Annex 29

Sediment Transport with the Danube River Flow and Sedimentation Rates along the Danube-Black Sea Navigation Route

The transport of sediments with the Danube River flow is the key factor shaping the development of the Danube Delta branches, its outer coastline and sandbars. Consequently, the rate of sediment deposition along the Danube-Black Sea Navigation Route is mainly determined by the level and spatial/temporal variability of sediment flows in the Danube Delta.

The present assessment of sediment flows in the Danube Delta, their long-term and seasonal variability, spatial distribution, and grain size composition is based on the data of long-term hydrological study, carried out by the Danube Basin Hydrometeorological Observatory in the Ukrainian part of the Danube Delta over the period of 1961-2002. The results of this study, along with the relevant historical data (from 1840 onward) were summarised and presented in the "Danube Delta Hydrology" Monograph, published in 2004.

This assessment also incorporates the results of more recent hydrological surveys, including the monitoring data collected under the Integrated Environmental Monitoring Programme, designed and implemented as part of the Danube-Black Sea Navigation Route Project in the Ukrainian part of the Danube Delta.

Long-Term Variations in River Water and Suspended Solids Flows. The analysis of historical data on mean annual flow discharges and suspended solid loads in the upper part of the Danube Delta over the period of 1840 through 2002 (Figure 1) indicates that the levels of variation in river flows and sediment transport rates from year to year have been substantial. It should be noted that the value of variation factor for the sediment transport rates recorded over the 163-year period of observations is by 2.5 times higher than the variation factor for the mean annual flow discharges recorded over the same period. The overall time series of data on flow discharges and sediment transport rates have been conventionally divided into the following periods ("Danube Delta Hydrology", 2004):

- Period of conditionally natural hydrological regime (1840-1920);
- Period of slightly modified hydrological regime (1921-1960);
- Period of significantly modified hydrological regime (1961-2002).

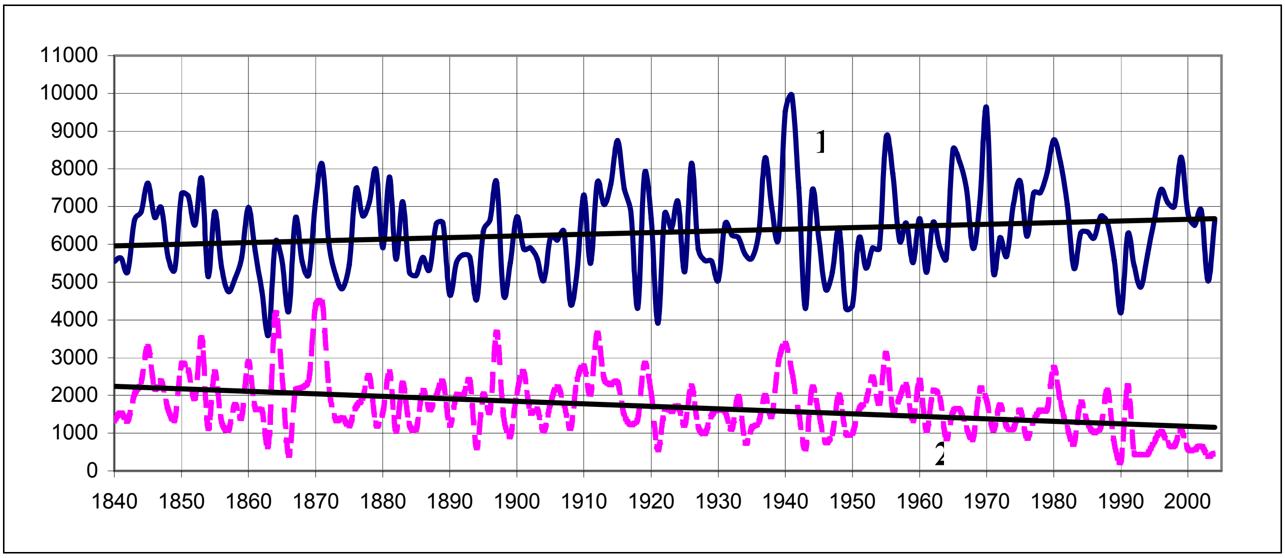

Figure 1. Changes in Mean Annual Flows (1) and Suspended Solids Transport Rates (2) in the Upper Part of the Danube Delta (1840 – 2002)

