4 ENVIRONMENT IMPACT ASSESSMENT OF THE DWNR

4.1 Geological environment

4.1.1 Subsurface and geotechnical conditions

The Danube Delta enters into structure of the Black Sea depression located within the alpine geosynclinal region. Northeast part of the Black Sea is attached to the outlying districts of East-European plate, where deep lying sedimentary rocks of tertiary, Mesozoic and Palaeozoic periods mildly slope down to the southwest. On these ancient rocks in the Delta the thick deposits of Cainozoic are located.

In structural-tectonic respect the area under study is within southwest part of the Black Sea adjacent area depression. Its formation is connected with sinking of Precambrian and epiherzinskiy blocks of Russian platform, which are divided by the belt of rift-valley type depressions. So the deposits forming the depression lay on crystal rocks of various age and genesis. The nearest laying rocks to the surface are terrigenous-carbonat formation of Miocene and early Pliocene, which are presented with clays, which upper boundary in the area of the Danube Delta occurs at the depth of 50-120 m.

The most ancient formations relate to the upper Pliocene period and are presented by clays, sands and bench gravels. Their upper boundary occurs at the marks of -20m – -36,8 m. In the area of Izmail town the deposits of kuyalnik layer are presented with heavy light-yellow sand clays occurring at the marks of -4 – -9 m.

Thickness of alluvial Holocene deposits is characterised with variety of lithologic composition. Mixed character, variable areal thickness of layers and variety of soils both in thickness and extension are subject to peculiarities of sediment accumulation in the Danube Delta. The river waters flow supplies bringing fragmental terrigene material forming the delta sediments predominantly loamy ones. Its accumulation is facilitated by absence of strong sea currents near the estuary part of the river, coagulation of thin material brought by the river. Among delta depositions, there are sizable delta sediments of organic particles mainly vegetable ones.

These depositions form powerful thickness among which there are rocks of various composition forming strata, beds, lenses, very often sharply tapering out, facially substituted here and there by other petrographic diversity of the rocks. It is typical for them the fine interleaving of rocks of various composition.

Top of the Kilia branch secondary delta is situated near Vilkove town. Here the geological-lithologic cross-section of the riverbed has particular mixed character: as a rule, on the surface there are clay and loamy silts of 3,3 m thickness, with fine and medium size sand with great contents of detritus and shell rock of 1,2 to 3,0 m thickness spreading under. Below a layer of loamy-clay depositions of various consistency and colour ranging from dark blue to grey with dark-coloured minerals and mica inclusions and additions of organic matter here and there can be traced.

In up-stream alluvium there is an increase in sand fractions: silts change for clay sand loamy soils, clays transform into clay sands, thickness of sand soils increase. Silt sediments are attached mainly to the bank areas of the riverbed, sand and clay sand ones are attached to the places where there is maximum of flow and depth.

The river, its branches and temporary rain streams, transports present-day sediments of the Danube. The above-water and under-water delta is formed by its sediments and the soils of various quality and properties are shaped on the floodplains. Sediments of the Danube sorted out by the river and the sea serve as good building material.

Soils of the riverbed consist of sediments carried by the river and the bottom sediments of the river, which is washed out weakly. At the Reni - Izmail Chatal reach (160,5 km – 116 km), with high flow velocity, fine sand with predominant particles of 0,1–0,25 mm occur, in the middle of the river the larger particles (0.25–0,5 mm) occur, and there are dusty and silted sand near the banks. Under thin layer of sand there are blue-grey ancient clay.

For the section from Izmail Chatal to the town of Vilkove (116 km – 18 km) the typical is a wash out of grey-white and yellow-grey ancient clay, though the flow in the channel line carries bottom fine sand in the bottom going into silt near the banks. In the Kilia delta the banks and river bed consist of clay silt (particles less of 0.01 mm) with sand inter-layers. In the largest branches of the Kilia secondary delta (Ochakivske and Starostambulske) the fine bottom sand moves along the waterway even in low water and in the smaller branches of the river it moves only in a flood. In some branches the move of the sand does not happen even in a flood.

In various years the *Rechtransproject* and other organisations carried out engineering-geological studies in the riverbed area at the rift places of the Danube River and at the sand-bar of the Bystre branch. In 2001 geotechnical works was carried out along the riverbed in the rift places. Composition of the bottom part of the riverbed area was specified.

The grounds of the littoral area of the delta are represented with fine-to-medium size sands, loamy sands, heavy and light loams, clay and loamy sand silts. At seaside of the Kilia delta a zonal distribution of the grounds are observed in the direction from the shore to the sea, mainly in parallel to the littoral periphery of the delta.

The sand zone occupies sand-bars of the branches and near-shore to the 5 meters bathymetric curve. In some places the boundary of this zone is shifted whether to 6-10 meters bathymetric curve or in the direction of the shore to the depth 1-3 m. The breadth of the zone is about 3-3.5 km. By its composition the sand in the specified zone is quite homogeneous, mainly fine sand, well sorted out. Sometimes the additions of medium size sand can occur closer to the shore, closer to the sea one can observe powder-like sand containing up to 5% of silt particles. A zone of sludgy sand is located on the seaside underwater slope and adjoins to the sand zone. Silt zone occurs in a wide strip at the depths of 10-25 m. Opposite the Bystre branch it makes about 3 km. A zone of clay silt is located inside the silt zone at the depths of 15-20 m

There are 9 geotechnical elements (GTE) marked out altogether on the DWNR

GTE-1:	Mica fine grey sand saturated with water
GTE-2:	Light, dusty, light, green-grey clay with carbonates inclusion from the medium-soft to the hard supple consistency.
GTE-3:	Dusty, mica sand with detritus inclusions, coquina up to 34%, saturated with water
GTE-4:	Light, dusty dark-grey supple clay with organics admixture up to 5%
GTE-5:	Light clay and heavy loam, both dusty with carbonates inclusions of yellowish-grey, greenish-grey supple consistency
GTE-6:	Sandy, light loam with organics admixture up to 6%, from soft to supple consistency
GTE-7:	Clay sand grey supple
GTE-8:	Heavy loam, dusty, supple, leaky
GTE-9:	Clay silt with sand inter-layers

So, while dredging the river bottom in the rifts and sand-bars the various lithologic differences can be met in the soils varying in their physico-mechanical features

Physico-mechanical features of the soils by the geotechnical study reports carried out at different time by *Rechtransproject*, *ChernomorNIIproekt*, *Ukryuzhgiprovodkhoz* are presented in Table 4.1.1.

Table 4.1.1 – Averaged physical-mechanical features of the soils

Name of GTE	Density, g/m^3	Porosity coefficient	Angle of interior friction. degrees	Adhesion. mPa	Soil group by the difficulty to work	
					By DBNP 22-1.99	By norms of DMRTU
Chernomorniyiproject. "The Danube –Black Sea channel". Bystre branch						
Loamy sand silt	1.88	0.943	15	0.005	I	I
Loam silt	1.85	0.992	2	0.012	I	I
Clay silt	1.68	1.514	0	0.012	I	I
Light soft supple loam	1.95	0.807	8	0.009	IV	III
Heavy clay. leaky supple	1.64	1.573	5	0.011	VI	IV
Dusty sand. medium density	1.86		23	0.002	II	III
Rechtransproject. "Vilkove Repair- Operational Base of the Fleet"						
Loamy clay silt	1.76	1.246	12	0.011	I	I
Leaky supple heavy loam	1.89	0.969	17	0.014	VI	III
Heavy loam. hard supple	1.97	0.760	18	0.022	VI	V
Fine to medium-sised sand with cockle-shell inclusions	1.97	0.380	31	0	II	III
Rechtransproject "Terminals of complex services of the fleet on the Danube river near Izmail town (76-79th km of the route of ship movement. Kislitskiy branch)						
Loamy and clay silt	1.63	1.385	14	0.017	I	I
Heavy loam soft supple	1.84	1.000	18	0.030	V	IV
Light loam hard supple	1.86	0.780	19	0.030	V	V
Rechtransproject. " Geotechnical conditions of the terminal construction of Izmail pulp mill"						
Loamy sand silt	1.80	0.960	12	0.003	I	I
Fine sand	2.00	0.720	28	-	I	II
Heavy loamy sand heavy. leaky	1.98	0.789	16	0.010	II	II
Ukryuzhgiprovodkhoz. "Regulator-gate of the Prorva channel (near Orlovka village)						
Clay sand silt to loamy silt	1.77	1.122	12	0.015	I	I
Supple clay sand	1.90	0.829	22	0.020	II	II
Fine sand	2.02	0.616	32	-	I	II

Table 4.1.2 – Averaged values of granulometric, composition of the grounds

GTE	**Diameter of particles, mm, contents of the fractions**						
	1- 0.5	**0.5-0.25**	**0.25-0.10**	**0.10-0.05**	**0.05-0.01**	**0.01-0.005**	**<0.005**
1	1.0	2.7	92.8	3.5			
2	0.4	0.9	2.0	16.8	25.0	23.1	31.9
3	1.6	3.2	62.2	16.5	6.8	2.1	7.6
4	0.4	0.9	2.0	16.8	25.0	23.1	31.9
5	0.0	0.1	0.5	27.9	30.9	17.9	22.7
6	0.2	0.5	9.2	41.2	21.9	7.4	19.6
7	0.3	0.7	37.8	24.8	21.0	3.9	11.5
8	0.2	0.9	7.8	20.2	32.0	13.2	25.7
9	0.8	1.4	1.3	3.1	37.8	20.3	35.3

4.1.2 Analysis of impact of planned activities on geological environment and the relief shaping processes

Impact on the geological environment while building the DWNR will be made by construction works for deepening the riverbed in the Reni –Vilkove section, however this impact is similar to the natural "flushing" of riverbeds and will not lead to the negative consequences.

According to simulations by the MSU Geography department [89], redistribution of water flow between the branches of the Kilia delta will be insignificant (within 1-2% of the total Danube runoff) as result of deepening of the rifts of the Kilia delta. However it will slight compensate actual and predict technogenic redistribution of water flow in favor of the Tulcea branch, which take place because of cutting-off of the Sulina branch and cut-off of the St. George branch. **Thus the impact of the planned dredging work on flow redistribution is positive for hydrologic regime of the Kilia delta, but inappreciable.**

Certain influence on geological environment is possible due to making a navigable "trench" through the sand-bar of the Bystre branch with underwater protective dam. Undesirable consequences may be caused by modifying of natural processes of shaping the underwater relief and instability of underwater relief shape. Stability of underwater constructions to the gravity and wave factors is provided by the adopted values for side slopes in FS of Investments, however they are exposed to the sedimentation and this makes it necessary to carry out permanent maintenance work of cleaning.

At the period of maintenance the protective dam and the opening, which will accumulate the sediments, can change the course of natural processes, which in the last years resulted in the growth of Ptichya spit. At the same time the dam will serve as a protection from the wave impact to the Ptichya spit under the heaviest northern winds.

One of the most long-term consequences of building the protective dam can be the acceleration of natural process of fore-coming of the sea delta marge in the area of sand-bar, building-up of near-estuary islands on the side of the dam and their junction with the shore.

Fears were also expressed regarding possible washing out of the spit as a result of passing ships, however according to the calculations of IMG (Institute of Maritime Geology, National Academy of Sciences of Ukraine) (*hereafter* IMG) [51] the spit stability, which minimal distance from the Sea access channel makes over 500 m, does not cause the fears as the impact of the waves in the area sufficiently less then the impact of wind waves and along-shore currents, which facilitated the spit creation.

Then uncontrolled increase of the water flows in the Bystre branch can result in slow wash-out of the branch banks, disappearing of alternative branches of the delta and worsening water conditions of the dependant wetlands.

