1958-1997 has shown that the mean annual water levels on Izmail g.s. and Kilia g.s. became lower, and on the Vilkove g.s. and the Primorskiy g.s. increased; monthly average levels during October on all gaging station were increased; at Izmail g.s. and Kilia g.s. the mean level during May was lower, and on the Primorskiy g.s. was increased a bit; on Vilkove g.s. the trend of May levels is not detected [15]. The main reasons of water-levels changes are: in upper current of branch (Izmail g.s., Kilia g.s.) – the changes of the branch discharge, in the bottom (Vilkove) - raise of the Black Sea level. The carried out contribution account of the runoff changes in the water-levels changes has shown, that the mid-annual levels because of these changes in the Kilia branch were decreased, and the mean water levels were increased.

Rise of the Black Sea level in the 20 c. – is well known fact, which is explained by the majority of researches by the positive water balance. In [16] it is marked, that, since 40th of 20th century, the intensity of eustatic rise of the Black Sea level on the average is 3-4 mm/yr. According to the estimations [15], retaining component of water-levels changes for 40 years in Primorske (beach) has made of 17 cm at the average conditions of the discharge and 24 cm in the low water, and the zone of by gradually fading backup has captured, accordingly, 70 and 160 km upstream the Danube.

According to V.N.Mikhaylov's estimations [4] the mean annual sediment runoff of the Danube in 1921-1960 was 67.7 million t/yr. After commission of some reservoirs, in particular, Dzherda reservoir in Romania and Yugoslavia (1969-1971) with useful volume of 3.0 km^3 and the banking magnitude at the lock of 34 m, the sediment runoff was decreased up to 42.2 million t/yr at an average. The turbidity of the river was accordingly decreased from 340 g/m^3 in 1921-1960 up to 202 g/m^3 in 1961-1993 (Table 2.4).

Distribution of sediment runoff by branches of the delta is approximately proportionally to the distribution of water runoff. An exception is made only for the most intensely activating and dying off branches. It is pointed out that the first has relative ascending discharges of sediment, and the second - a reduction in comparison with the shares of water runoff.

The change of the sediment discharges along the large and long branches (Kilia, Sulina, Georgiyev) is not significant, and sedimentation within the delta in the modern phase of its development is insignificant too. By some estimation [17], the discharge reduction of sediment lengthways of the Kilia branch in the snowmelt flood is no more than 5-10% that is within the limits of measurement accuracy. Nevertheless, sedimentation on the non-banking parts takes place and the slow increase of the delta surface and silting of lakes proves it. Silting of lakes is promoted by the development and degradation of aquatic plants. The area of some lakes is slowly moderated in the internal part of delta.

The water temperature in the delta branches is the greatest in July - August (23-24°C at an average, maximum - 28°C), and the least - in December - February (at an average of 1-1.5°C, minimal – about 0°C).

The ice phenomenon in the Danube delta does not happen every year, and the resistant ice standing is fixed less, than for 50% of winters. Quite often the branches are plated with ice 2-3 times for winter but in some winters there is no even ice motion on the river. The average ice standing duration is 18 days, maximum - 70 (1954-1955). The average dates of pre ice standing and spring ice motion are accordingly on January, 6-15 and on February, 18-25. The greatest ice depth is 60 cm (on separate areas - up to 80 cm) is fixed at the end of January. Ice motions (especially spring) are rather frequently escorted by the ice gorges. In the last decades for the navigation extension and prevention of ice gorges the ice sheet is broken artificially. The strong ice gorge in the Kilia branch low ground has taken place, for example, at the end of January, in 1967. The water-level was lifted up to 2-2,5 m. [4]. The threat of catastrophic deluging has hung above Kilia and Vilkove. 2400 houses were flooded in Vilkove. Within 5 days scrambling with element was led; thus icebreakers and aim bombing from aeroplanes were applied.

In 40-50's years of the last century the runoff of dissolved substances was equal at an average of 52 million t/yr [18] that corresponded to the average mineralisation about 260 mg/l. The precise tendency of increase of the average mineralisation of the Danube water in delta about 290-300 mg/l in 1948-1965 up to 370 mg/l in 1985-1989 [19] has been revealed in the next years. Thus, the chemical runoff of the Danube has increased from 60 up to 76 million t/yr.

The seawaters as "wedge" of salted waters can penetrate into some delta branches during the low discharges and wind-caused rise of the level of coastal water. This is the shallow branch such as the Belgorod one or rather large branches, the bars of which are deepened for the purposes of shipping industry (Prorva and Sulina). Seawaters regularly penetrate at the bottom of these branches during the low water. The maximum range of seawaters penetration has been fixed in Prorva on 20.11.90 – 16.8 km [20]. The critical discharge in the Prorva and the Sulina branches, at the excess of which the seawaters do not penetrate in to the branches makes up 570 and 1350 m^3/s.

2.5 Hydrophysical conditions of estuary coastal zone of the Danube

There are two types of coastal currents – caused by wind and caused by river discharge. Within the Danube estuary coastal zone the wind currents are usually directed alongshore - from the north on the south - at the winds of northern points, and from the south north-up - at the winds of southern points. Almost all the year over the beach the winds of northern points predominate. Their repeatability within the year exceeds 40-50% and only in May and June is decreased up to 38-39%. Repeatability of the southern points winds during the most part of the year makes up 30-38%, being increased only in May and June up to 40-44%. Therefore the alongshore currents are also directed more often to the south. Consequently the most part of sediments is transported to the same part and the forelands and all the Kilia delta extends more intensely in the same direction. Velocities of wind-caused currents can makes up to 1 km/s at steady wind speed more than 14-15 km/s [4].

Discharge-caused currents occur in the coastal zone before the mouths of large branches. Behind the delta sand-bars of the Potapov, the Bystre, the Starostambulske, the Sulina and the St. George branches the discharge-caused currents in the snow melt flood makes up to 1-1.5 km/s. Discharge-caused currents swiftly die off aside the seas, being traced not further 3-4 km from the mouth.

Heaving on the Danube beach is moderate. The average height of waves is about 0.5 m with the period from 2.5 up to 5.5 s. According to the prevailing winds the wind heaving of the northern points (65%) predominates, which is also the strongest. So, the winds with the velocity more than 10 km/s are characterised by repeatability in January of 16-18%, in February of 12-14%, and on March up to 15%. All of them basically relate to the northern half of the horizon. Virtually no strong winds and heaving are observed in summer [4].

The accumulation of river sediments on the beach happens basically during the calm weathers or moderate heaving up to 2-3 balls. The velocities of discharge-caused currents from the Kilia delta estuary even at 1.5-2.0 km from the estuary ranges fall to such extend, that the mass accumulation of the basic part of the sediments [12] appears to be possible. Distribution of the suspended sediments in the thickness of waters also proves it: concentration in the estuary ranges makes up to 200-300 mg/l, and in 4-5 km from the range aside the open sea - only 30-50 mg/l. This difference of concentration is one of the parameters of river sediments intensity accumulation on the beach. At the same time, after heavy seas the local washouts of surface of talus train being already formed occur [7].

According to M.V.Mikhaylova [6] the total formation of the Kilia delta for 240 years the components of sediment balance are the following: the gain of volume of the talus train - 8.26 km³; the sediment load of the branch - 8.363 km³; carrying out of sediments on the big marine depths - 0.03 km³; contribution of marine sediments from the north with the along-shore current - 0.029 km³ and contribution out of sediments to the south - 0.102 km³. Thus, on the forming of estuary alluvial talus train (within the marine depths 15 m) and delta almost 99% of river sediments were taken. A share of the sediments, which have been carried away from delta and estuary deposition, makes up little more than 1%. Thus it was specified, that a share of the river sediments remaining in the estuary talus train, in the process of Kilia delta development was steadily being increased (from 60-80 up to 99%). As a whole it is possible to consider, that to the present time the Kilia delta is in the condition of dynamic balance within the quantity indicators of river and marine sediments [21].

By U.D.Shuysky's [7] estimation, made on the comparison of cross profiles of the underwater slope of the Kilia delta, the average specific accumulation for the period of 1955-1979 makes up 220 m³/m annually. At the length of marine delta margin (53 km) , the total volume of sedimentation has averaged 11.5 million m³ or 71% of the sediment load through cross-section at Vilkove. The similar estimation for the underwater slope of the Bystre sand-bar has shown, that only 21% of the Bystre branch sediment load (147.1 m³/m per year) is accumulated on the seashore. It can explain why the extending of the bank line is slowed down . According to the estimation [7] about 4,7 million m³ of suspended and bedload sediments go from the Kilia branch to the open sea to be added to the deep-water sediments of the adjoining part of the Black Sea. The sedimentary material is transported by currents basically to the southeast and to the south, alongshore within the harbour area, adjoining Romania and Bulgaria shores [3].

Result of the comparative analysis of the retrospective data of space shooting (1975-1988, 1988-2001) [22] have shown that the Starostambulske branch system is in the condition of activation as a whole. The sediment runoff in Starostambulske, Bystre and Tsyganka branches has increased. In some places of the Bystre branch the processes of river erosion take place. In the issue of the solid runoff accumulation islands on the south from the Bystre and the Starostambulske branches (Fig. 2.6) were formed. Dry territory has increased in the Tsyganskiy Kut bay and in the area of Kuriles islands. Accumulation process of the bank line along marine coast from the Potapov branch to the Starostambulske branch occurs. The analysis of snapshots has shown, that the tendency, described above, has a constant character within the period of not less than 30 years (Fig. 2.7).

The temperature of the surface layer of the coastal water has definitely seasonal pattern. being increased in July - August average temperature is up to 21-22°C (maximum up to 26-27°C), in December - February average temperature is 2-4°C (sometimes up to - 0.3…- 0.4 ^{0}C). In summer the temperature of the surface layer is higher, than the temperature on the bottom layer for 4-6°C (sometimes for 12°C). During the greatest heating vertical gradients reach 3-5°C on 1 m of depth. Homothermia is observed in the coastal water only in March – April, and in September - October [4].

The ice phenomena on the beach are not observed every year. The process of ice formation normally begins in December - January (for 2-4 days later, than in the Delta branches). The ice in the Zhebriyanska bay (to the north from delta) can reach 20-25 km, in other places of the coastal zone - 10-15 km. In the second half of February the ice sheet starts to demolish. In March the beach is completely free of ice.

Main and the most ecologically important feature of the estuary regime is the dependence of water salinity and the areas with the various degree of water desalination by the Danube runoff and wind regime [3, 23]. The surface layer of the coastal waters, where the salinity of water can be changed from 4 ‰ up to 15-16 ‰, is the most subject to the effect of the runoff and wind. On the depths more than 8-10 m the salinity of water in all seasons of year is usually more than 16%.