Additionally, the 1961-2002 period has been divided into three shorter periods (1961-1970; 1971-1984; and 1985-2002) in order to illustrate and assess the impact on the Danube River flow regime, caused by the construction and filling of two major reservoirs (the Iron Gate I (1971) and Iron Gate II (1985):

Table 1. Averaged Data on Mean Annual Flows and Suspended Solid Transport Rates in the Upper Part of the Danube Delta

Period (years)	$Q_{average}$, m³/s	W_Q, km³/year	C v_Q	$R_{average}$, kg/s	W_R, million tonnes/year	Cv_R	ρ, g/m³
1840-2002	6320	199	0.19	1710	54.0	0.47	270
1840-1920	6140	194	0.17	1990	62.8	0.41	320
1921-1960	6320	199	0.21	1660	52.4	0.40	260
1961-2002	6700	211	0.19	1230	38.8	0.46	180
1961-1970	7020	222	0.20	1520	48.0	0.33	220
1971-1984	6890	217	0.16	1450	45.8	0.34	210
1985-2002	6370	201	0.15	906	28.6	0.65	140

As can be seen from the Table 1, there has been an increase in the Danube River flow discharges over the whole period of observations, attributed to be the result of climatic change. The rate of increase in river flows due to precipitation growth has been so significant that it exceeded the growth in non-returnable water consumption in the Danube Basin.

The analysis of data provided in Table 1 indicates that there has been an obvious downward trend in sediment transport rates against a general increase in the flow availability in the Danube River. In the period of natural flow regime (1840-1920), the mean annual load of suspended solids in the upper part of the Danube Delta was at 62.8 million tonnes/year. The subsequent periods (1921-1960, and 1961-2002) have shown a progressive reduction in the suspended solids load: to 52.4 and 38.8 million tonnes/year, i.e. by 1.2 and 1.6 times, respectively. The rate of reduction was particularly obvious in the period 1985 through 2002, when the mean annual flow of suspended solids was at about 28.6 million tonnes, showing a 2.2-fold reduction when compared to the suspended solids loads under the natural flow regime. In 2003 and 2004, mean annual flows of suspended solids were at 12.3 and 15.2 million tonnes, respectively.

It should be noted that the variability of sediment transport rates remained very high even in the conditions of heavily modified hydrological regime. For instance, the mean annual flows of suspended solids in 1961-2002 varied in the range of 85.4 million tonnes (1980) to 8.5 million tonnes (1990). When compared to the natural flow regime, there was no significant change in variation factors for suspended solids loads over 1961-2002, which have even shown an increase in the recent years (Table 1). This graphically illustrates the wide margin of fluctuations in the suspended solids loads under the present conditions.

Seasonal Variations in Flow Discharges and Suspended Solids Loads. The river flow regime in the Danube Delta features a well-pronounced, lengthy and intensive high-water period in spring/summer, followed by a low-water period in summer/autumn. The spring/summer high-water period normally lasts from March through July, with a low-water period lasting from August to October.

In the period of natural flow regime (1840-1920), the spring/summer high-water flow contributed 51.9% to the total annual Danube flow discharged into the Black Sea. In the present conditions (1985-2002), the period from March to July accounts for 51% of the total annual flow. The highest flows have been recorded in April (12% of the total annual flow), May (11.8%) and June (9.9%).

Generally, there has been no significant change in the annual flow pattern in the Danube Delta. The construction of reservoirs in the Danube Basin has had little or no impact on the annual flow pattern due to their small storage capacities.

By contrast to the river flow pattern, the annual suspended solid flow distribution has been more uneven in the upper part of the Danube Delta. The high-water period (March to July) accounts for 64-65% of the total annual sediment load. The construction of reservoirs in the Danube Basin has resulted in the overall reduction in suspended solid flows during all seasons, though the annual distribution pattern for the suspended solid load has shown little or no visible change (Figure 2).