Within definite limits the increase of water discharge of the Bystre branch can facilitate preservation of water content of the Kilia delta (as counterbalance to measures taken by Rumania to increase water content of their own branches of the Danube delta, which impacts on the water regime of the northern part of the delta of extension of the Kilia branch and и accelerating of branch dying processes)

Calculations made by IMG using mathematical models of flow distribution and calculations of the water levels (1D-model) and calculation of the velocity plan and distribution of flow in the area of branching (2D-model) showed that opening of the river sand-bar will cause some redistribution of the flow in favor of the Bystre branch, mainly due to water flow decrease in the Ochakivske branch (less than -4%), while the runoff of Starostambulske branch will practically remain unchanged.

According to calculations by the Geography department of the MSU [89], the discharges of the Bystre branch will only rise by 1-2 m^3/s as a result of the sea approach channel creation, so this won't make any impact on water flow regime of other branches.

In the period of construction of the DWNR the monitoring of geological environment will be provided. At revelation of the changes in its conditions fraught with negative

consequences the proper protective measures will be carried out. In particularly, creation of the wing dam is provided for the Starostambulske branch at the beginning of the Bystre branch with the purpose of regulating distribution of the water flow by these branches as well as along the whole system of the Kilia branch delta. Stability of the Ptichya spit banks may also be maintained with engineering measures, in particularly, with appropriate configuration of the protective dams along the sea approach channel.

The passing ships waves can influence on the inshore territories along the Bystre branch at the period of operation of the DWNR. First of all such impact will influence on the most valuable ecotones at the merge of water and marsh biotopes. However, as it was established with simulation by IMG, the similar impact from fishing vessels and motor boats, which waves at fair speed is higher than from the large ships which passing over the DWNR with speed limitation of 7 knots. Besides there is frequent onset- phenomena under which periodic raise of the water level essentially exceed the height of waves due to passing of ships.

According to the data of IMG calculations [51] of depth of the ships waves near the riverbank being the result of superposition of transverse and divergent waves, the calculated value of the wave height is 15 cm less under the speed of 8 knots near the bank of the calculated cross-section. Height of waves will significantly depend on roughness of the shore.

In view of uniqueness and importance of the along-shore banks from ecological point of view as well as the complexity of the wave-forming processes under conditions of narrow fairway, that requires thorough experimental research on the models and environmental tests for the certain parameters entering in calculation proportions the IMG recommends to limit the vessels speed by 7 knots at the initial stage of operation. After receiving information of actual processes (wave height at different distances from the vessels, de-levelling of surface), the speed magnitude can be revised.

Calculations performed and real stability of the Bystre branch banks to the up-to-date wave loading (in particularly, from high speed small- size vessels) let us to count on conservation of these banks at the period of the DWNR operation. Permanent supervision of near-riverbed banks is included into monitoring program. In accordance with its results, a restriction of the vessels' speed in the Bystre branch can be adjusted if necessary.

4.1.3 Groundwaters

Concerning hydrogeologic conditions of the Danube Delta is attached to the western part of artesian basin of the Black Sea adjacent area. The most intense water exchange is noticed up to the depth of 100-300 m in the ground water developing zone dated to Quaternary and Neogenic – medium-upper Pliocene, Pontos, Meotis and Sbranchatic depositions [55, 56].

The peculiarity of forming the ground waters regime (their interconnection, inflow, discharge, chemical composition) is a considerable variability of lithologic composition, frequent interchange of water-containing and waterproof rocks, variable depositions in cross-section and in extension facilitating the formation of large number of aquifers which are typical for the mouth areas of large rivers.

Possible impact of creation of the DWNR on the hydro-geologic conditions within the considered area of the Danube Delta can spread only to the Quaternary zone of active water exchange of 20-30 m in thickness and partially on neogenic zone laying to the depths of 30-120 m. Aquiclude to form the aquiferous complex of this thickness is the clay strata of neogenic age - Miocene and early Pliocene.

Aquiferous complex in Quaternary depositions is spread everywhere and facies attached to alluvial, alluvial-dealluvial, sea, estuary and aeoline-dealluvial sands, clay sand and loams.

Aquifer in up-to-date alluvial and alluvial-dealluvial depositions spreads within floodplains of the Danube, its tributaries and gullies. Depth of ground water occurrence is from 0-2 m in coastal areas of the sea (in floodplains) up to 5-8 m in upper and medium parts of the Danube estuary area.

Inflow to the aquifer is mainly at the period of river floods, infiltration of precipitation, more rarely (at low-water periods) at the expense of inflow from underlying aquifers. Aquifer is unconfined, its saturated zone is 0,5-10 m, general direction of discharge at low water is to the riverbed, flows directed from the river to the flood plain lands and islands also occur.

Quality of the water is very varied and is characterised with natural increase of mineralisation from the upper to the estuary parts. On the most of the flood plain lands the value of mineralisation makes 1 up to 4 g/l. In near-riverbed areas the mineralisation drops to 1 g/l and less.

In the bottoms of largest gullies the aquifer soils are dealluvial loams, loam sand, sands. Thickness of saturated zone is not large and makes 1 up to 3-4 m. Depth to the water table is 2-3 to 5-8 m, mineralisation is high, exceeding 4 g/l. Aquiclude for this level are Quaternary foxy clays or Meotis clay depositions of Pliocene terraces.

Aquifer in the sea and the estuary-sea depositions is developed only along seashore and the estuaries and is attached to the sand forms of relief i.e. beaches, sand areas, spits, peninsulas, dunes. Width of these elements is from 2 m to 100 m. Waters have free surface and the lying depth from 0 to 2-3 m.

Quality of these waters is varied depending on a number of factors: rainfall per year, variations of water level in rivers and estuaries as well as storm and wave onset activity of the sea. Under the influence of these factors the fresh water lenses with mineralisation of 0,.6–2.9 g/l can form upon the sea salt waters.

Thickness of the aquifer is 10-15 m, the inflow is due to the infiltration of atmospheric precipitations, filtration of water from the sea and estuaries and overflow from underlying aquifers.

Aquifer in ancient alluvial depositions of above floodplains terraces is well developed in the valley of the Danube and in its large tributaries. Water-bearing soils are of sand-gravel depositions. Depth of the aquifer changes from 5 m within the 1st over flood-land terrace to 35-50 m on ancient Quaternary terraces. Thickness of saturated zone of soils is from 1-3 to 17 m, but in some cases may reach 30 m.

This aquifer is normally presented by a few hydraulically interconnected water-bearing layers being formed within terraces. Loess loams are the roofs of water-bearing complex; the bottom is the clay of Meotis. As a rule aquifer is unconfined except of adjacent riverbed areas where quick sinking of the terrace basis below up-to-date shore line is observed, hydraulic head reaches 20-30 m. The main inflow to the aquifer is due to rainfall infiltration. Mineralisation of water is up to 2 g/l. The waters belong to sulphate-carbonate natrium-magnesium type. In the Lower Danube this aquifer is often used for cold water supply.

Aquifer in aeoline-dealluvial (loess) depositions is developed on watershed spaces where it is formed on waterproof foxy clays. Its continuous spread is observed only in southeast part where they spread in band of 8-12 km along the estuary area of the Danube between the lakes of Kitai and Sasyk along the Black Sea between the lakes of Sasyk and Burnas.

Water-bearing layer is the lower part of loess thickness. Depth of the deposit is 10-20 m, thickness of saturated zone is from 1-3 m to 10 m. The aquifer is unconfined. The inflow to the aquifer is due to rainfall.

Water-bearing capability of the aquifer is insignificant. Prevailing mineralisation values of ground waters is 5-7 g/l are observed at the slopes of watersheds, at the watersheds itself the values are 1-3 g/l. In the coastal part ground waters with mineralisation over 10 g/l occur.

Besides increase in mineralisation of ground waters from a watershed to a slope it is a tendency of its increase from north to south. Chemical composition of the water is diversified. Thus in the area of developing slope between the lake of Sasyk and the lake of Burnas a mineralisation fluctuates within the limits 1-4 g/l, to the west of the lake of Sasyk it is over 4 g/l. Saltish waters are mainly hydrocarbonate-potassium and salt ones are chloride-natrium.

Analyses of aquifers of the zone of active water exchange of the region under consideration shows hypsometric highest position of the ground waters in quaternary aeoline-dealluvial loams regarding the others aquifers. This creates conditions for descending filtration of water through separate layers of clays and areal inflow in watershed areas from underlying aquifers.

Quaternary complex of water-bearing aquifers of thickness up to 30 m stretches under to the depth of about 150 m thickness of neogenic formation: in Pliocene, Pontos, and Meotis layers. Some of them having low mineralisation of water (up to 1 g/l) are used for cold water supply (Izmail town).

The indicated above water-bearing complexes represent upper hydrodynamic zone with rather intensive water exchange. The common for all complexes is the move of the ground water to the discharge areas from north to south, to the Black Sea with deviations of the current to the main riverbed of the Danube and its largest tributaries.

4.1.4 Analysis of impact of planned activities on growndwaters

Possible impact on hydro-geological conditions while building the DWNR can be because of measures related with dredge of the Danube and its branches riverbed in the places of forming the rifts and sand-bars. However this impact will be rather positive tendency since the water exchange between surface and ground waters will be intensified.

Deepening and clearing of the riverbed will not effect hydrodynamic conditions of ground waters – change of the water table – within the watershed of the Danube, as the steady conditions of inflow sources and discharge of hydraulically interconnected surface and ground waters is not changed, and possible insignificant deviations assimilate within the limits of seasonal magnitude fluctuations of water levels in the river and ground waters.

Shore dumps of sand-silt bottom sediments formed as a result of dredging can result in a rise of ground water and facilitate waterloging of the adjacent flood-plains. To prevent this negative impact the project provides building of the primary diking by the perimeter of shore dumps and arranging of drainage canals, which provide water drainage to the river.

During the floods will be washed, however the carryover of the pollutants from them will not influence significantly the quality of the surface and ground water owing to increasing the diluting capability of the river and under riverbed underground flow at these periods.

4.2 Ambient air

4.2.1. Evaluation of impact of emissions into ambient air during the construction period

The Rechtransproject has carried out calculations of the volumes and dispersion of the pollutants emission into atmosphere in riverbed part and sand-bar part of the DWNR at the period of construction [36].

In calculations the discharge sources, working in riverbed part and the sand-bar part of DWNR at a definite period of time are considered.

Basic data for calculation of pollutants discharge to the ambient air are presented in Table 4.2.1.

Calculations were made for 5 types of pollution: NO_2, C (soot), SO_2, CO and C_xH_y.

Maximum one-time emissions of the pollutants are determined per one hour consumption of fuel and their specific emissions at various loadings (Table 4.2.2). Summarised emissions of pollutants are presented in Table 4.2.3.