The recent researches [23] shown that the internal border of mixture zone of river and sea waters in the surface layer on the coastal zone (isohaline of 2 ‰) is at an average within 0-4 km from the estuary depending on the actual river discharge. The external border of mixture zone (≈16 ‰) is located at the distance of 3-20 km from the delta margin in different seasons. The increase of the Danube runoff widens a zone of water desalination, the reduction of the runoff narrows it; and it happens with some time lag. Winds of eastern points generally narrow a zone of low salinity in the surface layer; winds of western points widen it. Area of desalted waters against the estuary of large branches is normally spread in the snowmelt flood to the distance up to 20 km. During significant snowmelt flood or strong whipped wind the desalted waters in the surface layer can reach the Zmeiny Island, located more than in 30 km from the delta margin, resulting in decrease of water salinity up to 4-7 ‰ (at ordinary meanings of 14-16 ‰). At the same time at the inter-branch parts of seacoast waters with salinity up to 10-12 ‰ approach the sea-bank.

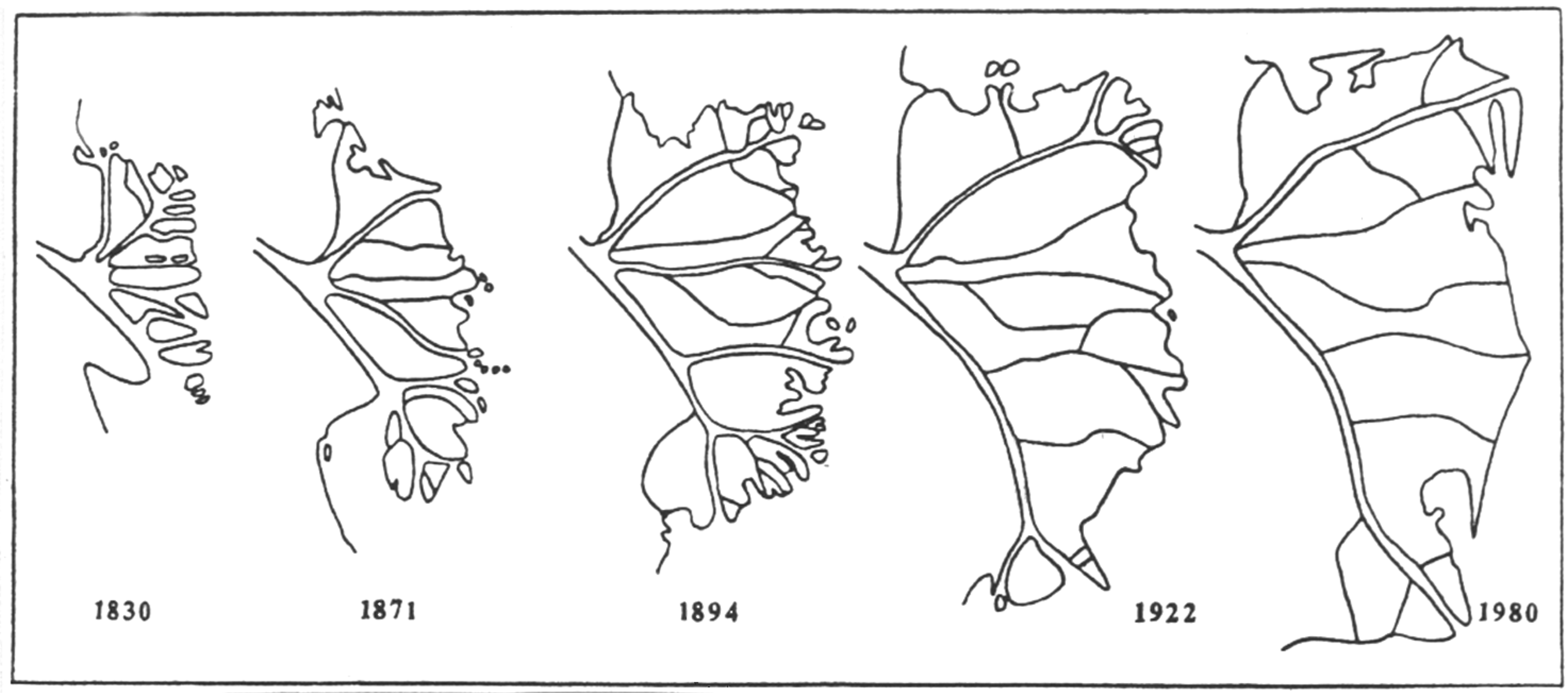


Fig. 2.1 - Evolution of the Kilia delta

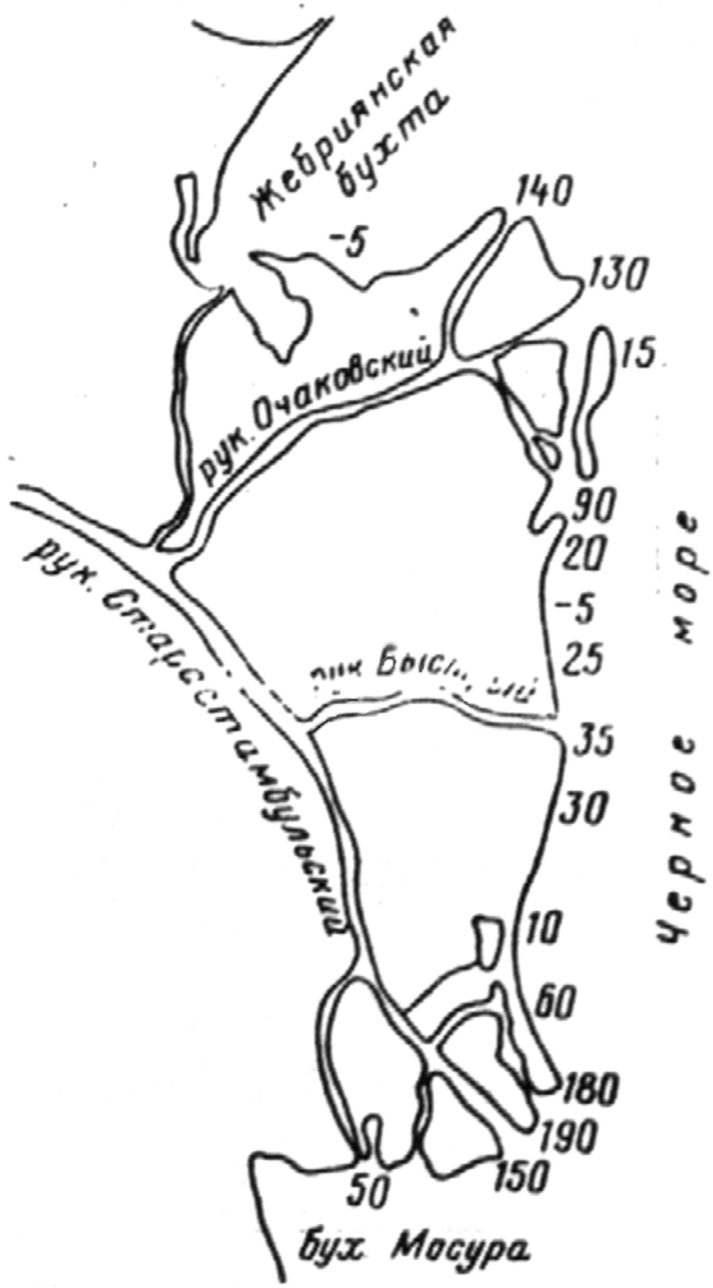


Fig. 2.2 – the Kilia delta of the Danube: figures are the average speeds (m/yr) of growth/washing out of the delta shore

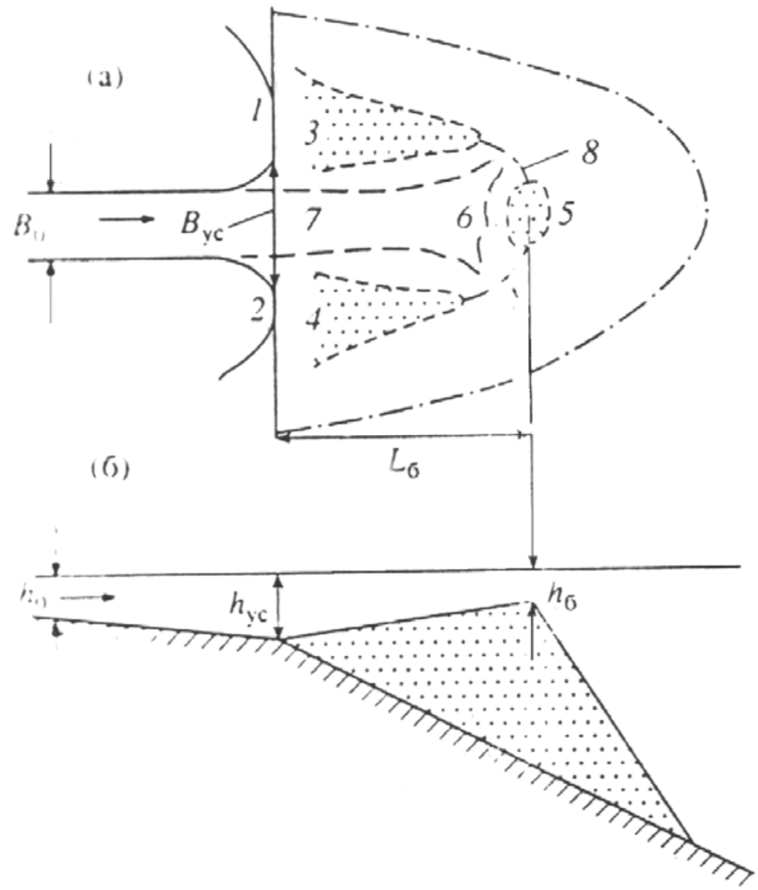


Fig. 2.3 – Delta bar in plan (a) and section (b)
1, 2 – left and the right estuary forelands, 3, 4 - their underwater parts,
5 - central sea bar or the bar part, 6 - bar hollows, 7 - estuary range, delta bar crest;
$L_{б}$ – bar length, $B_{б}$ –bar width (of the zone of seashore isobathic line contortion),
$h_{б}$ – maximum depth of the shallow gully on the delta bar crest,
B_{yc} – estuary range width, h_{yc}- average depth in the estuary range,
B_{y} – ave. channel width in the estuary part of the river,
H_{y} – ave. channel depth in the estuary part.