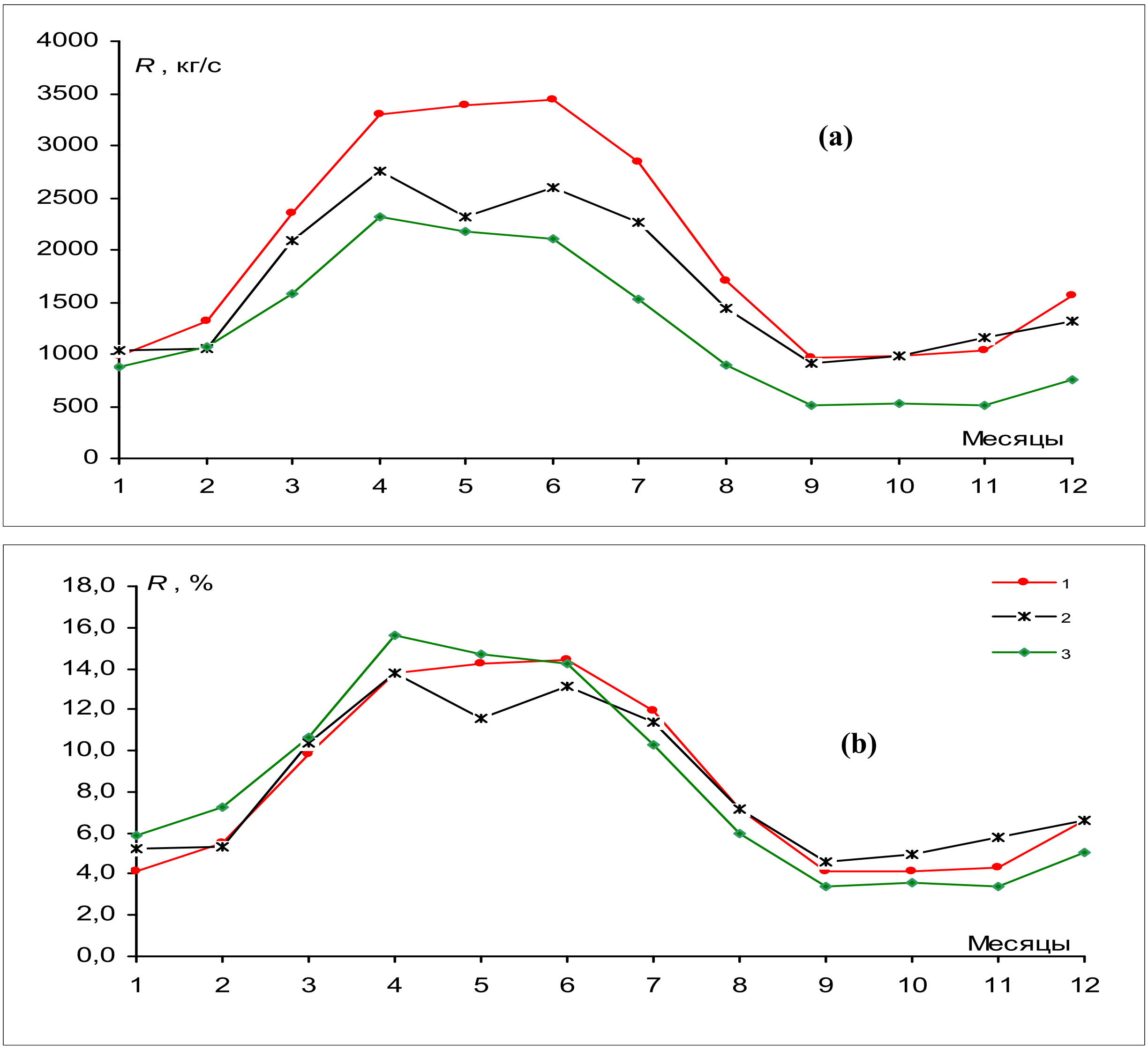

Figure 2. Suspended Solid Flow Distribution Pattern in the Upper Part of the Danube Delta (in kg/s (a) and % (b)) in Various Periods (Period 1: 1840 – 1920, Period 2: 1921 – 1960, Period 3: 1961 – 2002).