Table 4.2.1 – Input data for calculation of the pollutants discharge into ambient air while dredging

Activities	Type of floating vehicles					
	Dredge ship (src.# 1)	Chain-bucket dredge src.#2;3)	Self-propelled scow (src.#7)	Lighter (src.#6)	Floating crane with lifting capacity 16 t (src.#4)	Tug-boat (src.#5)
Fuel consumption, kg/hour	126.5	67.5	20.5	10.0	67.5	20.5
Unit discharge, g/kg of fuel:						
NO_2						
C (Soot)	63.0	83.9	75.1	65.1	83.9	75.1
SO_2	9.4	10.2	7.2	7.9	10.2	7.2
CO	6.0	6.0	6.0	6.0	6.0	6.0
C_xH_x	7.0	7.6	42.0	29.4	7.6	42.0
	12.0	12.0	12.0	12.0	12.0	12.0

Table 4.2.2 – Maximum one-time emissions of pollutants at dredging and construction works for the DWNR full development

Sources of emission	Pollutants				
	NO_2	C (soot)	SO_2	CO	C_xH_y
Dredge ship	1.328	0.198	0.126	0.148	0.253
Self-propelled scow	0.108	0.013	0.010	0.049	0.020
Chain-bucket dredge	0.944	0.115	0.067	0.085	0.135
Lighter	0.256	0.025	0.020	0.143	0.041
Floating crane	0.944	0.115	0.067	0.085	0.135
Tug-boat	0.171	0.016	0.014	0.096	0.027

Table 4.2.3 – Emissions of pollutants at the Phase I and at the Phase for full development of the DWNR

Sections and kind of work	NO_2		Soot		SO_2		CO		C_xH_y		Non-organic PM	
	Phase I	FD [1)]	Phase I	FD	Phase I	FD	Phase I	FD	Phase I	FD	Phase I	FD
1 Vilkove –Reni	10.503	36.076	1.565	7.601	0.999	8.061	1.171	33.501	1.999	12.383	0	0
1.1 Dredging	10.503	24.424	1.565	3.087	0.999	1.935	1.171	4.371	1.999	3.644	0	0
1.2 Bank dumps	-	11.652	-	4.514	-	6.126	-	29.13	-	8.739	0	0
2 Sea-Vilkove	1.172	22.755	0.137	2.835	0.086	1.721	0.204	2.486	0.171	3.426	0	0.326
2.1 Bank strengthening	0	16.539	0	2.014	0	1.191	0	1.685	0	2.384	0	0.275
2.2 Wing dike	0	3.320	0	0.402	0	0.239	0	0.334	0	0.476	0	0.051
2.3 Dredging	1.172	2.896	0.137	0.419	0.086	0.291	0.204	0.467	0.171	0.576	0	0
3 Sand-bar section	10.394	23.067	1.419	2.959	0.778	1.851	0.964	2.594	1.958	3.704	0	0.191
3.1 Protecting dike	6.959	15.259	0.846	1.833	0.498	1.076	0.630	1.336	0.995	2.154	0	0.191
3.Dredging	3.435	7.808	0.573	1.126	0.28	0.775	0.334	1.258	0.963	1.55	0	0
TOTAL:	22.069	81.898	3.121	13.395	1.863	11.633	2.339	38.581	4.128	19.513	0	0.517

[1)] Full development

For the whole period of the construction the machinery shall consume about 1700 tonnes of diesel fuel, so the payment for the environment pollution according to *the Order of fixing the norms of charges and its payment for environmental pollution* approved by Cabinet of Ministers of Ukraine No. 303 dated 1 March 1999 shall amount 1700x6=**10200** UAH. In the process of construction at the Vilkove-Reni section 748.8 tons of fuel will be consumed, i.e. the payment for the environmental pollution will make 748.8x6=**4493** UAH; construction of dumps expenses of 232.2 tonnes of fuel with corresponding pay for emissions of 232.2x6=1393; than **2834** UAH for the works– at the section the Sea – Vilkove, **2873** UAH for the works on the sand-bar. Payments for emission during the dumping to the river-bed and the sea dumps was calculated in the separate divisions to the projects of dumping.

Results of calculations on dispersion of pollutants in the near-ground layer made by the *Rechtransproject* showed that while operating on the rifts the MAC will be exceeded for NO_2 and soot on the source site only. Pollutants dispersion in ambient air results in decrease of NO_2 in sum with SO_2 concentration to the MAC at the distances up to 1300 m**,** and for soot up to 300 m.

At the sites of the ship the sea-Vilkove pass and the Sea access channel the excess above MAC in the area of source is also observed only for NO_2 and soot. The level of MAC for NO_2 reaches at the distance of 1240 m (Navigation Route) и 1400 m (see access channel), for soot – 300 m и 400 m (accordingly). Concentrations of other pollutants do not exceed the level of MAC in zone of the source.

While arranging a protective dam, MAC for NO_2 is obtained at the distance of 1300-1500 meters; for soot – up to 400 m. Emissions of SO_2, CO, C_xH_x are considerably less than corresponding MACs.

Considering the temporary nature of hydro-engineering works and absence of stationary sources of emissions there is no need for sanitary protective zone.

To decrease the near-surface concentration of the priority ingredient of NO_2 the project provides to disperse the mechanisation means and regulate its power as well as vary the demand factor for mechanisms. In case of unfavourable meteorological conditions (UMC) it is recommended to stop the work in full and stop the engines.

During operation of a dredge ship, floating crane, support fleet in the water area of the DWNT the personnel should have a permanent control (monitoring) of GOST 24585-81 and GOST 24028-80 observance on contents of exhaust gases of the ships' power installations.

4.2.2. Assessment of impact of emissions into atmosphere during the operation of the DWNR

Assessment of noise impact from the ships passing the DWNR has been made for a reach of 'Vilkove–the sea'. This section of the route adjoins to the territory of the Danube Biosphere Reserve, which is the most sensitive to the man-caused impacts (fig. 4.1).

During estimating the impact the following recipients were taken into account:

- **Coastal strips along the Bystre and the Starostambulske branches and the building-up territory in** a zone of Vilkove town, which applies to the zone of man-made landscapes of the DBR;
- Fragments of the DBR territory adjacent to the coastal strips.

In the zone of planned activity influence on the condition of the ambient air the natural and in some places the man-made vegetable groups are predominant including reed, narrow leaved reed mace, lake cane, apiculate sedge, white osier, triple-staminal crisp osier.

For calculation of the designed object impact on the ambient air a diesel-propelled ship of "Dzhankoy" type is taken as source (Table 4.2.1). A number of sources being at the section at the same time is 2; minimum distance between the sources is 500 m; one-way traffic, maximum speed is 7 knots (Table 4.2.5).

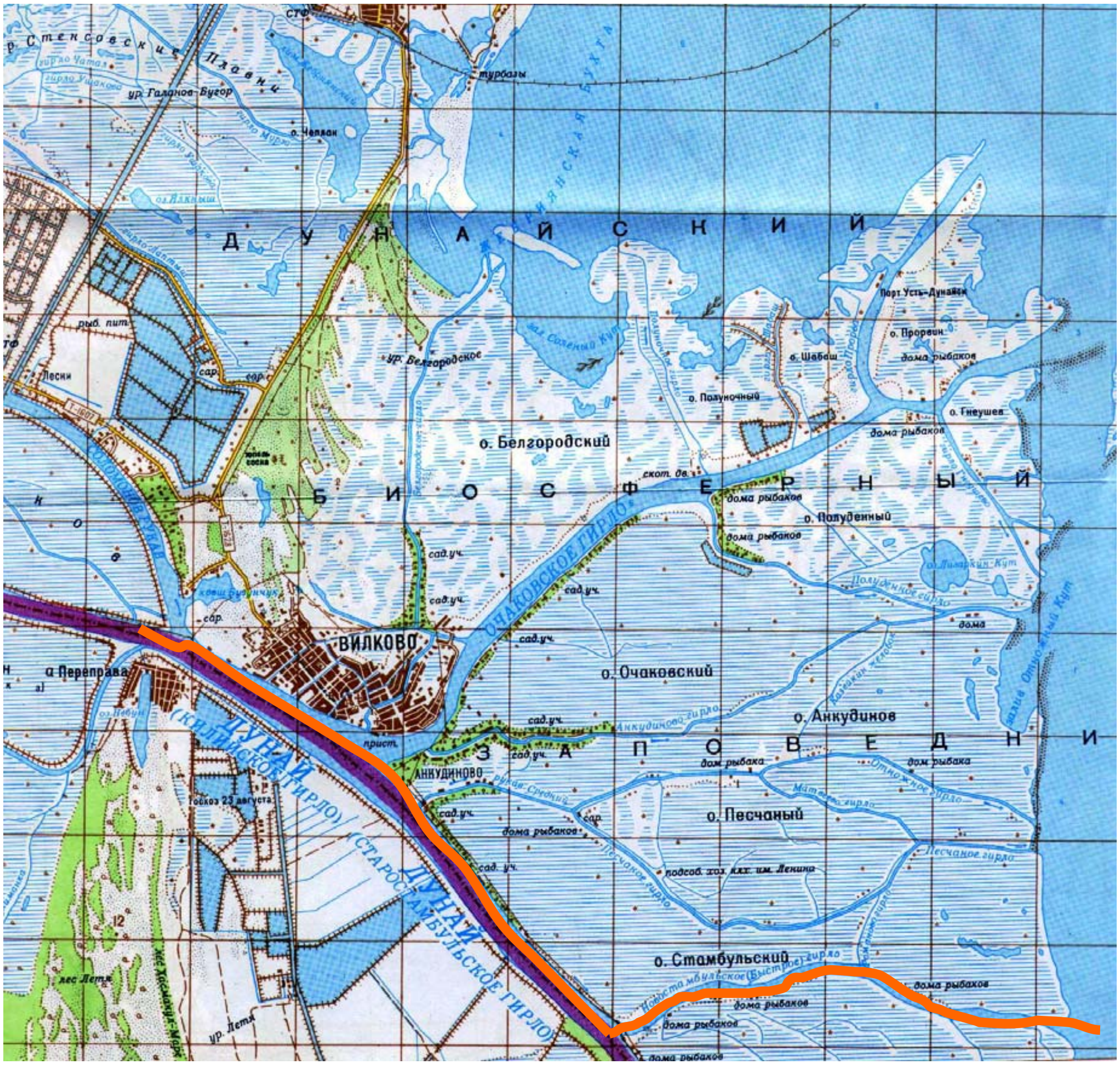

Fig. 4.1 – Situation diagram of the DWNR at the beginning of the Starostambulske branch - the Bystre (Novostambulske) branch

Table 4.2.4 –Specification of the vessel assumed for evaluation of impact [57, 58]

Performance specification of the motor ship “Dzhankoy”	Units	Values
Load-carrying capacity	t	8800,00
Number of main engines	1	Diesel
Main engine power	kW	3970,00
Main engine fuel consumption	g/kW*h	272,52
Number of additional engines	3	BW6NVD36 (6Ч24/36)
Power of the additional engine	KW	220,00
Fuel consumption by the additional engine	g/kW*h	160,00
Type and number of auxiliary boilers	1	Water-tube
Steam productivity of the additional boiler	t/h	2,50

Table 4.2.5 – Processing characteristics of the DWNR assumed for evaluation of the DWNR impact on air quality

Indexes of one-way passage traffic	Units	Values
Expected number of Navigation Routes per year	N/yr	569...1700
A number of Navigation Routes in 24 hours	N/24 hr	2…5
Maximum traffic speed	knot	7.0
	m/s	3.6
Calculated length of the Navigation Route	km	20
Width of the DWNR in the Starostambulske branch	m	120.0
Width of the DWNR in the Bystre branch	m	60.0
Safe depth	m	8.1
Minimum distance between ships	m	500

Calculation of ambient air pollution (CAAP) on the territory adjacent to the DWNR

CAAP is made according to the procedures OND-86 by means of “EOL” software. Meteorological and other input data necessary for CAAP are presented in chapter 2 of EIA. Emmissions of the designed object are estimated at 23°C and wind speed 3.0 m/s.

Effect of background sources on the DBR is inessential and not taken into account.

According to [58], NO_2, SO_2, CO, cCxHy and soot (Table 4.2.6) ingredients in diesel engine ships emissions are to be taken into account.

Table 4.2.6 – Specific emissions of ship’ engines [58], g/g of fuel

Index	Fuel			
	Diesel furl	Low- Sulfur Fuel oil	Sulfur fuel oil	High-Sulfur fuel oil
SO_2	3.9E-3	5.0E-3	2.0E-2	4.08E-2
CO	2.56E-2	5.3E-3	5.3E-3	5.3E-3
NO_2	6.81E-2	1.07E-2	1.07E-2	1.07E-2
C_xH_y	1.81E-2	5.0E-3	5.0E-3	5.0E-3
Soot (C)	6.1E-3	5E-4	5E-4	5E-4

According to the National Standards of Enterprises #201-97 there is no combined influence of these agents with background non-organic dust. So in the calculations a group of priority emissions is taken (NO_2, SO_2, CO, C_xH_y, C, $NO_2 + SO_2$) including a group of combined effect #36 “SO_2 and NO_2” with K.ci = 1. For the DBR the recommended MAC is taken in this report (Table 4.2.7).