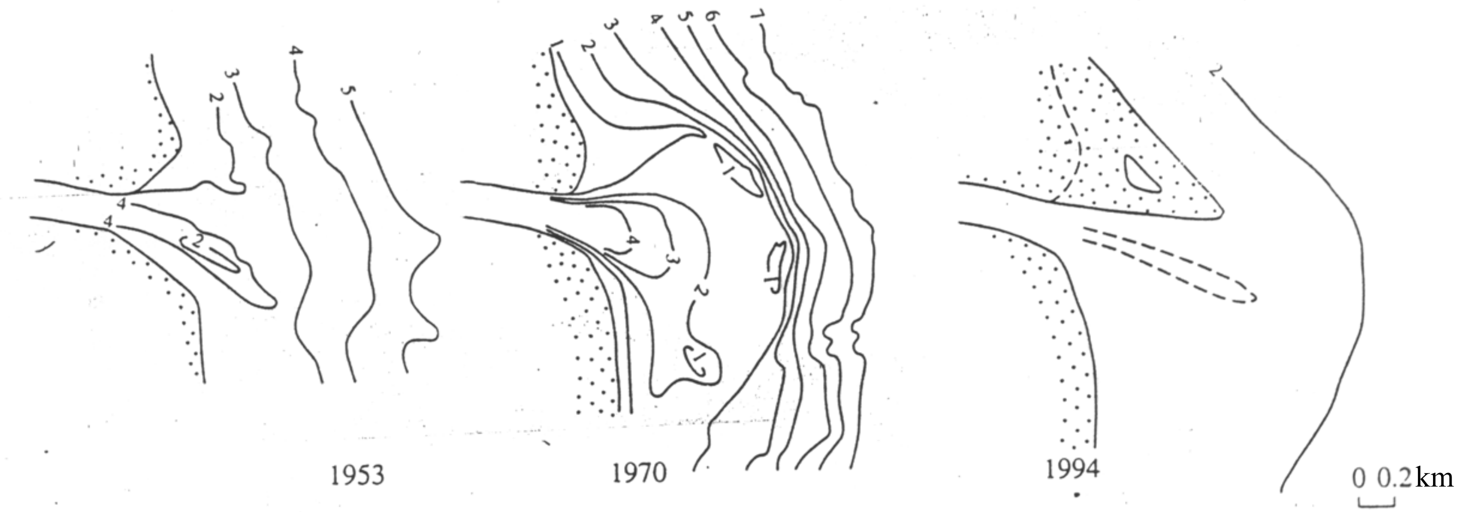


Fig. 2.4 – Creation of the bar in the Bystre branch mouth

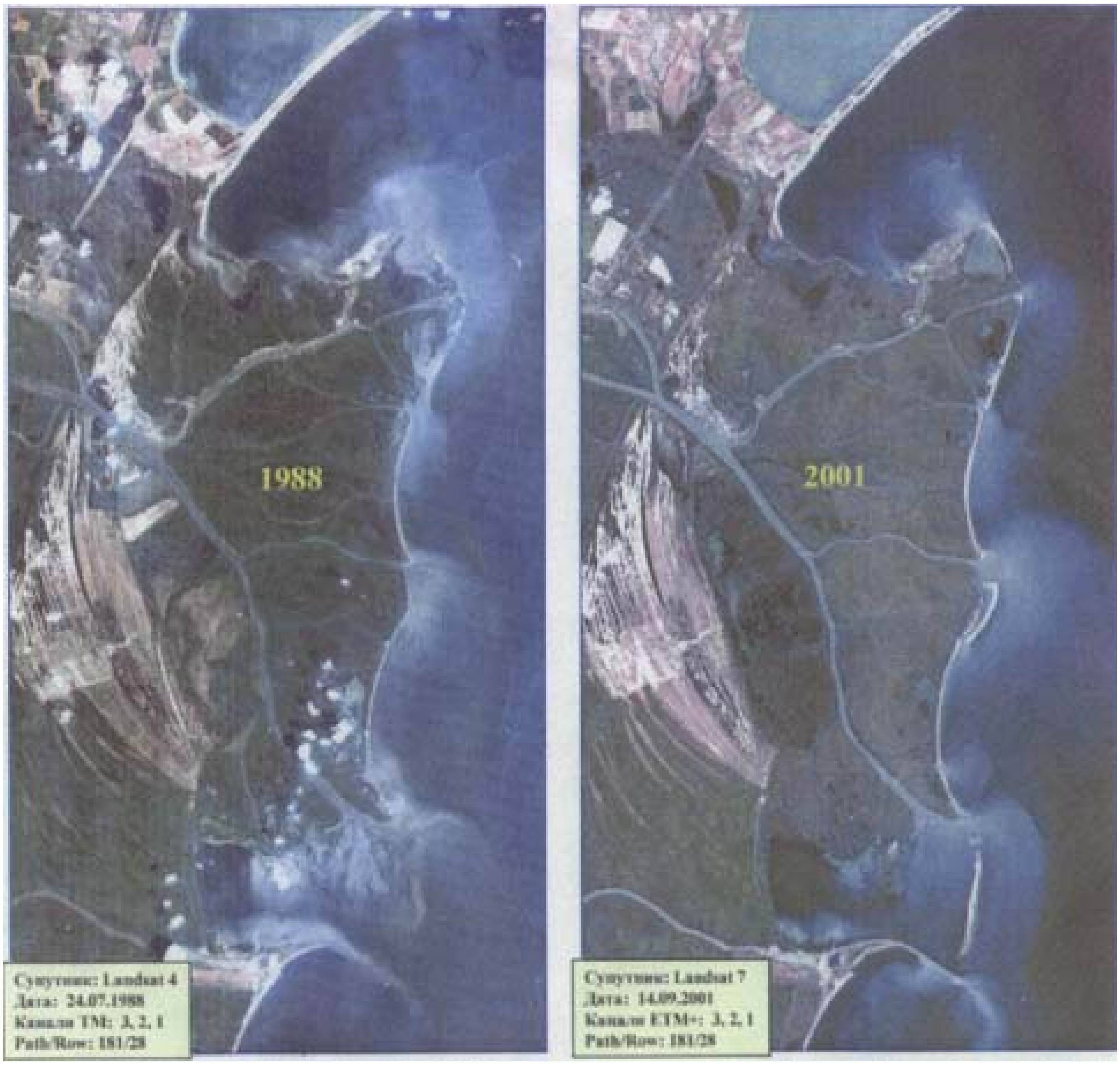
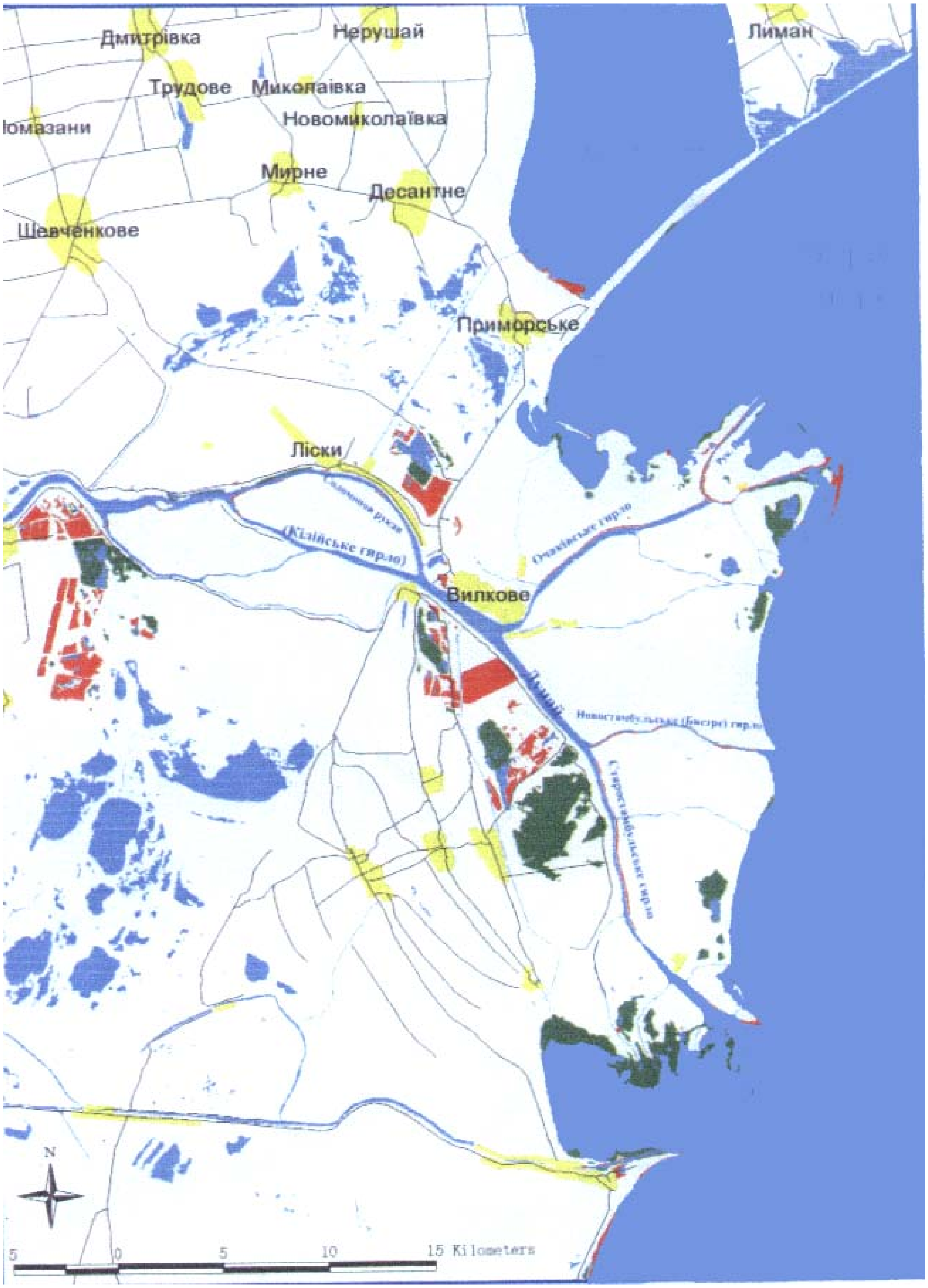


Fig. 2.5 – Discharge of river sediments into the Black Sea by the Danube Delta branches and forming spits