The analysis of current yearly flow distribution pattern for suspended solids (1985-2004) demonstrates a significantly higher variability of suspended solid flows when compared to the river flows. This can be illustrated by the following comparison of two years (1988 and 1995), which showed similar levels of flow availability, close to that of an average year. In 1988, the period from March to July accounted for 85.8% of the total annual suspended solid load transported with river flow, and for only 66.9% in 1995. The values of ratio between the maximum and minimum monthly flows of suspended solids were at 36.8 in 1988 and 8.2 in 1995. The 1988 total annual suspended solid load (67. million tonnes) was by 2.8 times higher than the 1995 load (24.3 million tonnes), though the total annual water flows were very similar (207 and 210 km^3 , respectively).

The 1985-2004 maximum was recorded in 1991, when the total annual suspended solid flow was at 71.0 million tonnes). Of that, 63.5% was transported with high-water flow. The same year showed the highest monthly average discharge rate (9800 kg/s) for suspended solids over the period of 1961 to 2004. It should be noted that the 1991 total annual river flow was slightly below normal (198 km^3).

In 1999 (a wet year with the total annual flow of 262 km^3), the distribution of the total annual suspended solid load over a year was similar to the 1991 pattern with 66.8% of the total annual load discharged over March through July, though the total annual suspended solid load was significantly lower (33.4 million tonnes).

The dry years normally show lower total loads of suspended solids, which are more evenly distributed over a year. For example, in a dry year of 1990 (total annual river flow 132 km^3), the total annual suspended solid load was only 8.5 million tonnes. Of that, 49.5% was discharged during a high-water period.

The differences between the yearly river flow and suspended solid load distribution patterns are mainly attributed to the fact that the major proportion of suspended solid flow transported during a high-water period, especially during a rainfall-induced flood event, comes from different parts for the Danube River catchment area. For example, the river flow, collected in the Upper and Middle Danube Basin, has lower turbidity levels relative to the river flow contributed by the Lower Danube tributaries. According to the data provided in the "Suspended Solid and Tractional Sediment Transport Regime in the Danube River" Monograph (1993), mean annual water turbidity levels in the Inn, Drava, Tisza and Sava Rivers are at 120 g/m^3, 86 g/m^3, 194 g/m^3, and 108 g/m^3, respectively. The Iron Gate reservoirs trap and retain part of the suspended solid flows contributed by the Upper and Middle Danube tributaries. The same source suggests that the mean annual turbidity levels in the Lower Danube tributaries are significantly higher, i.e. by about 10-fold (e.g. the Morava River (841 g/m^3), the Olt River (1,176 g/m^3), and the Siret River (1,660 g/m^3). The Danube Delta receives virtually all suspended solid load carried by these rivers. As a result, the highest turbidity levels in the Ukrainian part of the Danube Delta normally coincide with the extreme flooding events occurring in the Lower Danube catchment.

The Distribution of Suspended Solid Flow among the Danube Delta Arms. The study into the suspended solid flow distribution pattern is a much more sophisticated exercise than the analysis of river flow distribution pattern. This can be explained by: 1) a higher degree of imprecision involved in the measurements of suspended solid flows **(R)** relative to the river flow measurements **(Q)**; 2) highly variable and ambiguous dependence **R=f(Q)**; and 3) impact of erosion/sedimentation processes in watercourses on the distribution of suspended solid flows.