Table 4.2.7 – Maximum one-time (MACt) and averaged per 24 hours (MACd) Maximum Allowable Concentrations of contaminators in the air for population and biosphere [59]

Index	MAC, mg/m^3 By criteria of detrimental effect on the environment					
	Populated locality		Recreation zone		Biota (flora)	
	MACt	MACd	MACt	MACd	MACt	MACd
NO_2	0.085	0.04	0.068	0.032	0.04	0.02
CO	5.0	3.0	4.0	2.4	1.0	1.0
C_xH_y	1.0	(0.16)	0.8	0.128	-	-
SO_2	0.5	0.05	0.4	0.04	0.020	0.015
C	0.15	0.05	0.12	0.04	-	-
Dust	0.5	0.15	0.4	0.12	0.2	0.05

Note. Recommended MAC for biosphere is used

Determination of maximum one-time emissions (M.ote) of one ship with all machinery in operation

Maximum one-time emissions of main engine

Mass of maximum one-time emissions of one engine in territorial waters

$$M.ot = \frac{M.s.e \cdot C.std \cdot P.ef \cdot K.ter}{3600}$$

where

M.ot - maximum one-time emissions of the ship engine of the given type (g/s);
M.s.e - specific emissions of such-and-such substance by the engine (g/g);
C.std - standard fuel consumption by the ship (g/kW*hr);
P.ef - engine effective power; taken as 3970 kW (kW);
K.ter – factor of reduction in fuel consumption during moving in territorial waters; taken as 0,65.

Calculated maximum one-time emissions of the main engine in the territorial waters at the power of 3970 kW and standard consumption of fuel 272,52 g/kW*year:

$$M.ot.SO_2 = 3.9*10^{-3} * 272.52 * 3970.0 * 0.65 / 3600 = 3.9*10^{-3} * 195.3 = 0.7618 \text{ g/s};$$
$$M.ot.CO = 25.6*10^{-3} * 195.3 = 5.000 \text{ g/s};$$
$$M.ot.NO_2 = 68.1*10^{-3} * 195.3 = 13.300 \text{ g/s};$$
$$M.ot.C_xH_y = 18.1*10^{-3} * 195.3 = 3.535 \text{ g/s};$$
$$M.ot.C = 6.1*10^{-3} * 195.3 = 1.191 \text{ g/s}.$$

Calculated maximum one-time emissions of two auxiliary engines with the power of 2x220 kW and standard consumption of fuel 160,0 g/kW*hr:

$$M.ot.SO_2 = 3.9*10^{-3} * 160.0 * 440.0 * 0.65 / 3600 = 3.9*10^{-3} * 12.71 = 0.04957 \text{ g/s};$$
$$M.ot.CO = 25.6*10^{-3} * 12.71 = 0.3254 \text{ g/s};$$
$$M.ot.NO_2 = 68.1*10^{-3} * 12.71 = 0.8656 \text{ g/s};$$
$$M.ot.C_xH_y = 18.1*10^{-3} * 12.71 = 0.2301 \text{ g/s};$$
$$M.ot.C = 6.1*10^{-3} * 12.71 = 0.0775 \text{ g/s}.$$

Maximum one-time emissions from a boiler unit

Consumption of natural fuel C.b is determined approximately provided the consumption of 100 kg of fuel to produce 1 t of steam. For auxiliary boiler unit with steam output D = 2,5 t/year the maximum one-time consumption of the natural fuel C.ot.b = 250 kg/year or 69,44 g/s. Sulphur boiler oil is taken as the fuel (Table 4.2.8).

Table 4.2.8 – Fuel oil characteristics [58]

Parameter			Fuel oil				
			Low-sulphur fuel oil		Sulphur fuel oil		High-sulphur fuel oil
			Ф12	Ф 40	Ф5	-	-
Ash content of the fuel	A_r	%	0.1	0.12	0.05	0.12	0.12
Sulphur content in the fuel	S_r	%	0.6	1.0	2.0	2.0	3.5
Heat of combustion of fuel	Q_r	MJ/kg	41.45	40.74	41.45	40.74	39.90

$$M.ot.SO_2 = M.ot.b \cdot 0.02 \cdot S_r \cdot (1 - n.SO_2)$$

where

$M.ot.SO_2$ - maximum one-time emission of SO2 by a boiler unit (g/s);
C.ot.b - maximum one-time fuel consumption by a boiler unit (g/s);
S_r - sulphur content in fuel; taken as 2 % (%);
$n.SO_2$ - portion of SO2, which is bound by suspended particles in smoke gases, for fuel oil is taken as 0,02.

M.ot.SO2 = 69.44 * 0.02 * 2 * (1 – 0.02) = 2.722 g/s.

$$M.ot.CO = M.ot.b \cdot 0.001 \cdot Q_r \cdot K.CO$$

where

M.ot.CO - maximum one-time emission of CO by boiler unit (g/s);
P.ot.b - maximum one-time fuel consumption by a boiler unit (g/s);
Q_r - heat of fuel combustiona; taken as 74 MJ/kg (MJ/kg);
K.CO - specific quantity of CO per 1 GJ of heat; at combustion of fuel oil in chamber furnace of steam and hot-water K.CO = 0,32 kg/GJ (kg/GJ).

M.ot.CO = 69.44 * 0.001* 40.74 * 0.32 = 0.9053 g/s

$$M.ot.NO_2 = M.ot.b \cdot 0.001 \cdot Q_r \cdot K.NO_2$$

where

$M.ot.NO_2$ - maximum one-time emission of NO2 by boiler unit (g/s);
P.ot.b - maximum one-time combustion by boiler unit (g/s);
Qr - heat of fuel combustion; taken as 40.74 MJ/kg (MJ/kg);
$K.NO_2$ - specific quantity of GJ of heat subject to steam productivity of boiler (0,076 kg/GJ) (kg/GJ);

Steam productivity	D	t/hr	0.5	1.5	2.5	6.5
Specific emission	$K.NO_2$	kg/GJ	0.06	0.07	0.076	0.10

M.ot.NO2 = 69.44 * 0.001 * 40.74 * 0.076 = 0.215 г/c.

Soot: $M.ot.C = M.ot.b \cdot A_r \cdot K.sus$

where:

M.ot.C - maximum one-time emission of soot by boiler unit (g/s);
P.ot.b - maximum one-time combustion of fuel by boiler unit (g/s);
A_r - ash content of fuel; taken as 0,12 % (%);

K.sus - portion of suspended particles in smoke gases; K.sus = 0,01 for steam and water-heat mazut boilers.

$$M.ot.C = P.ot.b * A_r * K.sus = 69.44 * 0.12 * 0.01 = 0.0833 \; g/s.$$

A group of substances of combined effect $NO_2 + SO_2$ has the priority impact because of aggressiveness to biota , which stipulates 82.3 + 8.0 = 90.3 % of danger by passing the ships through the territory of the DBR (Table 4.2.9, Fig. 4.2).

Table 4.2.9 – Maximum one-time emissions from one ship

Pollutant	Maximum one-time emissions M.ot, g/s			
	Main engine	Auxiliary engines	Boiler unit	Total
SO_2	0.7618	0.0496	2.7220	3.5334
CO	5.0000	0.3254	0.9053	6.2307
NO_2	13.3000	0.8656	0.2150	14.3806
C_xH_y	3.5350	0.2301	-	3.7651
C	1.1910	0.0775	0.0833	1.3518

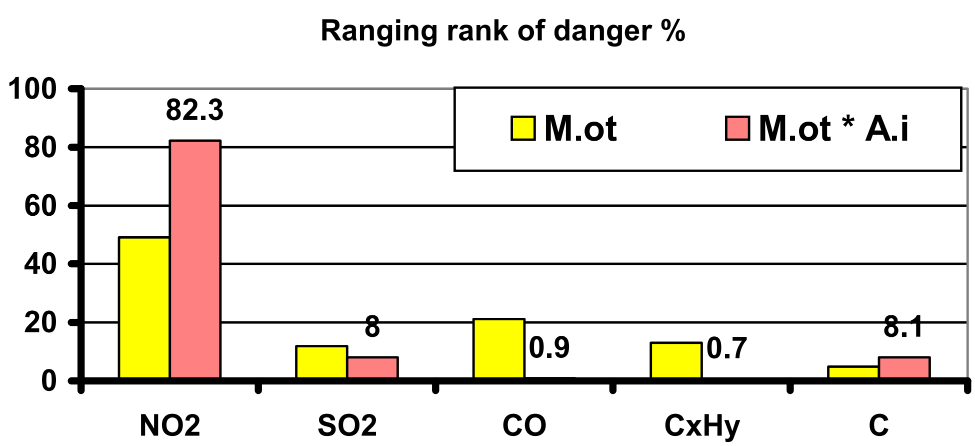

Fig. 4.2 – Ranking of emissions of one ship by one-time maximum mass M.ot (% of total emission) and by criteria A.i * M.ot..i (%) subject to a factor of aggressiveness A.i regarding environment (biota) [62]

Maximum one-time emissions of one ship under speed limit traffic

Moving in complex conditions of the channel or a natural stream is performed under restricted speed. For a diesel engine a dependence of emissions on the motion speed has non-linear nature. For a diesel-propelled ship of "Djankoy" type the dynamic characteristic of main engine emissions is not provided. According to scientific sources the certain range of dependence of emissions on motion speed was identified (Fig. 4.3), for critical emissions of NO_2 upper (NO_2.u) and lower (NO_2.l) boundaries of emissions values are shown. According to a conservative estimation of the motion at a speed 0.2 of maximum emissions of CO is increased as much as 2.63 times, C_xH_y as much as 1.42 times, and soot – as much as 1.18 times. Yet the mass of critical emissions of NO_2 is decreased 3.3 times less, emissions of SO_2 is decreased 1.04 times less.