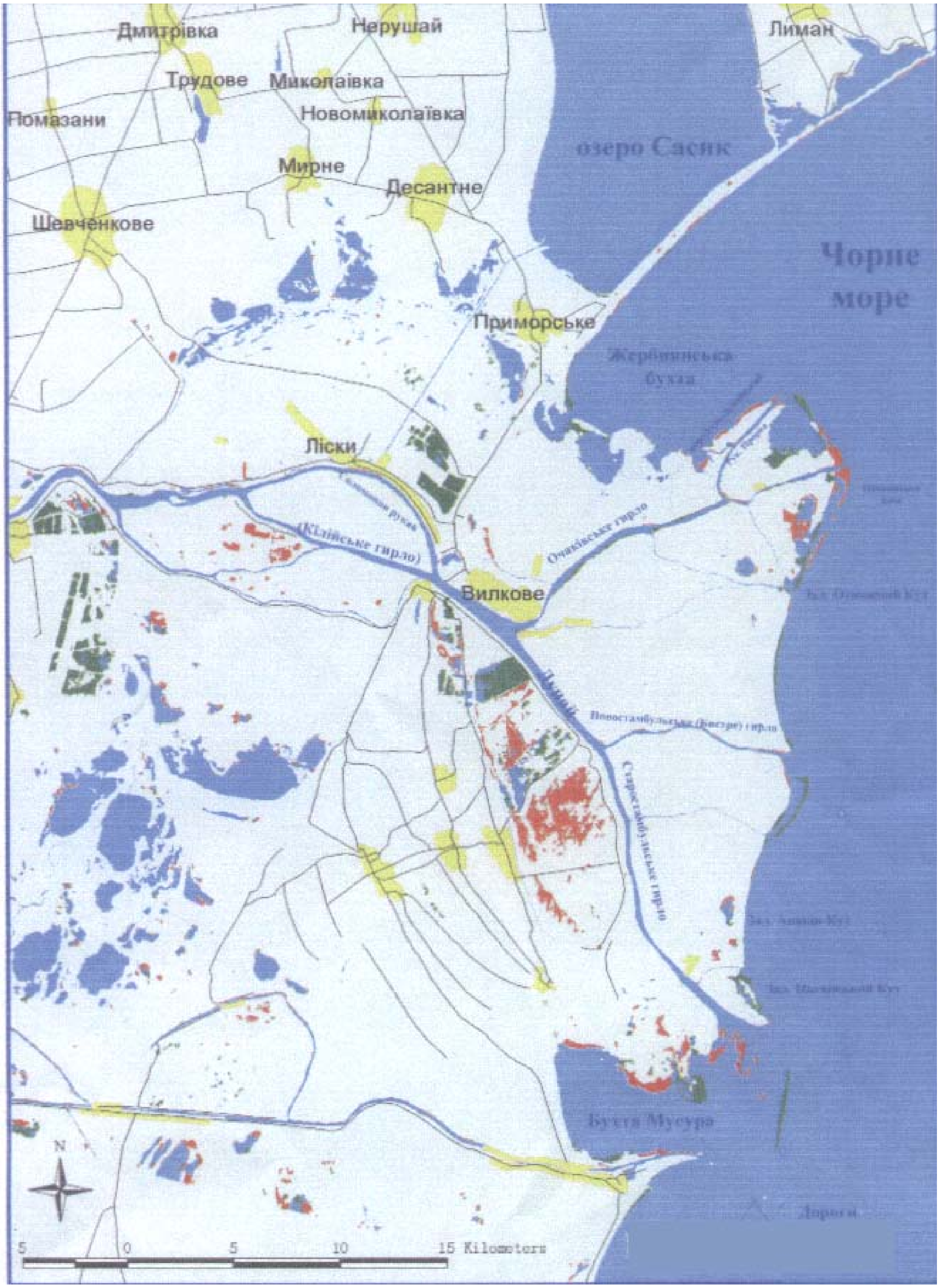


- Water surface

- Accumulation and dewatering

- Erosion and submergence

Fig 2.6 - Changing of the shore line and areas of water bodies in the Danube delta, fixed after comparison of satellite data of the *Landsat* for the years 1975 and 1988



- Water surface
- Accumulation and dewatering
- Erosion

Fig. 2.7 – Changing of the shore line and areas of water bodies in the Danube Delta, fixed after comparison of satellite data of *Landsat* for the years 1988 and 2001

2.6 Impact on the Danube delta formation and hydrophysical conditions

Anthropogenic effect on the riverbed evolutions of delta formation is traced from the end of the 19th century. [4]. For example, it is known, that at the end of the last century the tendency of the Tulcea branch degradation, for the renewal of which hydrotechnical works on its cut-off and deepening were conducted in 1880-1902, had been revealed. Before the World War I, Russia performed similar works in Severny branch with the purpose of shipping. Thus a period of large-scale intervention to the natural regime of the Danube delta had begun. First of all, it was practically complete bilateral reinforcement of the riverbanks by dike dams (from Reni to Vilkove from the Ukrainian side practically completely and partially from Romanian), the islands including, with the subsequent involving flood plain continental and island lands to the agriculture processes; separation of the delta lakes from the river system by a system of locks and channels; replacement of natural anabranch (the Skunda, the Rapida and other) for man-made channels, clearing and deepening of the beds (the Sulina branch), water intake and effluent along the river, etc.

The reinforcement of the riverbanks, which, hamper the water flow on the wide flood plain lands, changes slopes, velocities, regime of sediment load, especially during the periods of active forming of the river-bed (high waters, snowmelt floods) and has great influence on the delta forming. For example, in the range of 40-th km (the Laptysh branch, the Mezhkolkhozny channel now) the breadth of water flood reached up to 10 km at a passing of significant high waters in natural conditions. In the conditions of reinforcement of the banks the flow was concentrated in the main channels up to 900 m of width. A number of stabilising capacities of great volume, which transformed floodwater waves, had excluded from water exchange. This essentially changed the water regime of the Danube delta.

By 1971 the area of diked lands in the Romanian part of the delta has already reached 430,000 ha, in Ukrainian part - more than 30,000 ha. The length of dams only in the Ukrainian territory along the Danube and delta branches has made up to 118 km, and from the Danube lakes side - 71 km, on the islands - 102 km.

The largest Danube's lakes of the Kilia delta are located in the territory of Ukraine. Now they are used as reservoirs, with which the irrigating areas about 73,000 ha are linked that correspond to the normative volume of abstraction of 250 million m^3/yr. The actual area of irrigation and the volume of water abstraction change from year to year, but these figures give the idea concerning the degree of delta water resources involving in the agriculture processes. In the delta the advanced network of irrigating and drainage channels is built, where water goes by gravity, through locks or with the help of the pumps. Lagoon Sasyk (to the north from the delta) is cut off from the sea and also converted into the reservoir for the Danube water; storage and useful volume of this reservoir is 0.53 and 0.235 km^3 respectively [4].

In the beginning of 20th century the harbour area of Stentsovsko-Zhebriyanski Plavni stretches from Shevchenko Village up to Primorsk Village [24]. In the middle of the 30th the motorway Vilkove-Primorskiy had been built, and in the 50-60s the active assimilation of flood plain lands with the reinforcement of separate plots began, which were then built up, occupied and actively involved in the crop rotation. For the prevention of periodic flooding of localities the protective lock lengthways along the Kilia and the Solomoniv branches had been built. At the same time the Laptysh channel, which had born water to reedbeds, had been silted, and the Mezhkolkhozny channel (1950), and the Tupikovy channel (1974) are built instead of it, which have connected the Danube and the SZhP in modern borders. In 1971 the Mezhkolkhozny channel has been continued by the Dunaisky channel, which had crossed the bottomland up to the radical shore and had submitted the Danube water up to the Tatarbunar irrigating system, that had actually converted the main rivers of the drainage basin of Nerushay and Drakulyu reedbeds into the 'anti-rivers'. Simultaneously northern border of reedbeds also had been separated by the locks within the strip of the connection of the native shore with the area of the reedbeds down up to Primorske village. In the body of the lock of Vilkove-Primorske motorway, built in 30th, in 70th bridges have been replaced by locks-spillways and, thus, reedbeds have been ultimately separated from the Danube and the Black Sea and inhibited in modern borders. Their regime became to be completely under control. These structures have decreased the SZhP area almost for 20%. In the 70th the southern part of reedbeds was separated by the Prapor and Gosleskhoz locks and occupied for I, II and III Liskovsk rice systems that has decreased the SZhP area by 30%. Thus, prior to the beginning of 80th, the general SZhP area was moderated in the comparison with the natural almost by 50%. In 1980 the Danube – Sasyk channel was built. It crossed SZhP area and shared this area in Stentsovsk and Zhebriyanski parts, linked only by duker under the channel with the area of cross section of 8 m^2, which is place at the former mouth of Murza river. Thus, the forming of the circuit of water flow in SZhP area had been finished.

In the natural regime reedbeds accumulate the Danube water and the natural runoff of their own drainage area. At the modern level of the development, on watershed of the SZhF a number of irrigating systems, and five reservoirs is placed, the channel net is converted into the collector-drain ways and discharge to reedbeds the mixture of natural runoff and collector-drainage waters. Thus contribution of the Danube water happens practically by the residual principle. Hydrodynamic regime of the SZhP has a number of differences from the regime of the Danube branches: the slowed down flows, the big roughness of the channel because of the vegetation development, availability of 'dead areas', etc.

As the subject of anthropogenic effect *plavni* are unique as for ratio magnitude of the anthropogenic pressure and the natural resources.

2.7. Conclusions to Chapter 2

1. The Kilia delta of the Danube River represents a permanently developing system of branches and territories between them (islands), the majority of their surface being covered with water and occupied with the *plavni* (reedbeds). High speed of delta evolution is accounted for extensive river sediment load.
2. The feature of the EIA of the DWNR is that the continuous delta evolution and the consequent variability of hydrological and hydrophysical conditions render determining effect on all natural and technogenic entities located within the delta.
3. The general direction of delta evolution is determined by the interaction of the river and the sea and revealed in the following phenomena and processes which permanently take place:
   - Extension of changeable marine delta margin towards the sea;
   - Uprising of new and degradation of old delta branches, change of their quantity and redistribution of the river flow between them;
   - Formation of the shallow-water areas of the seashore –(bars) in front of the branches mouths as a result of sedimentation in a zone of interaction of river discharge and sea currents and heaving;
   - Change of the water pattern of the islands territories in the direction of water exchange deceleration in wetlands, and lowering of the water level during the process of degradation and reduction of the branches number.
4. The analysis of the Kilia delta history shows, that its alluvial talus train, basically, was formed at the beginning of the 20th century. Within the 20th century computed range-component increment of volume of the talus train has made about 10% of its volume, that allows to characterise the modern condition of the Kilia delta as a phase of relative dynamic balance. As a whole the accumulative processes in the Delta and the processes of abrasion (capes and bars) compensate each other. Thus the talus train almost completely consists of river sediments.
5. Since the end of the 19th century on the delta development escalating effect is rendered by anthropogenic factors, first of all – branches reinforcement reduced to the scale change of the water regime of branches and islands and laid the foundation of agricultural assimilation of flood

plane continental and island lands. Anthropogenic intervention has amplified with the regulating and cut-off of some delta branches. So, on the catchment's area of the Stentsovsko-Zhebriyanski Plavni a number of irrigating systems, five reservoirs is placed, the channel net is converted into the collector-drain ways and the mixture of own natural runoff and collector-drainage waters discharges to reedbeds. However even such large-scale technogenic effect has not resulted in significant changes of the basic laws of the delta development, though has seriously broken the water regime of some territories.