For these reasons, the synchronic measurement technique was applied to estimate the distribution (R) of suspended solid flows among the Danube Delta arms (The Danube Delta Hydrology, 1963, Mikhailov et al. 1967). This technique involves the plotting of relationships between the actually (and as far as possible simultaneously) measured suspended solid flow rates (**R**) or water turbidity levels (**ρ**) at various gauging locations. The mean annual flow rates of suspended solids at two gauging locations (115 km ($\mathbf{R_{115}}$) and 20 km ($\mathbf{R_{20}}$)) were compared in order to estimate the losses in suspended solid flow along the Chilia arm. The following relationship equation was produced for the period of 1981-2002, with the correlation factor of 0.987 (Figure 3):

$$\mathbf{R_{20}=0.896\ R_{115}-9} \qquad (1)$$

The analysis of synchronically measured rates of suspended solid flow (R) and water turbidity levels (**ρ**) along the Chilia arm produced similar results. This is illustrated by the following relationship equations, with the correlation factors being at 0.960 and 0.919, respectively:

$$R_{20}=0.960R_{115}-115 \qquad (2)$$
$$\rho_{20}=0.916\rho_{115}-23 \qquad (3)$$

This analysis indicates that the current rate of reduction in the suspended solid flow, estimated for the Chilia arm section between the 115th to the 20th km, is 4-10%.

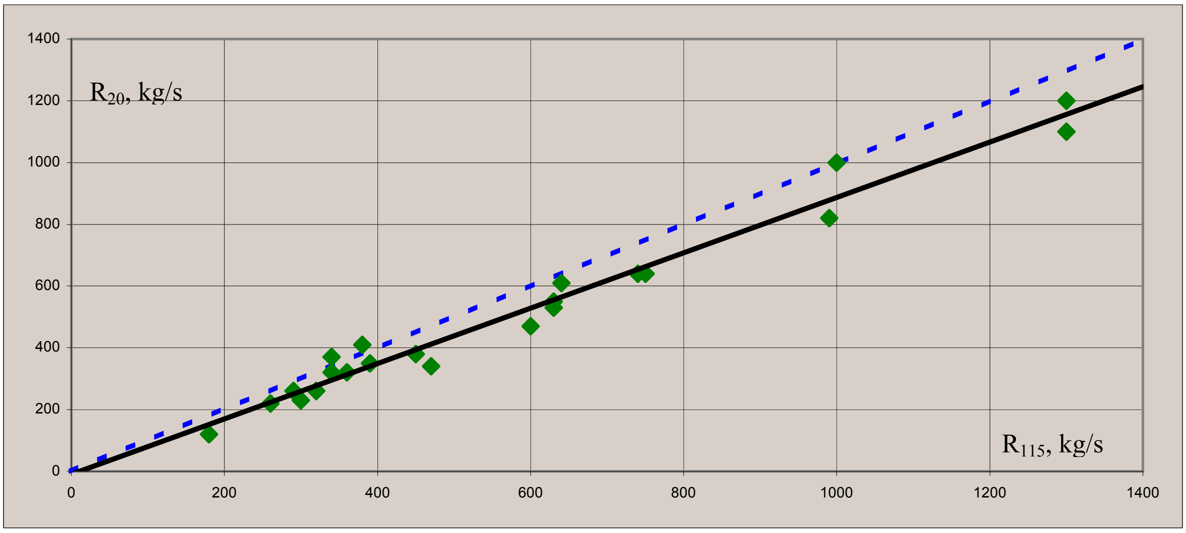

Figure 3. Graph Showing the Relationship between the Mean Annual Suspended Solid Flows at Two Gauging Locations in the Chilia Arm (115 km and 20 km) over 1981 – 2002 (Dotted Line: $R_{20} = R_{115}$)

The results of earlier studies (The Danube Delta Hydrology, 1963, Mikhailov et al. 1967) indicate that the percentage distribution of suspended solid flow among the Danube Delta branches is very close to that of the river flow. More detailed analysis of recent data, undertaken by the specialists of the Danube Hydrometeorological Observatory, indicates that the levels of water turbidity, synchronically measured at the head of the outer Chilia Delta (gauging location at the 20th km), in the Ochakiv Branch (15.5 km), in the Starostambulsky Arm downstream of the Bystre Branch, and in the Bystre Branch itself) are very close (Figure 4).