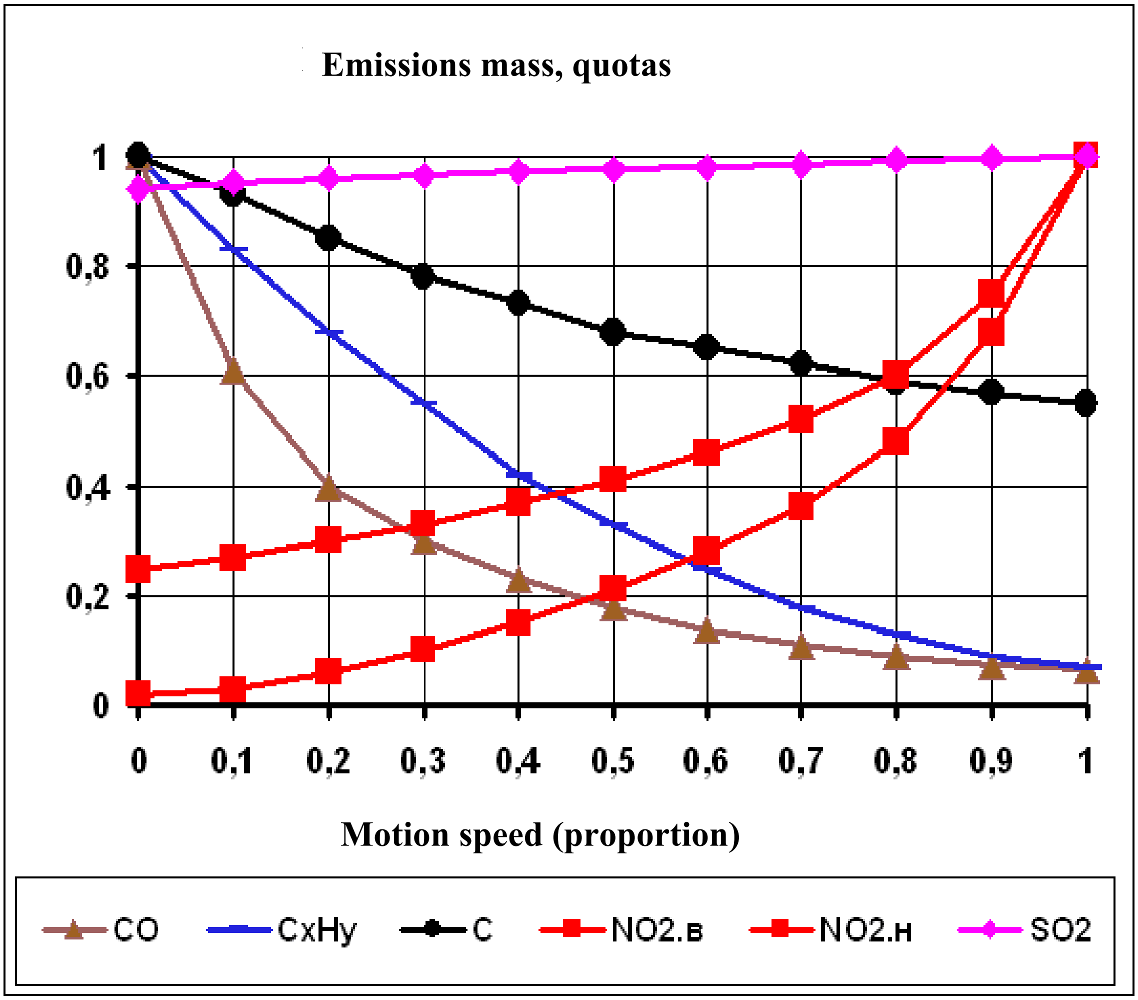

Fig. 4.3 – Generalised dependencies of diesel engines emissions on motion speed of transport facility

Preparation of cartographic base, identification of emission sources location

Preparation of cartographic base was carried out according to "Technical recommendations on radio-ecological evaluation of territory by means of map-making" [63]. Climate category according to SNiP 2.01.01-82, annual average air temperature, most cold month and its average temperature, estimated temperature of the most cold 5 days, a warmest month and its average temperature, average temperature at 13 o'clock of the warmest month, absolute minimum and maximum of the temperatures for the corresponding years, mean monthly temperatures, mean annual and seasonal wind rose (%), most frequent winds during a year and their annual average recurrence 20 % at certain average speed at the most cold and warm months. Data preparation for the calculations at "EOL" program in accordance with OND-86 was realised by means of GIS «Microstation».

Standard methods of impact area size estimation doesn't acceptable for the case of the DWNR. Previously it is necessary to evaluate the impact zone for one ship in immobile position. Corresponding graphs are obtained by means of "EOL" according to OND-86. On this basis a critical pollutant with maximum radius of impact zone is determined. This is a group of combined effect $NO_2 + SO_2$.

For ultimate dynamic evaluation based on a radius of impact zone and a motion speed the parameters of planar source of emissions are determined [sec.7.6 OND-86] for two ships in the mode of a motion at a minimal distance of 500 m between them.

Graphs of pollution by one immovable ship

Graphs of pollution are given for wind speeds 0,.5 and 3.0 m/s. A radius of impact zone is determined in steady conditions, which is necessary for further determination of critical pollutants in emissions and dimensions of planar sources for dynamic conditions of traffic (Fig. 4.4-4.9).

At a speed of wind 0.5 m/s (nearing to a calm) the contaminants are concentrating closer to the emissions source, at 3.0 m/s – a hazardous area is increasing. For example, at the distance of 1 km a concentration of contaminants of a group of combined effect NO_2+SO_2 at the wind speed 0.5 m/s is 5.54 MAC.ot, at 3.0 m/s – 10,5 MAC.ot, concentration of NO_2 at the wind speed 0,5 m/s - 5.32 MAC.ot., at 3.0 m/s – 10.1 MAC.ot. The most hazardous pollutant is NO_2. At the level of 1 MAC the radius of impact area is about 3.2 km both for NO_2+SO_2, and for NO_2.

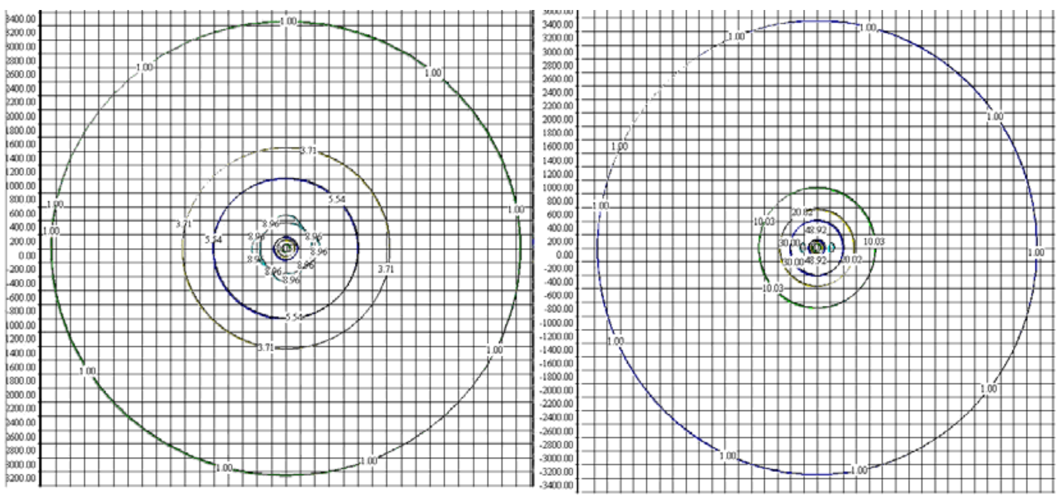

Fig. 4.4 –Dispersal area of a group of combined effect NO_2 + SO_2 by one ship in immobile mode at the speed of wind 0.5 m/c (left) and 3.0 m/c (right). At 1 MAC level a radius of the impact area is about 3.2 km

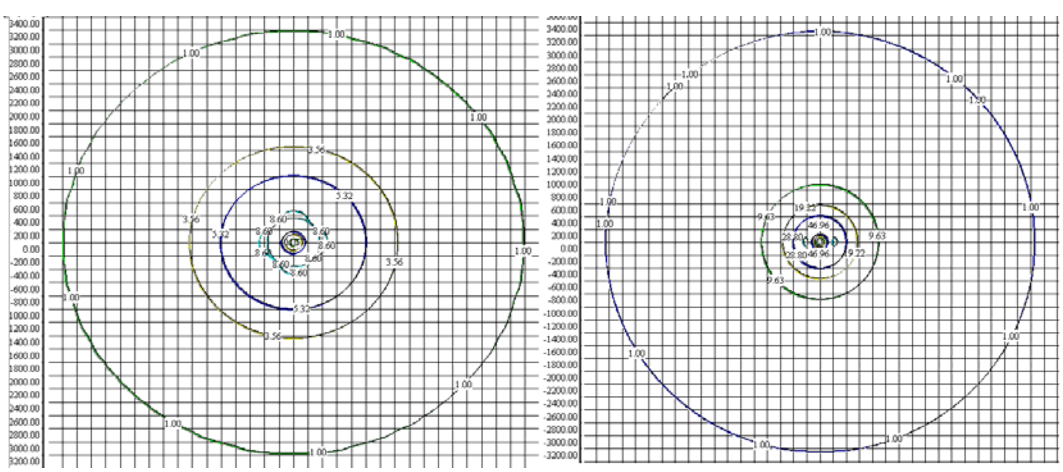

Fig. 4.5 – Dispersal area of NO_2 from one ship in immobile mode at the wind speed 0.5 m/s (left) and 3.0 m/s (right). At the level of 1 MAC radius of the impact area is about 3.2 km

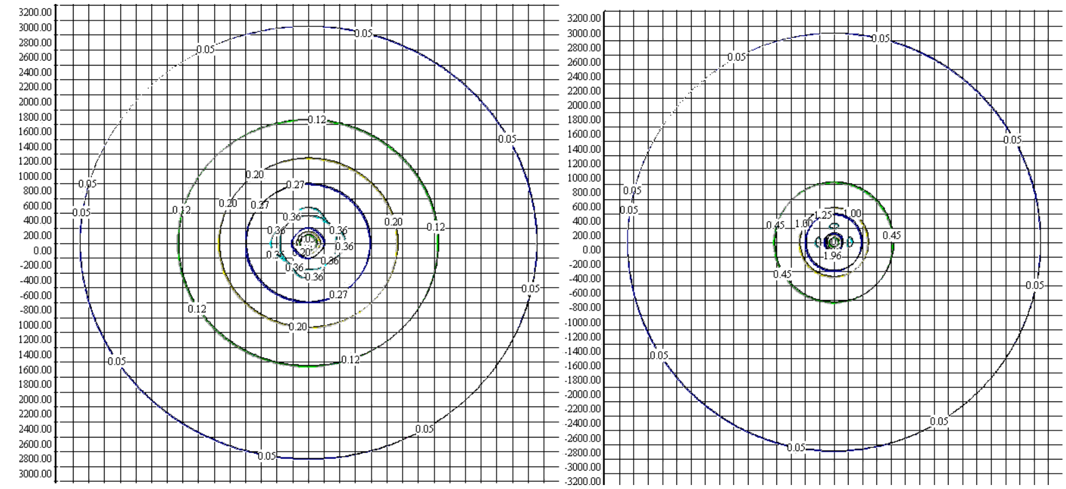

Fig.4.6 – Dispersal area of SO2 from one ship in immobile mode at the wind speed 0.5 m/s (left) and 3.0 m/s (right). At the level of 1 MAC radius of the impact area is about 0.25 km at 3.0 m/s.

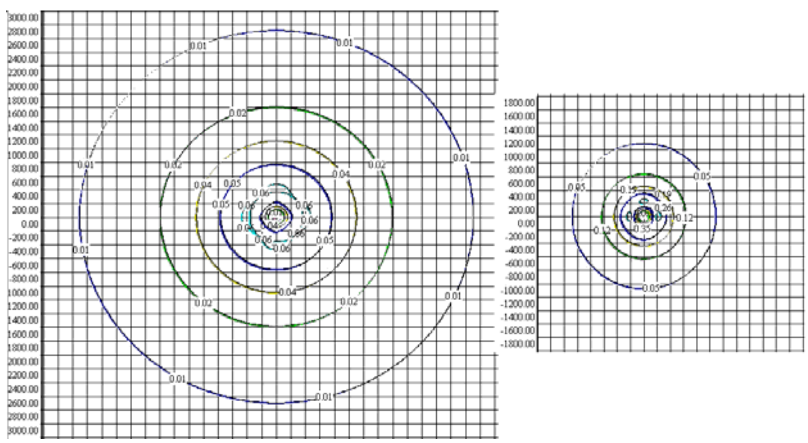

Fig.4.7 – Dispersal area of CO from one ship in immobile mode at the wind speed 0.5 m/s (left) and 3.0 m/s (right). At the level of 1 MAC radius of the impact area is less 0.25 km at 3.0 m/s.