6. Flow control on the up-stream reaches of the Danube River during the last several decades has resulted in the consecutive reduction of sediment load without reduction of a mean annual water runoff. This phenomenon measurably inhibits the process of branch silting and can be considered as the positive factor for the creation of the DWNR.
   However huge long-term and seasonal variation of sediment load is preserved subject to as well as ccorresponding variation of the amount of operational dredging and probability of *force majeure* condition during the DWNR operation.
7. If the current tendency of sediment load reduction in the Danube River will be preserved hereinafter, then on the background of the predicted rising of the sea level and growth of the relative role of marine heaving the Kilia delta can change the tendency of the development, and proceed in the delta type, which is formed in the conditions of marine factors prevailing.
8. Together with evolutionary changes in the delta there is also a number of periodically repeating hydrologic processes. The most important are the wind-caused rise-fall phenomena, short- and middle-term variability of water discharge and sediment load. These processes cause the variations of water levels in the branches and reed marshes and deformations of the riverbeds..
9. The technogenic effects of construction and operation of the DWNR will happen on the background of the determining effects of the above-mentioned natural processes, strengthening or weakening some of them.
10. According to the analysis of delta hydrodynamic conditions in the area of the approved variant of the DWNR, the positive factors of environment are:
    - the slowest delta margin extension in the estuary area of the Bystre branch – in comparison with the other parts of marine delta margin;
    - ongoing increasing of the proportion of the Kilia delta runoff, which passing through the Bystre branch;
    - carrying out of the great bulk of sediment load by the Bystre branch outward the beach (though this factor is not stable: for the last years the process of bar prolongation in front of the branch and its extension towards the sea with the simultaneous development of the right-bank foreland, which has received the name of Ptichya spit became more active);
    - rather fast ascending depths of water behind the sand-bar area.

3 General characterization of the DWNR design

3.1 Necessity of creation of the DWNR in the Ukrainian part of the Danube delta

The Danube River courses within the territories of Germany, Austria, Slovakia, Hungary, Yugoslavia, Bulgaria, Romania, Moldova and Ukraine. It is the major transport way of the Central and Western Europe. 15 countries of Europe have connection with the Danube as with a transport artery. Due to acting canals such as the Main-Danube Canal (linking the Danube with the Rhine river basin and the North Sea), and the Danube-Black Sea Canal practically all the river ports of Central and East Europe have a direct outlet in the seas of Atlantic ocean, the Black Sea including. Canals that will connect Danube with the Adriatic and the Aegean seas are being projected and built.

Countries of European Economic Community are looking for the ways of transportation of cargoes to the Asian region and back, trying to form transport corridors (the Black and Caspian seas including) in which the significant part of the cargoes can be shifted on a water transport being the cheapest method of transportation of goods.

The Sulina and the St. George branches of the Danube belong to Romania now, as well as the monopoly to pass of vessels to the Danube-Black Sea part.

During the 19-20th centuries Romania had created the base for organisation of the ship course line:

- The Sulina channel is an artificial international Navigation Route for ship with width of 60 m fit for passing of sea vessels and the vessels of river-sea mixed floating;
- The Cernavodă - Constanța – South channel with two locks, width at the bottom is 80 m;
- The Medjia - Novodari port canal, links Novodari port with Cernavodă - Constanța canal at the area of Medjia port;
- Cutoff of the St. George branch is carried out additionally (Table 3.1).

Since the Cernavodă channel with branch of Medjia-Novodari (an estimated value about two billions of US dollars) put into operation in 1986 Romania had intercepted a flow of cargoes at the Danube River – the Black Sea (passing draft up to 2.5 м).

Table 3.1 - Ship courses acting within the territory of Romania

Names of channels	Year of taking into use	Length, km	Depth, m
Sulina	1858	79.6	7.30
Cernovodă-Constanța	1984	64.2	7.0
Medjia-Novodari	1988	26	
St. George		121.6	–

At present Ukraine has no its own deep-water pass to the Black Sea though the deepest Kilia branch. The large Ukrainian sea ports are located there. They are Reni and Izmail, as well as Kilia and Vilkove. Prosperity of all Pridanube region directly depends upon their efficiency.

Pridanube economic area includes Izmail, Kilia, Bolgrad, Reni districts of Odessa region. Inhabited localities are situated here predominantly along the Danube and along-banks of fresh reservoirs (*Pridanube lakes*). Pridanube region is characterised by the predominance of large settlements with 60-70% of population concentrated. Unique geographical position of Pridanube has made for the appearance of large commercial, distribution and transport centres along the banks, which substantially define the level of development of all economic area as a whole. Izmail is the centre of the area, in which the important functions of national economy are concentrated – industrial, transport, port-distribution, administrative and managerial, educational, cultural and so on.

Transport-industrial functions are typical to a greater extent for other big town (Kilia, Reni, Vilkove).

The transport complex, making use of the geographical advantage of the Danube waterway, serves as the main hail growth factor of Pridanube cities development. The most important territory-structural characteristics of Pridanube are determined by the Danube water-way functioning. As a whole, in the functional organisation the food industry dominates (about 60% of commercial output). However industrial specific character of the area is determined by the production of a marine cycle – shipbuilding, ship repairing, fishy. In Izmail industrial centre as the most important components food industry, mechanical engineering and metal-working (including 2 shipyards), pulp and paper industry are distinguished.

Other Danube towns are characterised by lesser scale of industrial production, but similar function-structural features. So, the core of Kilia industrial centre is the local shipyard, in which 1/10 part of the whole population of the city are employed. Industrial site is forming around the shipyard, where some food factories use production infrastructure of the shipyard. Danube thoroughfare has decisive importance for Kilia, which is located 35 km from the nearest railway station.

Development of marine and river industries is determined by the region specialisation in inter-district and international distribution of labour. Izmail and Reni ports are directed predominantly to the export, and Ust-Dunaysk to the import freight flows. The most important carrier of cargo by Danube in Ukraine is the Ukrainian Danube Shipping Co. (UDS), which included 4 ports (Izmail, Kilia, Reni and Ust-Dunaysk), and 2 shipyards. Before the stoppage of through navigation canal UDS transported by the river about 12.5 million of tones of freights; total cargo handling of ports made up from above 21 million of tones (Reni – 10.8 million t, Izmail – 8.1, Kilia – 0.3, Ust-Dunaisk – 2.1 million t). Ships of steam navigation ensure considerable density of passenger traffic on the line “From the Alps to the Black Sea». But at the beginning of 90’s the role of Kilia estuary as a navigation Danube branch, which connects Ukrainian ports with the sea, greatly decreased because of the non-ensuring of necessary depths on Prorva channel during a long period of time. Ships of UDS were forced to use Sulina channel even for cabotage shipping operations and to bear sizeable exchange costs. War in Yugoslavia and shut-off of through course up-stream Danube have aggravated the situation.

Sharp shortening of cargo-passenger flows of Ukrainian ports (Reni, Izmail, Kilia, Vilkove and Ust-Danube), high channel dues for ship passing of Sulina narrow strait have such a result that cargo processing, ship-building and ship-repair works were practically stopped. Consequently, the deductions to the social needs were sharply reduced. The reduction of work places, overprofiling of the highly skilled staff and worsening of social-economic situation of the population leads to the socio-economic decrease in the region.

At present the only ship passage acting in Ukraine that is through the Ochakivske branch, the Prorva branch, and the connected channel, providing passing of ships with draft up to 2.5 m, steadily silted, and operation volumes of its dredging is constantly increasing.

The creation of the deep water Navigation Route of its own for Ukraine is now considered a most urgent problems of geopolitic and economic significance without the decision of which Ukraine will finally lose one of the branches of the transport corridor, and the shipping line of the Danube with the Black Sea will be completely monopolized by Romania. Such a situation is leaded to the large economic losses not only for Ukraine, but also for the countries of Europe, first of all for the Danube ones.

Taking into account the geopolitical key position of Ukraine in the Euro-Asian region at the crossing of the shortest transport ways, the government has ratified the programme of creation and functioning of the national connection lines of international transport corridors.

A fundamental principle that all sea and river ports of Ukraine shall be included into the international transport system and connected with the nearest transport corridors directly or through the radial courses is taken as the basis of the program in relation to the water transport.

International Transport Corridor No. 7 (Rhine - Main - Danube), that includes Izmail, Reni, Ust-Danube ports is the priority passage having connection with the ports in which it is necessary to create the specialised fundamental water transport-warehouse complexes (TWC) – terminals. Availability of such a high-power water-way as the Kilia branch is the presupposition for creation of the ship course line connected with this corridor of the ship passage at the Ukrainian part of the Danube delta with the guaranteed depths of the vessels outlet to the sea.

The international community is interested in realisation of the considered transport lines. Their interest is dictated, first of all, by the economic reasons, which are caused by the reduction of the cargoes delivery way from Europe to the countries of the Middle East, Northern Africa and back.

the DWNR creation will cause the increase of fuel-energy and trade-economic independence of Ukraine in strategic context.

In the social-economic aspect the creation of the DWNR will allow to ensure the employment of the population of the region and to raise its standard of living.

The creation of the DWNR will violate the monopoly of Romania at the Danube waterways, and, accordingly, it will cause the reduction of cost of ship passage through the Danube.

Ukraine can gain the greatest economic advantage by engaging of transit cargo flows - as it had been already done in recent times by a number of countries of the Central and Northern Europe.