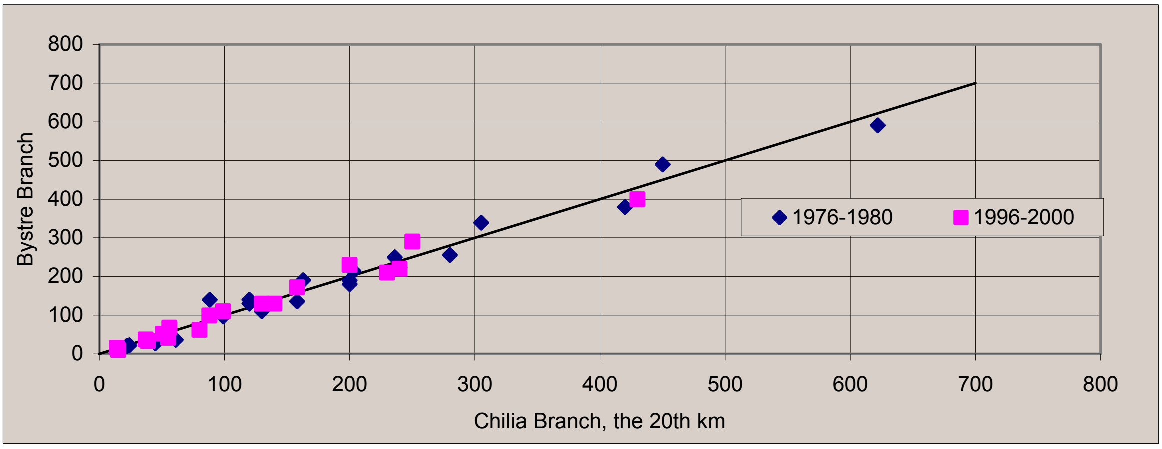

Figure 4. Graph Showing the Relationship between Average Turbidity Levels in the Chilia Branch (the 20th km) and Bystre Branch (head), Based on the Synchronic Measurements of Suspended Solid Flow Rates

This analysis illustrates the fact that the proportion of suspended solid load carried through the head of any branch of the Chilia Delta matches the proportion of river flow received by a river branch during any phase of the hydrological regime. Moreover, the close similarity of synchronically measured turbidity levels enables the estimate of daily loads of suspended solids, based on the data on daily flows, discharged through each of the Delta branches, and daily turbidity levels measured in the Chilia Branch (the Vylkovo gauging station).

Tractional Sediment Load. The objective assessment of the tractional sediment load in the Danube Delta is very important in examining the impact of sedimentation process on the construction and operation of the Danube-Black Sea Navigation Route. It is unfortunate that reliable techniques for measuring the tractional sediment load are nonexistent.

The bottom sampler measurements, carried out in various years in the Danube Delta, indicate that the tractional sediment load in the majority of cases accounts for less than 1% of the suspended solid load (Hydrology..., 2004).

A slightly different picture emerges from the analysis of the tractional load estimates based on the characteristics of the bottom sediment ridges (Measurement Manual..., 1978), produced by the Danube Hydrometeorological Observatory for the Danube Delta area in 1987-1996. The following trends in the bottom sediment ridge characteristics were identified on the basis of the collected hydrometrical data: the minimum, average, and maximum ridge heights were 0.2-0.3 m, 0.5-0.8 m, and 2.0-3.0 m, respectively. Their lengths ranged from 7-10 m to 130 m, with the average lengths being at 15-25 m during the low-water period and 60 m during the flood (high-water) period. The ridge shifting velocity varied from 3-4 m to 13-21 m per day. The estimated tractional sediment load was at 3-4% of the suspended solid load carried with river flow, with the former showing a decrease during a high-water period, and increasing during a low-water period.