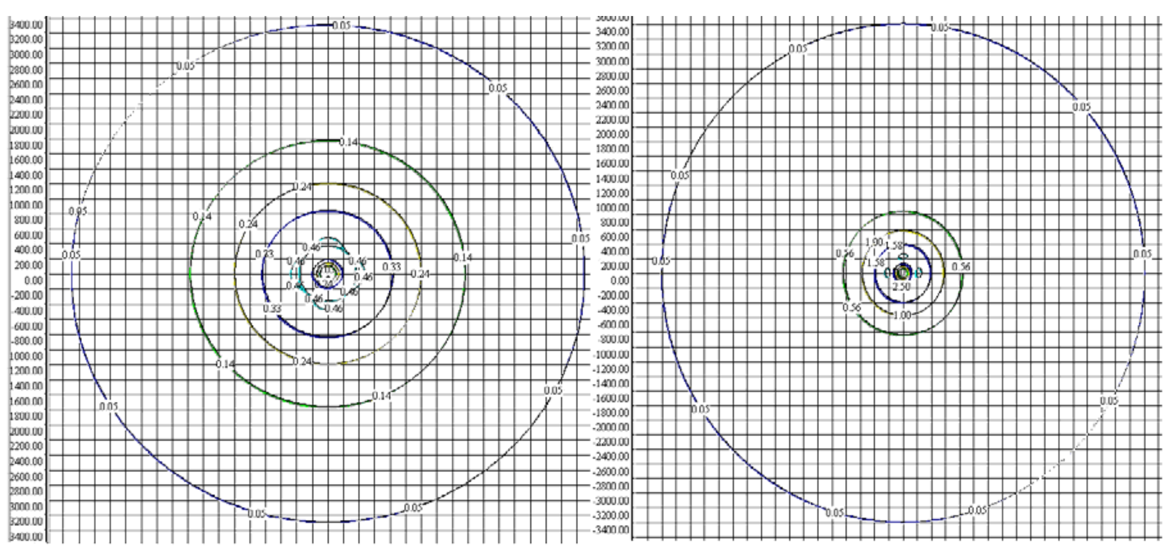

Fig.4.8 – Dispersal area of soot (C) from one ship in immobile mode at the wind speed 0,5 m/s(left) and 3.0 m/s (right). At the level of 1 MAC radius of the impact area is 0.6 km at 3 m/s, 0,05 MAC – 3.3...3.4 km

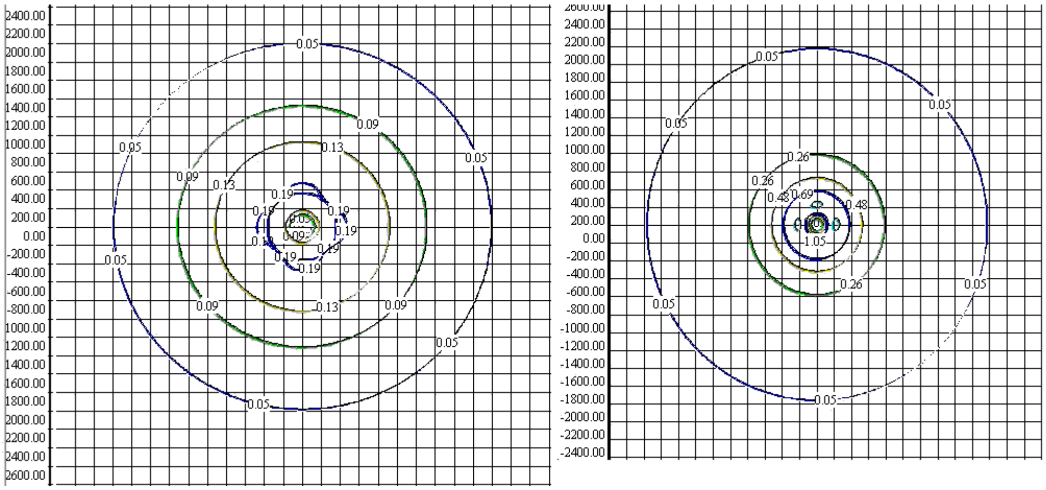

Fig.4.9 – Dispersal area of CxHy from one ship in immobile mode at the wind speed 0.5 m/s (left) and 3.0 m/s (right). At the level of 1 MAC a radius of the impact area is less 0.1 km, 0.05 MAC – 1.0...1.2 km

According to these calculations the most hazardous for near-the-route territory of the DBR are the emissions of the group of combined effect NO_2+SO_2, which contaminants concentrate in the area of 3...5 km in radius (0.5...1.0 MAC.ot for the populated locality) provided the source of emissions is located in one site and a dispersion is conditioned by a wind.

Estimations of a pollution extent in steady regime of a source exceed many times the dynamic estimations, because the motor-ship passes by every estimated point (EP) for very short time. In particular, a ship moves 1 km off the EP for 5...25 min, that is less of normative time of 30 minutes for determination of one-time maximum concentrations. Accounting of the sources mobility is realised below.

Graphs of the DWNR pollution in moving mode

While moving in the channel and streams it is advisable to take into account the main engine emissions without emissions of auxiliary engines and boiler units. The motor-ships emissions are distributed along the route. According to clause 7.6 of OND-86 the emission of mobile sources is reduced to a planar source. The worst case is when 2 ships is moving one way at the same time at the distance of 500 m. Then when the first ship is passing by the estimated point of concentration, the concentration of pollutant rises to maximum, then decreases, then rises again to a maximum in 2.5-3.0 minutes with coming of the second ship, then it finally decreases. Distribution of location of the motor-ships along planar sourceis assumed as uniform. At evaluation of maximum one-time concentration (standard time of impact is 30 minutes) the less part of the planar source the ship passes in 30 minutes the less will be its contribution to the total emission of the source.

Maximum one-time evaluation of C.ot (MAC.ot) at V.max

The length of considered part of the DWNR is 20100 m. Moving in the channel with maximum speed V.max = 7 knots lasts 93 min. Determination of maximum one-time emissions is done for 30 min. At that a motor-ship passes only 30/93 = 0.32 part of the channel length. I.e. **when moving at maximum speed along the whole 20100 m length planar source the maximum one-time emission will amount 0.32 of the mass of emissions under stationary conditions.**

Evaluation of the mass of main engine emissions which was made for stationary conditions, accepted with the 0.32 factor due to a passing by ship of a part of the flat source, and the 2.0 factor due to a possibility of simultaneous location of 2 ships in the channel – the corrective factor is 0.64 (Table 4.2.10).

Table 4.2.10 – Input data for calculation of maximum one-time pollution C.ot of the near-the-route territory of the Navigation Route by "EOL" program subject to a moving 2 motor-ships at the distance of 500 m at maximum speed V.max

Parameter	Designation	Units	Value
Size of the flat source	L x B	m	20100.0 x 100.0
Height over earth surface	H	m	10,0
Temperature of			
Air-steam mixture	T.asm	$^{\circ}C$	+ 90.0
environment	T.env	$^{\circ}C$	+ 23.0
Substance			
	SO_2	g/s	0.49
	NO_2	g/s	8.51
	CO	g/s	3.2
	C_xH_y	g/s	2.26
	C	g/s	0,.76

Project solutions are necessary to take on the basis of evaluation of dispersion of the most hazardous group of pollutants of combined effect NO_2 + SO_2 (Fig. 4.10), especially that the harmful effect of C_xH_y and soot on the biosphere have not been discovered. Pollution of CO, C_xH_y and C is not critical, because it is much less of MAC.ot.

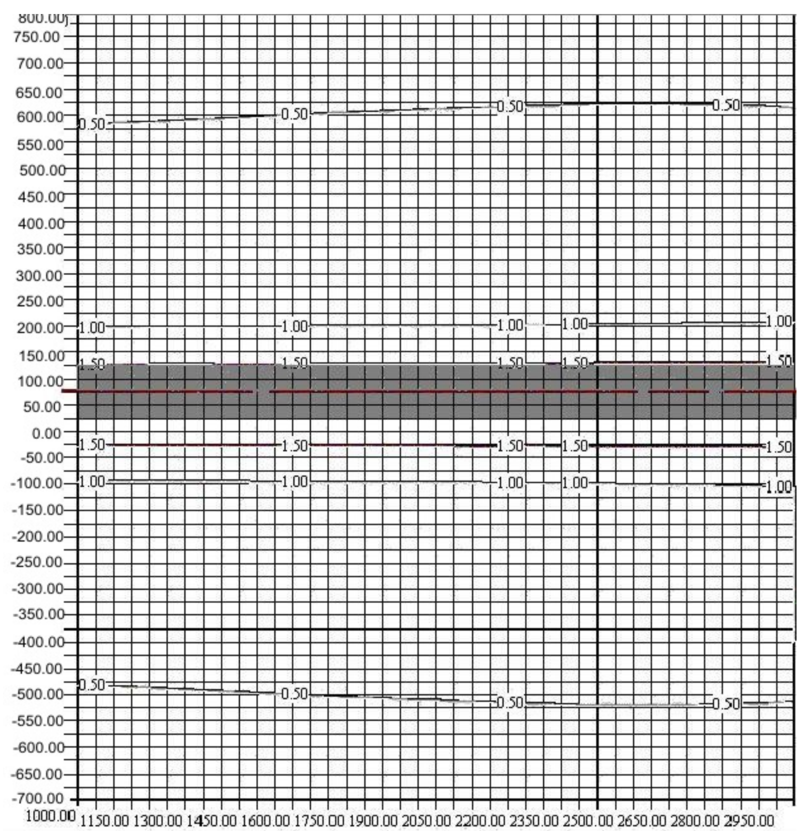

Fig. 4.10 –C.ot for NO_2 + SO_2 in the units of MAC.ot for the population of near-the-route territory of the DWNR subject to moving of 2 motor ships at the distance of 500 m at maximum speed V.max = 7 knots. On the diagram the value of isoline 1 MAC.ot.NO_2+SO_2 is about 5 MAC.ot.bio.NO_2+SO_2 for biota. The dark strip is the Navigation Route.

The weighted acceptable concentration of the group of combined effect No. 36 for biota MAC.ot.bio.NO_2+SO_2 differs from MAC.ot.NO_2+SO_2 for population about 5 times. When moving at the speed of V.max = 7 knots the maximum one-time emission with C.ot.bio over 1 of MAC.ot.bio covers a considerable part of near-the-route territory.

Some methodological discordance in maximum one-time evaluation for 30 minutes and the actual situation in mobile sources along the routes. Evaluation of daily average concentrations of pollutants -(C.da) is more adequate to the situation.

Evaluation of C.da (MAC.da) at V.max

2 annual average ship passing are predicted per 24 hours, although in the future this number can increase to 5, and due to an irregularity of the traffic can increase to 10 ship per 24 hours. Basic data for calculations are presented in Table 4.2.11.

Table 4.2.11 – Basic date for calculation of daily average C.da in units of C.da.bio of near-the-route territory of the DWNR subject to the traffic of 2 ships pass per 24 ours at maximum speed V.max

Parameter	Designation	Unit	value
Size of the flat source	L x B	m	20100,0 x 100,0
Height over earth surface	H	m	10,0
T of air-steam mixture	T.asm	°C	+ 90.0
T of environment	T.env	°C	+ 23.0
Sulphurous anhydride	SO_2	g/s	3.275
Nitrogen dioxide	NO_2	g/s	7.315

For calculation of C.da (MAC.da) value in the situation when ships moving at maximum speed V.max = 7 knots (time of moving through the given section channel is 1.55 hours) the M.ot (g/s) is necessary to correct in the following way:

- to multiply by 2.0, that takes into account 2 ship passes per 24 hours;
- to divide by daily factor of 15.48 = 24/1.55;
- to multiply an emission mass M.ot.NO_2 by the factor 4,25, which takes into account the ratio of MAC.ot.NO_2 = 0,085 for the population and MAC.da.bio.NO_2 = 0.02, and mass of emission M.ot.SO_2 to be multiplied by the factor of 33,3, that takes into account the ratio of MAC.ot.SO_2 = 0.5 and MAC.da.bio.SO_2 = 0.015 mg/m^3;
- a corrective factor of 2*4.25/15.48 = 0,55 is applied to the mass of maximum one-time emissions M.ot.NO_2; the factor of 2*33.3/15.48 = 4.3 is applied to the M.ot.SO2 ;
- In this case the “EOL” will determine the isolines of the daily average biota pollution by the combined effect group No36 at the circular wind rose (Fig. 4.11–4.13).