For the definition of the supposed size of ship flow according to the order of "Delta - pilot" state enterprise, the adviser of joint venture "Tikon" - has carried out an audit-marketing investigation, an expert estimation of the basic strong and weak aspects of the future DWNR including in comparison with the such ones of the competitors. For the definition of competitiveness of the undertaking the experienced authoritative experts had been involved. As a result of the analysis the forecast estimation of the market share which can be developed was given: as for native ship-owners - 81%, foreign ship-owners - 65%.

The market analysis has shown, that the average quantity of ship passages per a year across the Tulcea branch after Yugoslavian bridges breaking down has made up to 850 ship passes, native ship-owners make up about 13% of it. Thus, forecast quantity of ship passages through the projected channel at present base will make:

a) for native ship-owners 850 x 0.13 x 0.81 = 89 ship passages,

b) for foreign ship-owners 850 x 0,87 x 0.65 = 480 ship passages.

In total: 89 + 480=569 ship passages.

After the reconstruction of Yugoslavian bridges (2004-2010) the quantity of ship passages can be restored up to the meaning of the 80th years - 1100-1700 two-way ship passages.

In Table 3.2 are given the pro forma data concerning the quantity of two-way ship passes, as well as the real quantity of the other kinds of services - pilotage and SMCS.

Table 3.2 - Volume of services (number of ships)

Year:	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Services of SMCS – international shipping	379	492	596	718	841	955	1051	1149	1246	1343
Services of SMCS – coastal shipping	70	91	110	133	156	177	195	213	231	249
Ship pass (channel dues) - native ship-owners	70	91	110	133	156	177	195	213	231	249
Ship pass (channel dues) - foreign ship-owners	379	492	596	718	841	955	1051	1149	1246	1343
Pilotage services (dues) - up to Reni - international shipping	379	492	596	718	841	955	1051	1149	1246	1343
Pilotage services (dues) - up to Reni - coastal shipping	48	63	76	92	107	122	134	147	159	172
Pilotage services (dues) - up to Izmail coastal shipping	22	28	34	41	48	5	60	66	71	77

3.2 Characteristic of the project

The type and the class of the projected DWNR was defined as the alternative to the Navigation Route through the Sulina branch, which is referred to the VII class of the inner water ways of E-category.

The DWNR has the following characteristics:

The type of the waterways – of the international importance;

The class of the waterway – super main waterway in accordance with the rules of State Standard of Ukraine DSTU B V 2.3-1-95;

The VII class – in accordance with the European classification of the waterways.

The reach of the main river-bed of the Danube (Izmail Chatal - Reni), which is the part of the projected DWNR, was referred to the higher, the VII class of the waterways of the E-category.

The development project provides the creation of the navigational channel on the first phase, which will guarantee the passage of the vessels with the draught of 5.85 m and with the following dimensions: L = 125 m; B = 17 m; T = 5.85 m.

Table 3.3 Parameters of the DWNR

Sect No.	Draft set	Sector name (conditionally)	Sector borders *, m	Sector length, m	DWNR width (by the bottom), m	DWNR depth, m		Slope base
						Phase I	Full development	
1	0115-1.1-GDN.1	Sand-bar part	–1,898 – 1,534	3,432	100	7.65-8.32	8.72-9.52	1:9
2	0115-2.0-GDN.1	Sea – Vilkove	1,534 – 10,000 10,000 – 20,585	8,466 10,585	60** - 120	7.0	8.4	1:6
3	0115-3.0-GDN.1	Vilkove – Izmail Chatal	20,585 – 116,000	95,415	120	7.0	8.4	1:6
4	0115-4.0-GDN.1	Izmail Chatal – Reni	116,000- 170,360	54,360	120	7.0	8.4	1:6
1-4		TOTAL LENGTH:		172,200				
	incl. the sector of international Navigation Route	Izmail Chatal – Reni (state border)		54360				

** positioning of the linear co-ordinates of the beginning and ending of the sectors was determinemade in accordance with the fixed position of the Vilkove gaging station – at 18 km from the mouth of the Bystre branch.*
*** It was accepted by analogy with the Sulina and the Prorva channels.*

The Phase I in the project of creation of the DWNR was stipulated as experimental on the basis of the Decree of the President of Ukraine No. 502/2003 from 10.06.03. This had allowed to carry out complex monitoring during construction and on the basis of its results to advance negative consequences for the environment. It is especially important as the DWNR passes through the zone of anthropogenic landscapes of the DBR.

The construction of the DWNR on full development is provided to carried out under operating conditions of the experimental Navigation Route continuously after performance of works on the first phase. Such decision is stipulated under development of FS and became possible on the basis of joint work with Institute of Hydromechanics of the NASU on substantiation of the accepted technical decisions. The basic technical decisions, namely choice of direction of the sea approach channel, construction of turning dam at the beginning the Bystre branch, protective dam on a sea sand-bar for minimization of the Navigation Route silting and maintenance of reliability and safety of navigation were checked and optimised by mathematical and physical methods of modelling. Researches of formation of ship-caused waves and their influence on Ptychiya spit and riverbanks of the Bystre branch, formation and propagation of a salty wedge upstream the branch with taking into account of works on creation of the sea approach channel, also were carried out by researchers of the Institute of Hydromechanics.

The direct transition from the Phase I to works on full development of the DWNR will allow:

1) To ensure reduction of cost of construction due to reduction of expenses on relocation of construction machines and pump-dredgers;

2) To reduce terms of construction as a whole and, accordingly, the period of noise, mechanical and chemical influence of building engineering on environment;

3) To avoid repeated influence on bottom ecosystem at stepwise dredging of rifts: at continuous development of rifts up to design parameters the restoration of bottom biocenoses will take place in shorter term, and it will reduce damage to environment;

4) To speed up restoration of sludge ponds, in which is stored developed on rifts ground, and to reduce terms of returning of grounds in agricultural use;

5) To speed up recondition of an ecological status of a sector of coastal waters in the area of sea dump which is taken out at construction the sea approach channel and clearing of bed of the Bystre branch: the natural burial of storing sediment will take place during the first high water, as the dump is located in section of sedimentation of suspended substances loaded by the branch;

6) Due to presence of the developed project on full development, if necessary, on the basis of monitoring results, urgently to begin construction of necessary protective or controlling structure, without development of the local project.

The list of works on full development of the DWNR includes:

1) Finishing up the SAC to design parameters (continuation of works of the Phase I);
2) Construction of a protective dam on the bar (continuation of works of the Phase I);
3) Construction of the DWNR in river-bed part, conditionally divided into three sectors:
   - Sea – Vilkove (continuation of works of the Phase I);
   - Vilkove – Izmail Chatal (continuation of works of Phase I);
   - Izmail Chatal – Reni (the Prut river outlet, state boundary of Ukraine);
4) Construction of hydraulic engineering structures on sector Sea – Vilkove;

The works at items 1 and 3 are direct continuation of works of the Phase I. They cannot result to quite other ecological consequences in comparison with works carried out at the Phase I. By results of complex monitoring the corrective amendments can be brought in to terms of their realisation.

The performance of the projected works at items 2 and 4 will be made only on the basis of results of experimental operation of the DWNR and complex monitoring, in connection with which the amounts of works, constitution and configuration of structures will be concretised.

Table 3.4 – Dredging operations at creation of the DWNR

Objects	Volume of dredging, m³		
	TOTAL	Phase I	Full development
Dredging of rifts, total	**6,381,308**	**1,880,930**	**4,500,378**
incl. at the Reni – Izmail Chatal section	79,720	-	79,720
at the Izmail Chatal – Vilkove section	5,705,600	1,726,700	3,978,900
in the Starostambulske branch	520,020	154,230	365,790
in the Bystre branch	75,968	-	75,968
Sea approach channel	**2,873,600**	**1,683,600**	**1,190,000**
Construction of the protective dam	**123,120**	**90,000**	**33,120**

Table 3.5 – Dredged Sediments Storage

DWNR Sections and kinds of dumps	Volumes of storage, m^3			Note
	TOTAL	Phase I	Full develop-ment	
Reni – Izmail Chatal	–	–	–	Dumping of dredged sediments into bed dumps
Izmail Chatal – Vilkove	**4,058,620**	**1,726,700**	**2,331,920**	Dumping of dredged sediments to the sea dump
incl. coastal dumps	3,325,020	1,726,700	1,598,320	
bed dumps	733,600	–	733,600	
Vilkove – Black Sea and Bar part	–	–	–	Dumping of dredged sediments to the sea dump
Sea dump	**5,319,408**	**1,927,830**	**3,391,578**	Established volume of the dump – 5,361,000 m^3

Table 3.6 – Hydraulic facilities of the DWNR

DWNR Sections and objects	Length, m			Environment Protection Function
	TOTAL	Phase I	Full development	
Turning dam	350	–	350	Limitation of water outflow and silts on the Bystre branch, prevention of washout of coasts and coastal drift, decreasing of the volume of operational dredging.
bank stabilization structure (sect 1–4)	2,107	–	2,107	Prevention of coastal washout of Starostambulske and Bystre branches
incl in the Bystre branch (sect 3–4)	1,662		1,662	Prevention of coastal washout of the Bystre branch
Protective Dam	2,830	1,040	1,790	decreasing of the washout of the seaward access channel and the volume of operational dredging, decreasing the wave acting on the Prichya spit

Table 3.7 – Areas of bed damage in the period of the DWNR construction

Sections of the DWNP and kinds of works	Areas of bed damage, m^2		
	TOTAL	Phase I	Full Development
Reni – Izmail Chatal – development of riffles	**72,470**	**–**	**72,470**
Izmail Chatal – Vilkove, total	**3,384,780**	**1,121,105**	**2,263,675**
incl. . development of riffles	3,184,780	1,121,105	2,063,675
dumping into bed dumps	200,000	–	200,000
Vilkove – the Black Sea, total	**500,976**	**171,000**	**329,976**
dredging of riffles	376,400	171,000	205,400
bank stabilization structure	111,326	–	111,326
construction of the turning dam	13,250	–	13,250
Bar part, total	**1,398,960**	**579,050**	**819,910**
incl. the construction of the seaward access channel	1,175,850	482,850	693,000
construction of the turning levee	223,110	96,200	126,910
Sea dump – dumping	**1,978,200**	**580,000**	**1,398,200**

Thus, the development project of the contractor design on complete development in parallel with realisation of the Phase I of DWNR creation allows, on the one hand, to speed up construction, reducing thus period of negative influence on environment of construction works and promoting intensification of reconstruction ecosystem processes, and on the other hand - to keep the full opportunity of the account of results of the experimental DWNR operation at the further realisation of the project.

The basic kinds and amounts of works on creation of the DWNR are given in Table 3.4. Situation plans of Navigation Route track and area of the sea approach channel are placed in Annex G.