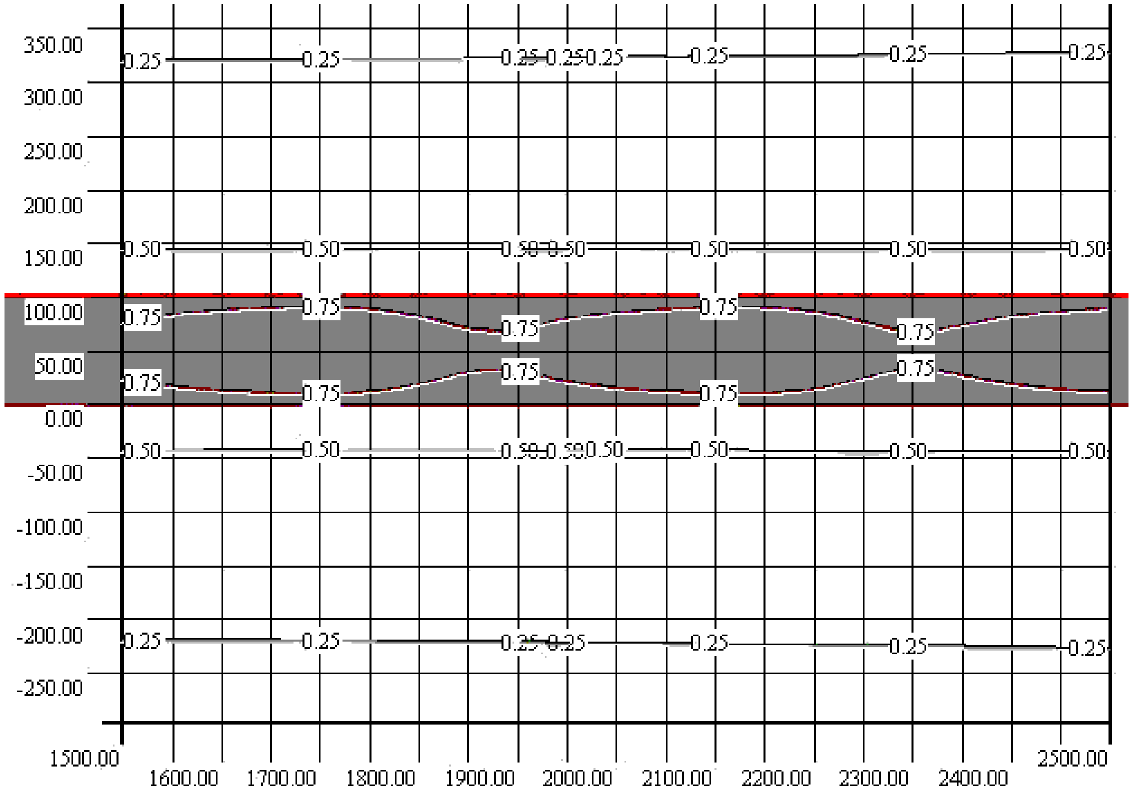

Fig. 4.11 – C.da.NO_2+SO_2 in the units of MAC.da.bio.NO_2+SO_2 for biota on near-the-route territory of the DWNR subject to 2 ships pass at maximum speed of V.max = 7 knots.

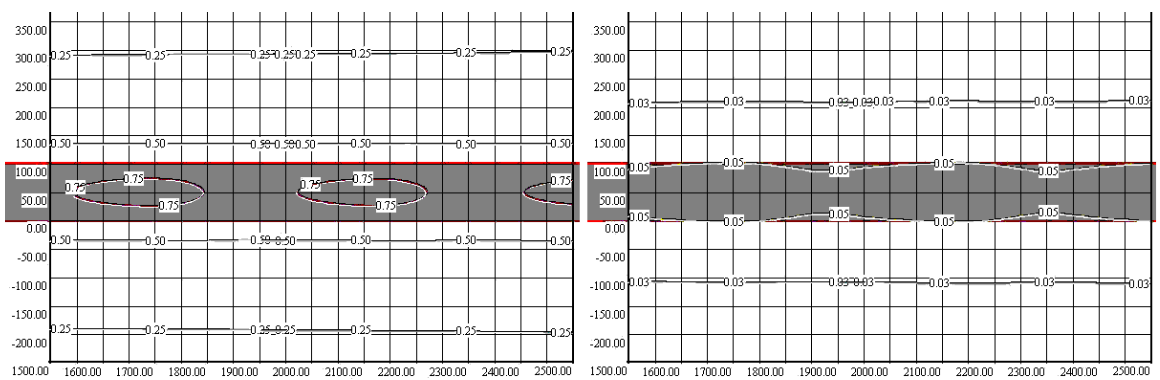

Fig. 4.12 – Daily average concentration C.da of NO_2 (left) and SO_2 (right) in MAC.da.bio units for biota on near-the-route territory of the DWNR subject to 2 ships pass daily at maximum speed V.max = 7 knots. Dark stripe is the Navigation Route.

So by the MAC.da criterion, which is adequate to the situation in the DWNR, the impact in the reserve area will not exceed the recommended norms for biota, including conifers, at maximum possible number of ships pass per 24 hours at maximum speed of 7 knots.

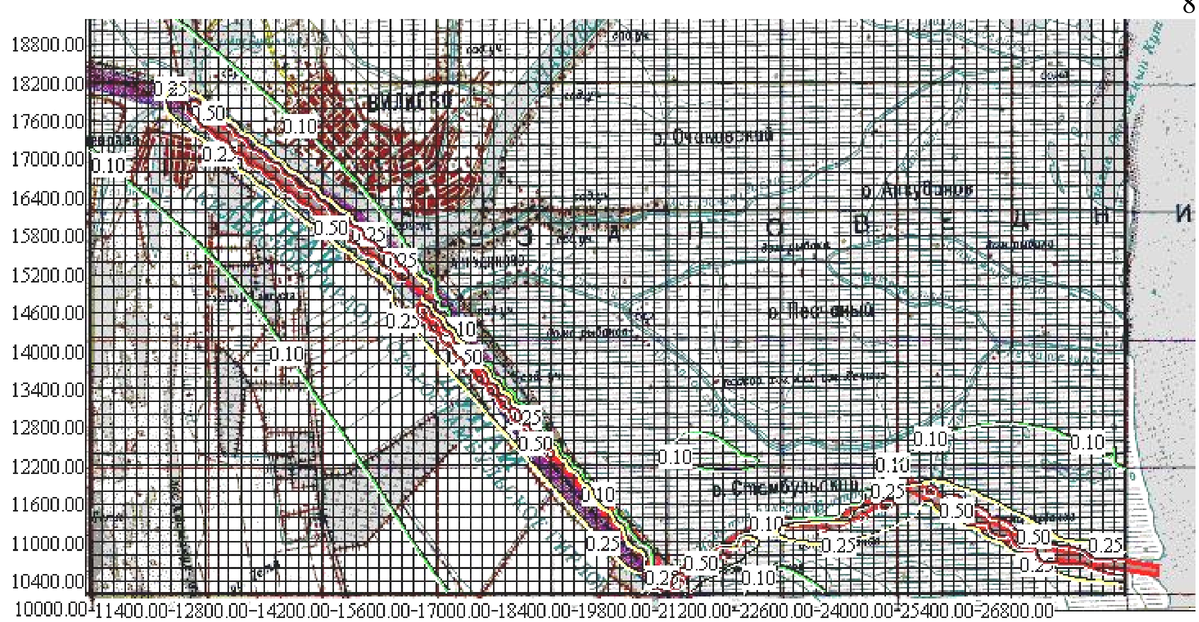

Fig. 4.13 – C.da.NO_2+SO_2 in MAC.cc.bio.NO_2+SO_2 units for biota on near-the-route territory of the DWNR, subject to 2 ship passes daily and moving at maximum speed V.max = 7 knots.

4.2.3 Assessment of noise influence within the building period

Calculations of the noise effect during the construction period were made by the *Rechtransproject* [36].

Main source of noise during the DWNR construction period is diesel motors of dredge ships and tug-boats.

Noise characteristics of these sources are taken from Table 1.12 from the “Reference book on the protection from noise and vibration of residential constructions and public buildings”, Kiev, 1989.

Equivalent level of noise from dredge ship at the distance of 25 m makes LA.equiv = 59 dBA, tug-boat – LA.equiv = 57 dB(A).

During operation of the ships with different noise characteristics, the equivalent noise levels are added by energy (SNiP 11-12-77).

Difference in the levels is equal to: 59 - 57 = 2 dB(A). Coming from this difference, the addition is 2 dB(A): 59 + 2 = 61 dB(A). So the calculated equivalent noise level generated by two sources equals 61 dB(A).

Decrease of the noise level subject to the increase of the distance to the source is determined by the formula

$$\Delta LA = 10 \lg r/r_o, \text{ dB(A)}$$

where: r = the minimal distance between calculated point and acoustic centre of sound from the ship, m; r_o = distance of 25 m, where equivalent noise level is 61 dB(A).

For the riverbed part: ΔLA = 10*lg 50/25 = 10 x 0.301 = 3 dB(A).

For a sand-bar: ΔLA=10*lg 2000/25 = 10 x 1.903 = 19 dB(A).

Decrease in noise level through noise suppression by atmospheric air is determined by formula: $\Delta L_B = 5 \cdot r/1000$ dB(A)

for the riverbed part: ΔL_B = 5 x 50/1000 = 0.25 dB(A).

for a sand-bar: ΔL_B = 5 x 2000/1000 = 10 dB(A).Total decrease of the noise equals:

for the riverbed part $\Delta L_B = 3.25$ dB(A).;

for a sand-bar $\Delta L_B = 19 + 10 = 29$ dB(A).Level of acoustic pressure on the shore subject to a decrease equals:

for the riverbed part: 61 – 3.25 = 56.75 dB(A),

for a sand-bar: 61 - 29 = 32 dB(A).

Taking into account consideration that in the calculations of the distance to a shore is accepted minimal (50 m), in fact it makes 50 - 100 m, one can regard that in a riverbed part the level of acoustic pressure corresponds to the normal index for a residential areas in day time (55 dB(A)), and will be far less for a sand-bar.

4.2.4 Evaluation of noise impact at the period of the DWNR operation

Evaluation of a noise impact from the ships passing through the DWNR is shown for the section from Vilkove to the sea (see Fig. 4.1).

Methodical requirements to the noise evaluation

Normative maximum permissible equivalent L.A.eq.s and maximum L.A.max.s levels dB(A) of noise for the territories of the various functional purposes established in Ukraine, are shown in Table 4.2.12.

Table 4.2.12 - Normative maximum permissible equivalent L.A.eq.s and maximum L.A.max.s levels dB(A), of noise for the territories of various functional purposes

Function of the territory	L.A.eq.s		L.A.max.s	
	Day	Night	Day	Night
Territory, adjacent to the dwelling houses, medical and recreational establishments, boarding schools, child pre-school institutions [65], rest homes, boarding houses, libraries, built-up areas of settlements [60, 64]	55.0	45.0	70.0	60.0
Territory of the 1st echelon + 10 dB(A) of an apartment block, which exists + 5 dB(A) [64; 60 (Enclosure No.16)]	70.0	60.0	80.0	70.0
Areas of tourism and recreation [64]	50.0	40.0	85.0	75.0
Sanatorium and health resorts area [64]	45.0	35.0	60.0	50.0
Reserves and special nature reserves [64]	25.0	20.0	50.0	45.0

Noise characteristic of the water transport canals L.A.eq, dB(A) – this is an equivalent level of sound at the distance of 25 m from a ship side, which is determined during 8 hours of the most noisy night and day period [57].