The sea approach channel (of 3.1 km) is projected with width by bottom 100 m, depth 9.52 – 8.72 m at LWL, equal - 0.48 mBS on seashore. The mark of designed bottom: - 10.00, - 9.50 and - 9.20 mBS. Slopes base 1:9 of left-bank slope-formed at the sea approach channel at first stage, is stipulated to save. Widening of channel bed up to 100 m will be carried out with shifting of the sea approach channel axis by 25 m to the right (Annex G). In planned constitution the parameters of widening of the sea approach channel on turn are determined for vessel with radius of rounding equal 2000 m in accordance with the SNiP 31.31.47-88 (Regulations and Norms of Construction of Sea Channels).

Direction of track of the sea approach channel: 128º - 308º.

Movement of vessels: single-direction running.

The protecting dam by extent of 2830 m is stipulated on the sand-bar for deviation of along-shore currents and sediment transport, and also for reduction of influence of wave on navigation. The location of dam is accepted on the basis of modelling researches. Its width on top is 3-4.50 m, mark of back varies from 2.20, 1.70 and 1.20 mBS. Slopes base changes from 1:3 up to 1:1.5 depending on wave influence (Table 3.5).

Table 3.8 - Characteristic of parameters of protecting dam

Part of dam	Length of part, m	Height of estimated wave, m	Slopes base :		Mark of back, mBS	External paving of slopes
			from side of channel	from side of the sea		
Lower	805	3	1:3	1:3	2.20	Stone, d =800 mm
Middle	805	1.6	1:1.5	1:3	1.70	Stone, d =600 mm
Upper	1220	0.8	1:1.5	1:1.5	1.20	Stone, d =300 mm

The dam is designed as stone fill of trapezoidal section, on a layer of crushed rock filter.

Stone fill is stipulated from unsorted rock stuff with 50% contents of stone with diameter of 300 mm, 600 and 800 (for the upper, middle and lower parts of the dam respectively). On the external slope, subject to wave influence, a stone fill with the primary contents of stone with diameter 800 mm and 600 mm is stipulated (on a sector of the destroyed wave).

The sector of the dam by extent 1040 m is designed at the Phase I as a temporary structure, which construction should be proceed up unceasingly to achieve complete designed length and full section.

In connection with the experience of new building materials in hydraulic engineering abroad, offered by German firm *Josef Möbius Bauaktiengesellschaft* variant of a design of a dam with application of sleeves from geotextiles *Stabilenka*® 120/120 by *HUESKER* was also considered in the development project ‘on full development’. This variant allows to reduce volume of expensive (taking into account of transportation) stone production and terms of construction. The filling of sleeves is provided by a local sandy ground, it is possible with the additives for hardening. For filtering and protective means the application of mats and mattresses by the *Terrafiks* B609G of *Haye Fasertechnik GmbH and Co. KG* is provided in the basis of the dam.

The sea - Vilkove sector is projected on the Bystre branch with width by bottom 60m (single-direction running 1.534 km – 10.000 km), and on the Starostambulske branch – 120 m (two-way traffic, 10.000 km – 20.585 km). Slopes base - 1:6.

In places the direction of the track a little bit differs from the track projected at the Phase I, when the clearing of the channel was not required. The curves on turns are inscribed with radiuses of 1000 m and more. The exception makes radius of turn on the entrance in the Bystre branch from the Starostambulske branch (800 m), where there is a smooth adjunction of single-direction running Navigation Route with two-way traffic one.

Given sector rift (11th km) is subject to clearing up to a mark of design bottom equal - 8.66 mBS. Except specified rift, in separate places on the bed of Navigation Route the insignificant clearing of the channel of the Bystre branch (4 and 6 km) and the Starostambulske branch for ensuring of estimated design parameters of the DWNR is stipulated.

On other part of the given sector of the DWNR the currents have natural parameters providing the pass of vessels with estimated dimensions, and natural width of the Navigation Route is much wider of estimated one.

On the Starostambulske branch, downstream the source of the Bystre branch (outside of the Navigation Route) the partial clearing right-bank shoal border up to design mark is stipulated, that will ensure fractional diverting of water and sediment runoff from the Navigation Route. Extent of a sector of dredging – 550 m. Now specified shoal border works as a natural barrier, directing a water and sediment flow into the Bystre branch. The expediency of the given technical measure is proved by conclusions of Institute of the Hydromechanics of the NASU, however it is recommended to carry out the dredging of shoal border on the basis of actual and modelling researches within the framework of monitoring.

On the given sector, according to the FS, the construction of hydraulic engineering structures is stipulated, which list is given in Table 3.4.

A turning dam (11th km of the DWNR) is projected as underwater, diving, towering above by a surface of bottom by 2.60 m, with head on mark –of - 4.60 mBS. Width of the turning dam (by its back) – 3.0 m, length – 350 m (Annex H). Mathematical simulations can correct a length of the dam. . Along the dam and around of head the tail areas from stone fill on a layer of rubble are projected. The basic purpose of the turning dam is rejection of bedload sediments from the direction of the Navigation Route and the stabilisation of live section of the Bystre branch.

Bank stabilization. On the root of the turning dam – at the left bank of the Starostambulske branch upstream from the Bystre branch source (section 1), and at the Y-track – on the right bank of the Bystre branch and the left bank of the Starostambulske branch (section 2) – is provided a stabilization of the bank slope and the bed of the navigable slot by stone fill over small rock layer. On the sectors of the left bank of the Bystre branch between the 6th and 9th km of the DWNR, where bank river erosion has been observed (sections 3-4), a construction of spur dikes with enrockment over the crushed rock layer having the top width – 3 m, which deflect the flow and provide the bank stability is projected. A reinforcement of section 1 and 2 is obligatory. A necessity of a bank stabilization on sections 3 and 4 and priority of works on any section will be decided during monitoring.

The given sector of the Navigation Route requires the special supervision and, probably, decision on acceleration of construction of first-priority elements of the complex of hydraulic engineering structures specified by the project.

The Vilkove – Izmail Chatal sector (20.585 – 116.000 km) with extent of 95.415 km is projected with width by bottom of 120 m for ensuring of two-way traffic of vessels. Slopes base for various engineering-geological conditions is determined in accordance with the SNiP 31.31.47-88 for separate geotechnical elements and it is 1:6 and 1:1.5. The curves on turns are inscribed with radiuses 1000 m and more, except for turn on a site of 98th km, where radius of turn is 700 m, that it is necessary to take into account at creation of local rules of navigation and navigating map. The axis of track of the projected Navigation Route with the purpose of reduction of dredging works volumes is approached to the maximal and design depths of existing watercourse of the Danube River, as far as it was possible, based on conditions of safety of navigation and situation of state borders.

On the given sector 10 rifts are subject to clearing.

On Izmail Chatal - Reni section (116.000 – 170.360 km, mouth of the Prut River, state border of Ukraine), with extent of 54.360 km navigation is carried out on existing waterway of the international Navigation Route. Limited dredging is planned on two sites (see Tabel 3.4). On all extent of the sector width of Navigation Route – 120 m and design depth – 8.40 m is provided. The radiuses of turn are projected as 1000 m and more.

The sea dump is intended for storing of sediments taken on sites of channel downstream Vilkove and in bar part. The allocation of dumping site by the area **269.2** ha on depth **22 m** was made at the Phase I. It represents a circle by diameter 1 Mile with co-ordinates of the centre: **45°19′13″ N, 29°51′58″ E**.

The Sea dump is located on distance more than 8 km from the coastal line to the east of entry in sea approach channel. During a high water it is in a zone of river suspended solids dispersion. In that way the natural burial of storing ground and prevention of the output of water polluting substances from it are provided.

Capacity of dump is 5361000 m³ at design average thickness of a ground layer of 3 m.

Coastal dumps of ground are intended for storing basic mass of ground of dredging, developing on sites from Vilkove to Reni. Location of the dumps is linked up to places of repair of existing meliorate protective structures. Areas, allocated for dumps belong to unsuitable lands and are allocated in temporary usage. Thus the taken out ground after consolidation will be used for construction and repair of earthen protective structures. It is not also excluded the opportunity of usage of dumps as greenlands since low contents of toxic substances in the stored ground will be ensured.

At designing of dumps the banking of territory is stipulated. On water-sick grounds, their arrangement is provided by excavators, on dry valley – by bulldozers. Along dams of primary banking, on external border of a platform of dump, the arrangement of drainage channels is stipulated, which provide derivation of drainage waters to existing watercourses. This decision meets conditions, put at allocation of grounds.

The hydraulic fill is supposed to conduct with the arrangement of drain pool. Calculated way of clarification of pulp depends on granularity of stored sediments, width and depth of pool. The parameters of all dumps provide an opportunity of clarification of pulp. The place of discharging of the clarified water is recommended, which can be improved at creation of the execution project.

On all platforms chosen for dumps (Table 3.6), the certificates of allotment of land are made and approved. In addition to coastal dumps the **channel dumps** are stipulated with the purpose of reduction of the area assigned to coastal dumps.

Table 3.9 - List of coastal dumps

# of dumps	Location, km	Area, ha	Mark of filling, mBS/height, m	Volume, m³
3	76.20 – 74.60	11.00	2.50/1.2	132000
6	67.45 – 67.05	35.00	3.20/3.0	1050000
9	61.40 – 60.40	13.00	2.50/2.0	260000
11б	50.20 – 49.90	10.00	2.80/2.6	260000
12б	45.60 – 45.20	15.00	2.50/1.0	150000
13 *a* and 13 *b*	39.00 – 39.50	5.60	3.50/0.0	168000
14	36.70 – 35.50	4.50	4.00/2.6	117000
15	31.10 – 30.00	9.66	2.20/2.1	202860
16	29.50 – 27.40	21.21	1.90/1.67	354200
TOTAL		**124.97**		**3424660**

Channel dump "Protoka" is projected on disappearing anabranch upstream of Maikan island between a coast and anonymous island with depths up to 2.2 m (km 37.40 – 36.40). Filling of this anabranch is recommended from below upwards with diking made with dredging sediments. Design capacity of dump at reaching the mark of 1.3 mBS makes 333600 m³, area of filling – 12.2 ha. Storing of an unconsolidated ground will be made from hopper pump-dredger. At development on rifts grounds, such as clay, carried out by chain-bucket dredge ships, the ground will be stored in deposit and to be withdrawn wherefrom by a stationary pump-dredger with further deposition into channel dump.

Channel dump is designed also on the site of river reach of 60.60 – 59.60 km with marks of bottom - 20-21 mBS. At filling up to marks of - 15 mBS and the area of filling of 7.8 ha, design capacity of this dump is 40000 m^3. The storing of sediments will be made from self-propelled lighters and hopper pump-dredgers.

Scientific substantiation of a location of dumps with EIA are executed by RC Noosfera and co-ordinated by Inspection of protection of the Black Sea.

At calculation of total time of construction, volumes of the dredging works were determinative. For accounts following initial data and the hydrological and ecological restrictions are accepted:

- Cessation of work for the period of fish spawning - 1 month per year;
- Working period at performance of works on the sand-bar (with account for negative wind-heaving and glacial events) - 12 dpm, 165 dpy;
- Working period of performance on the river - 22 dpm, 250 dpy;
- Sea motions up to Beaufort makes 2 - 74.8%;
- Repeatability of a wind with speed 10 mps makes up 21.05%; 25 mps – 0.08%;
- Daily productivity of pump-dredgers - 3500 – 4000 m³/d;
- Daily productivity chain-bucket hydraulic dredge ships - 2000 – 2500 m³/d.

At the Phase I at construction of the Navigation Route seven chant-bucket hydraulic dredge ships and two pump-dredgers were simultaneously involved. On development of rifts the work simultaneously of pump- and chain-bucket hydraulic dredge ships was provided. The attraction to work on complete development the same hydraulic dredge ships will allow to reduce expenses on relocation. Because of the sites of works are not concentrated, but are allocated along a channel and a beach on length off-track of the DWNR (Table 3.7), such quantity of simultaneously working engineering is technologically possible, economically justified and ecologically safely.

Table 3.10 - List of location of hydraulic dredgers along rifts on the section 'Vilkove – Izmail Chatal'

Kilometres of Navigation Route	Volume of dredging, m³	Slopes base	Possible hydraulic dredge ships
112.5 – 115	16,800	1:6	Hydraulic pump-dredge ship "2 Prorvin"
76.00 – 77.00	42,300	1:6	DN 601 with double transfer under DE21
71.00 – 75.50	349,800	1:6	Hydraulic pump-dredge ship DN-1 DN 601 with double transfer under DE21
68.50 – 71.00	95,650	1:6	DN 601 with double transfer under DE21
64.00 – 68.50	437,900	1:6	Hydraulic pump-dredge ship "Arbatski"
60.00 – 64.00	555,310	1:6	Hydraulic pump-dredge ship "2 Prorvin"
46.50 – 53.00	611,800	1:1.5	"Tixi" and "Danube" under DE21
33.00 – 39.00	369,800	1:1.5	DN 601 DN 601 "E. Kolodochka" under DE 21
31.00 – 33.00	276,000	1:1.5	Hydraulic pump-dredger DN-1
26.00 – 31.00	583,300	1:6	Hydraulic pump-dredger DN-1
20.50 – 26.00	640,300	1:6	Hydraulic pump-dredger DN-1
Total	**3,978,900**		

At construction of hydraulic engineering structures ship crane, barges, towboats, sea shalandas, lighters will be involved. The construction is carried out in parallel with development of grounds at the passing of vessels, that allows to reduce its terms to 18 months, including two months of the preparatory period and month of an interdiction (the spawning period).

The safety of navigation along the DWNR 'Danube - Black Sea' will be provided in accord with normative documents, including ones of the Danube Commission.

The Ministry of Transport of Ukraine nominated *Gosgidrografia* State Establishment as institution responsible for navigation-hydrographic ensuring of safety navigation on the Danube River is (by the Order of No. 132 of 24.05.2004). .

Navigating conditions of the sea approach channel on full development includes floating warning marks: lighted marine buoys of types BMBL-00 (01) and BML (ESS-95), and also spar marine buoys such as BM-86, and also leading marks installed on an entrance of the Bystre branch from the sea approach channel.

Navigating travelling conditions along the channel sections of the DNWP provides using of floating signal marks - buoys of types A.1, A.2 and A.3.

At an initial phase of navigation in accordance with the SNiP 31.31.47-88 the estimated safe speed of vessels in the sea approach channel is established 10 knots, on a sector of the Bystre branch - 8 knots. For prevention of damage by waves of levees the movement of vessels in the Bystre branch to carry out with speed up to 7 knots before reception of results of full-scale supervision over wave influence on coast of branch is recommended. On other sectors - the speed of movement is regulated by local rules of navigation.

3.3 Analysis of sources, types and factors of environmental impacts

During the fulfilment of the works concerning the creation of the DWNR the principal factors of the environmental impact will be the following:

- the machinery and floating craft, used for the dredging of the sediments in the area of the of the DWNR (predominantly in the areas of the existing rifts) and for the transportation of these facilities to the areas of the temporary and the permanent storing;
- mechanisms and floating craft, which are used for the construction of bank stabilization structures and water flow control structures in the source and along the banks of the Bystre branch;
- the machinery and floating craft, used for the creation of the slot, which is necessary for the passage of the vessels through the sand-bar of the Bystre branch, for the construction of the protective dam and during the transportation of the excavated sediments to the sea dump;
- the bottom sediments, transported to the places of the coastal and underwater dumps from the channel part of the track as well as from the area of the Bystre branch's sand-bar.
- construction materials, used for the construction of the protective and control hydraulic structures.

During the operation of the DWNR considering the importance of the periodical fulfilment of the repair and renewal operations for all the mentioned sources of the influence will remain, although the intensity of their influence will be considerably reduced.

The principal sources of the environment impact will become the changed hydromorphological parameters of the delta elements, through which the DWNR passes. It concerns also the cargo and passenger vessels, passing through the DWNR.

The factors of the impact of these sources on the **subsurface** are the changes of the bottom and coast relief, taking place during the carrying out the works as well as the potential changes of the delta evolution, caused by the alterations of the hydrodynamic conditions in the sand-bar area of the Bystre branch.

The factors of the influence on the **ground and surface water** are the following:

- the damage to the bottom surface in the places of dredging operations as well as the building of the protective dam and the channel and the sea dumps;
- the alteration of hydrologic regime of the branches of the passage of the DWNR and in the area of the sand-bar of the Bystre branch as the consequence of carrying out of the mentioned works and due to the passage of the vessels;
- the discharge of the suspended solids and of the dissolved contaminants into the water from dredged and dumped bottom sediments during the creation and operation of the DWNR;
- the discharge of the contaminants into the water due to violation of regulations of the passage of the vessels and in cases of emergency.

The factors of the influence on the **ambient air** in the period of creation and operation are the gas and aerosol emission of the pollutants into the atmosphere as well as the noise in case of the operating of vessel engines, constructional mechanisms and auxiliary floating facilities.

The factors of the influence on the **soils** in the period of the creation of the DWNR are the dumps of the excavated bottom sediments in the specially allotted areas and the eventual changes of the water regime of the delta grounds.

In addition to the above-mentioned physical and chemical influences in case of the heightened content of the radioactive nuclides in the bottom sediments the operations with them would cause the ***radiological*** impact on the environment.

All the above-mentioned man-caused factors, changing the abiotic conditions of the delta ecological system, can influence indirectly (in same cases also directly) on **the plants and animals kingdoms** of its principal biotypes – waterways, flooded areas and coastal waters.

The characterization of the above mentioned factors and processes, which can be caused by them in the components of the environment, as well as the possible environmental consequences, are given in Table 3.11.

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 = 850 m^3/s	µg/l						15			32.5
	at discharge = 1350 m^3/s	µg/l						9.6			20.4
	at discharge = 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	
	totals	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.

		Dimens.	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	$1 \cdot 10^{-3}$	$3.2 \cdot 10^{-5}$	$1.0 \cdot 10^{-5}$
	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	$1.08 \cdot 10^{-2}$	$3.42 \cdot 10^{-4}$	$1.08 \cdot 10^{-4}$
	The concentration increment in the water column due to the excavation								
	at discharge = 850 m^3/s	mg/l	0.0114	0.900**	1.800***	0.300			
		µg/l					$1.27 \cdot 10^{-2}$	$4.02 \cdot 10^{-4}$	$1.26 \cdot 10^{-4}$
	at discharge =1350 m^3/s	mg/l	0.0072	0.567**	1.134***	0.189			
		µg/l					$0.80 \cdot 10^{-2}$	$2.52 \cdot 10^{-4}$	$1.14 \cdot 10^{-4}$
	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»

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

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

3.4 Conclusions to Chapter 3

1. Development of the river and marine economy determines the specialisation of the region in inter-district and international distribution of labour. Industrial specialisation of the region is determined by the industries of a marine cycle: shipbuilding, ship repairing and fish-processing. The transport complex, making use of the geographical advantage of the Danube waterway, serves as the main factor of development of Danube towns.

2. Decrease of navigation of last years along the Ukrainian part of the Danube because of the non-ensuring of necessary depths on the channelled Prorva branch results in the degradation of industrial and transport centres. Construction of the DWNR is the necessary condition for revival of these key industries of the region.

3. Creation of an own deep Navigation Route has become a most actual task of geopolitical and economic importance for Ukraine, without solution of which Ukraine will finally lose one of the branches of the transport corridor, and navigation connection of the Danube with the Black Sea will be completely monopolised by Romania. Such situation is fraught with large negative profit for economics of not only Ukraine, but also other European countries, first of all the Danube ones.

4. The trace of the DWNR along the Bystre branch, creation work for which has begun in accordance with the approved development project of the Phase I of construction, meets the following criteria:

- one of the least volumes of operational dredging;
- of the similar variants in respect of operational dredging volume - the least volume of excavation during the construction;
- competitive cost of construction;
- straight course of the Bystre branch with sufficient natural depths, which excludes necessity of construction work in the branch itself;
- relatively small velocity of delta extension on this part of its marine edge;
- relatively rapid increase of depths out of the bar, which allows to rely on the long enough operation of the DWNR.

5. The construction of the Navigation Route at full development is provided to be performed at using the experimental Navigation Route directly after the Phase I on the basis of physical modelling, performed by the IHMNASU, and complex monitoring of the environment, which has been held from the beginning of the construction.

6. Working of a project for full development simultaneously with the performing of the first stage of the creation of the DWNR allows to speed up the construction, thereby shorting the period of negative influence of the construction work to the environment, and contributing to the intensification of reduction ecosystem processes, on the other hand, to maintain the possibility of utilizing the results of the experimental DWNR operation during the project further implementation.

7. Construction of the DWNR at full development will impact directly and indirectly on the basic environmental components, affected zones of which may considerably differ. Their environmental impacts is the subject of the next chapters.