Noise level of ships' traffic in an area of an apartment block

At a total the traffic intensity of 2 ship per hour the equivalent noise level makes 55 dB(A) at a distance of 25 m off a broadside of regular motor ship of «Dzhankoy» type [57, Table 1.12]. For the 1st echelon of an apartment block, which faces the ships, a allowable level at day time is 70 dB(A) with the background level of 45 dB(A). Total noise level from two sources is determined by the formula:

$$L.A.eq.s = 10 \cdot \lg \sum_i 10^{0.1 \cdot L.A.eq.i}$$

Even without taking into account a reduction of noise level by a distance we have energy summation of the background (45 dB(A)) and additional (55 dB(A)) noise levels at day time:

$$L.A.eq.s = 10 \lg (10^{4.5} + 10^{5.5}) = 55.5 \text{ dB(A)},$$

that is much less of 70 dB(A). In similar way we have summation of the background (40 dB(A)) and designed (55 dB(A)) levels at night time:

$$L.A.eq.s = 10 * \lg (10^4 + 10^{5.5}) = 55.1 \text{ dB(A)},$$

that is less of 60 dB(A). So without extra measures the DWNR **will not influence on the human habitat.**

Noise level of the ships traffic in reserve area of the DBR

Normative level of noise for the territory of the DBR is 25 dB(A) at day time and 20 dB(A) at night time. However the existing background noise level on the most part of the territory of the DBR due to small distance from the active transport communications and industrial objects is much over 20…25 dB(A).

An approximate evaluation of a possible distance of noise penetration by means of the standard method [68]:

$$R.noise = 10^{\frac{L.A.eq.src - L.A.eq.s + 10.2 \cdot K.\text{cov}}{11.7 \cdot K.\text{cov}}}$$

where: R. noise = intensity of noise penetration to a territory [m]; L.A.eq.src = noise level of a source [dB(A)], L.A.eq.src = 55 dB(A); L.A.eq.s = acceptable noise level for the DBR [dB(A)], L.A.eq.s = 20 dB(A); K.cov = factor of noise suppression by a cover, K.cov =1.2 for bushes, and K.cov = 0.9 for water.

For water surface:

R.noise.water = $10^{(55 - 20 + 10.2 * 0.9) / 11.7 * 0,9}$ = 15743.4 m = 15,7 km.

For bushes R.noise.b = $10^{+ (55 - 20 + 10.2 * 1.2) / 11.7 * 1.2}$ = 2259.6 m.

Such unreal estimations by the standard method are stipulated by unfounded determination of the allowable noise level in the reserve territory at 20...25 dB(A).

Achievement of such low levels of noise in given natural environment is impossible. For example, the sound insulated chamber "of free sound field" (anechoic chamber) of the Kiev scientific institute of otolaryngology is a cube with thick sound-proof brick walls, installed on a separate vibroprotective (rubber shock absorption) foundation in an inner room of the institute. Inside the chamber there are foam-rubber wedges, which are perpendicular the walls, ceiling and the floor. A visitor moves on the metal grid, which goes over the wedges of the floor. On the whole the system of noise-cancelling provided a background level of 27...28 dB(A). With such silence some people had dizziness for a short time.

Below a reduction is analysed on a noise level by some protective factors. It is shown that **there is a possibility of reduction of a contribution of the designed object** to the level less than 20 dB(A), though checking the calculated estimations is impossible due to the existing background level.

A reduction in noise level on the way from a source (D) to a calculated point (CP) due to noise suppression and reflection of acoustic waves:

$$L.A.eq.cp = L.A.eq.src - dL.A.eq.\text{sup} - dL.A.eq.msr$$

where: L.A.eq.cp = noise level in the calculated point (CP) [dB(A)]; L.A.eq.src = noise level of a source [dB(A)]; dL.A.eq.sup = noise suppression in the environment [dB(A)]; dL.A.eq.msr = noise reduction due to the planned measures [dB(A)].

$$L.A.eq.\text{sup} = L.A.eq.d + dL.A.eq.\text{cov} + dL.A.eq.air + dL.A.eq.an$$

where: dL.A.eq.d = noise reduction by a distance [dB(A)]; dL.A.eq.air = noise reduction by air absorption [dB(A)]; dL.A.eq.cov = noise reduction due to a land cover [dB(A)]; dL.A.eq.an = noise reduction due to a look angle [dB(A)];

$$L.A.eq.mrs = L.A.eq.scr + dL.A.eq.grn$$

where: dL.A.eq.scr = reduction in the noise level by protection screens [dB(A)]; dL.A.eq.grn = reduction in the noise level by green plantings [dB(A)].

For the DWNR all the factors of the noise reduction occur but dL.A.eq.an.

Estimation of noise reduction was fulfilled according to the existing methods [57, 62, 66-70].

Effective distance to a bank is 25.35 m. Existing plantation strips along the currents are 5...200 m wide and include reed, narrow-leaved cattail, lake cane, apiculate sedge, white, fragile and triple staminal osier. The reed plays the basic role in the noise suppression. Besides taking into account the noise insulation of the existing plantation strips (version 1), a possibility of creation the man-made noise-absorbing plantations was taken into account as well (version 2).

Version 1: Man-made plantings coastwise are not provided

To evaluate a width of the area of noise impact the calculated point (CP) is taken 5 m off the coastline. **Distance from the CP from a route axis (conditional acoustic centre) is 65 m. Distance from CP to a source = – 35 m (subject to a vessel width), reference distance isf 25 m.**

dL.A.eq.d = 10 lg (65 / 25) = 4.15 dB(A).
dL.A.eq.air = 0.005 * 35 = 0.17 dB(A)
K.cov = 0.14 * 35 * 10-0.3*0.5 / 1.5 = 2.31 > 1;
dL.A.eq.cov = 6 * lg (2.31+2 / (1 + 0.01 * 2.31+2)) = 4.23 dB(A).

A complex screen is formed due natural conditions (bank elevation + plantation). It has effective height of over 3 m.

Noise suppression **by this screen** of unrestricted length is
dL.A.abc = 18.,2 + 7,8*lg (30.10 + 5.22 – 35.01 + 0.,02) = 14.44 dB(A).

Subject to all these factors (with no man-made plantations) the excess over the normative level of the equivalent noise in the calculated point is

L.A.eq.CP – L.A.eq.s = 32.01 – 20.0 = 12.01 dB(A)

Table 4.2.13 –Evaluations of noise level reduction in the 1st version.

Equivalent noise level			**Factors of noise absorption**
L.A.equiv. of a source	**55.00**	dB(A)	**At a distance 25 m off a broadside**
dL.A.eq.d	- 4.15	dB(A)	By distance
dL.A.eq.air	- 0.17	dB(A)	Absorption by air
dL.A.eq.cov	- 4.23	dB(A)	Absorption by cover
dL.A.eq.abc	- 14.44	dB(A)	Natural screen of 3 m high
dL.A.eq.total	**- 22.99**	dB(A)	**With a complex of factors**
L.A.eq.CP	**32.01**	dB(A)	**Estimated level at CP**
+ dL.A.eq.CP	**12.01**	dB(A)	**Surplus of MAC = 20 in CP**

Estimation of a possible distance of noise penetration in near-a-route territory, according to [68], is:

$$R.noise = 10^{\frac{dL.A.eq.CP - dL.A.eq.s + 10.2 \cdot K.\mathrm{cov}}{11.7 \cdot K.\mathrm{cov}}}$$

where: R.noise = noise intensity penetration on territory [m]; L.A.eq.CP = noise level of a source [dB(A)], L.A.eq.CP = 32.01; L.A.eq.s = permissible noise level for the DBR [dB(A)], L.A.eq.s = 20.0; K.cov = factor of absorption by plant cover, K.cov = 1.2...1.4.

For plant cover:
R.noise = $10^{(12.01 + 10.2 * 1.2) / 11.7 * 1.2}$ = 53.4 m for K.cov = 1.2
R.noise = $10^{+ (12.01 + 10.2 * 1.4) / 11.7 * 1.4}$ = 40.3 m for K.cov = 1.4

So in the 1st version (with no man-made plantings) exceeding of normative level of equivalent noise is expected in a margin of 45...60 m coastwise, i.e. within a zone of the man-made landscapes.

Version 2 (man-made plantings along the river bank)

Reduction of negative zone of noise impact is possible due to the dense man-made plantations within 10 m off a bank line. Due to banks elevation the height of a complex noise absorption screen will be 8 m on conditions of adding **an extra 5-row strip of green plantings of 10 m wide.** At that the calculated point shifts at a distance of 10 m off bank line. **A distance from a calculated point (CP) to the route axis (conditional acoustic centre) is 70 m, from CP to the bank – 10 m, to a source – 40 m subject to a ship width, reference distance is 25 m.**

dL.A.eq.d = 10 lg (70 / 25) = 4.47 dB(A).
dL.A.eq.air = 0.005 * 40 = 0.2 dB(A).

Reduction in the noise level dL.A.equiv.cov with acoustic soft cover of the territory is
K.cov = 0.14 * 40 * 10-0.3*0.5 / 1.5 = 2.64 > 1
dL.A.eq.cov = 6 lg (2.64+2 / (1 + 0.01 * 2.64+2)) = 4.88 dB(A).

With adding an extra 5-row strip of the bank green plantings of 10 m wide and 8 m high **the noise reduction by a screen** of unlimited length is dL.A.abc = 18.2 + 7.8 lg (30.92 + 11.93 – 40,01 + 0,02) = 21.76 dB(A).

Conservative estimation of noise absorption of a planting **strip** of 10 m wide, which is part of a complex noise absorption screen is 5 dB(A).

Results of the calculations (Table 4.2.14) show that the inshore buffer strip of 10 m wide with extra man-made 5-row plantings of 8 m high is enough to assure normative level of a noise impact at the boundary of the reserve territory.

Table 4.2.14 Estimations of the noise reduction level in the 2nd version: with adding an extra 5-row strip of the green plantings (width = 10 m, height = 8 m)

Equivalent noise level			Factors of noise absorption
L.A.eq.s	55.00	dB(A)	At a distance of 25 m off a ship side
dL.A.eq.d	- 4.47	dB(A)	by a distance
dL.A.eq.air	- 0.20	dB(A)	absorption by air
dL.A.eq.cov	- 4.88	dB(A)	absorption by a cover
dL.A.eq.scr	- 21.76	dB(A)	combined screen
dL.A.eq.grn	- 5.00	dB(A)	by green strips
dL.A.eq.total	- 36.31	dB(A)	By a complex of factors
L.A.eq.CP	18.69	dB(A)	Calculated level at CP

4.2.5 Summary on the effect of the DWNR alternatives on air environment

- Execution of hydro-engineering works during creation of the DWNR will not cause the ongoing abnormal air pollution.
- Emissions from mobile sources will have short-term and local nature; stationary sources of air pollution both during the construction and operation of the DWNR are missing.
- The acoustic pressure at riversides while executing the construction works and ships passing through doesn’t - exceed normative value of 55 dB(A) for residential areas and normative values for reserved territories (25 dB(A)) at the distance of 50-60 m off the bank line are expected.

  Reduction of the strip width up to 10 m is possible, subject to 5-row dense wood-with-shrubs plantations along the river. Taking into account that the inshore 50 m strips along 5the Bystre and the Starostambulske branches is belong to a zone of the man-made landscapes, the DWNR operation is permissible according to a criteria of noise impact.
- The next factors of impact on biological objects are missing completely or, due to their insignificance, have no effect on the environment:
  - Electromagnetic fields of production facilities;
  - Ultra-high-frequency emission from the ship’s communication facilities;
  - Heat pollution of water and air (by contours of water cooling of engines, exhaust gases);
  - Vibration, high-frequency and ionising radiation;
  - Radioactive pollution.
- Under conditions of passing the DWNR along the DBR territory an emphasis must be done on disturbance and deterrence factors for fauna, such as: emission into ambient air (smells), noise and light. In this connection the regulations of passing the ships along the territory of the DBR will provide the injunction on applying the ships hooters, music broadcast on deck, especially for passenger ships and limitation of ship speed that will decrease negative impact on the reserve fauna and will influence positively in ecological education of tourists.