Another estimate of the tractional sediment load for the upper part of the Danube Delta, based on more precise characteristics of bottom sediment ridges of various types (by N.I. Alexeevsky's technique), was presented in the monograph (Danube Delta Hydrology, 2004). This estimate puts the annual tractional sediment load to about 7.18 million tonnes/year (or 18-24% of the total current suspended solid load of 30-40 million tonnes per year). It was assumed that the average density of deposited sand was 1,700 kg/m^3. If one assumes the average density of sand deposits as 1,400 kg/m^3 (which is closer to the actual sediment density measurements in the Danube Delta), then the estimated tractional sediment load would be at 5.91 million tonnes/year (or 15-20% of the average suspended solid load).

It can be concluded that the contradictions in the available actual measurements and estimates do not allow a more reliable assessment of the current tractional sediment load and its distribution among the Danube Delta arms. It may be assumed that the actual value of the tractional sediment load in the Danube Delta might be higher than the above estimates, suggesting its stronger impact on the development of the seaward part of the Delta.

Grain Size Distribution of Sediments. From 1986 onward, the Danube Hydrometeorological Observatory has carried out the comprehensive study into the spatial and temporal patterns of the grain size distribution, both for suspended solids and bottom sediments in the Danube itself (54 mile) and its largest branches within the Ukrainian territory (Chilia, Ochakiv, and Starostambulsky (Danube Delta Hydrology, 2004).

The summary of the particle-size analysis of suspended solid samples is provided below:

- The median diameter of the suspended solid particles is largest at the peak of a high-water period, progressively decreasing towards the end of this period;

- The grain sizes of 0.2-0.1 mm, 0.05-0.01 mm and below 0.001 mm are predominant at all sampling locations and during all hydrological phases;
- The grain sizes of 0,05-0.01 mm are predominant during a high-water period, while the particles below 0.001 mm prevail during a low-water period;
- The largest particle diameters, measured in the suspended solid samples, range from 0.5 mm to 0.6 mm.

The results of similar analysis of tractional/bottom sediment samples are summarised below:
- There is an obvious downward trend in the median diameters of bottom sediment particles during a transition from a high-water period to a low-water period, and as one moves in the downstream direction;
- In all sampling locations along the Chilia branch and the Chilia Delta itself, the grain sizes of 0.5-0.2 mm (20-50%) and 0.2-0.1 mm (25-60%) are predominant during all hydrological phases;
- The largest sand particles diameters are normally within 1-2 mm;
- There is an obvious downward trend in the bottom sediment densities as one moves in the downstream direction, from 1,500-1,600 kg/m^3 (Danube) and 1,400-1,500 kg/m^3 (Chilia arm) to 1,300-1,400 kg/m^3 (Ochakiv and Starostambulsky arms).

The average density of bottom sediments in the mouth sections of the Chilia Delta branches is 1,100 kg/m^3 (Danube Delta Hydrology, 2004).

The Sedimentation Rate Estimates for the Danube-Black Sea Navigation Route. The estimating of sedimentation rates along a navigation route, especially in its dredged sections, is a very complicated exercise. A reliable assessment of the repair/maintenance dredging needs requires an integrated approach that combines the hydrological projections, physical/mathematical modelling tools, and a special hydrological/morphological monitoring programme.

It is still possible to provide a preliminary estimate of sedimentation rates in the Danube-Black Sea Navigation Route, based on the expert judgement and knowledge of spatial/temporal trends in the suspended solids/sediment loads carried with the Danube flow, which have been described in the previous sections of this document. This estimate suggests that up to 10% of the total annual suspended solid load, carried via the Chilia arm, is retained and deposited along the river section between the Izmailsky Chatal and Vylkove. Based on the data provided in Table 2, the annual suspended solid load, received and retained in this section over the past 25 years, ranged from 0.44 million tonnes (2003) to 4.74 million tonnes (1980). Assuming that the average density of bottom sediments is 1.4 tonnes/m^3, the estimated annual sedimentation rates range between 0.31 to 3.39 million m^3, with the average annual rate of 1.31 million m^3 over the period of 1980-2004. A more precise estimate of the proportion retained within the dredged sections of the Danube-Black Sea Navigation Route requires a regular monitoring programme that employs the up-to-date measurement techniques.

Table 2. Annual Suspended Solid Loads Received by the Chilia Branch (115 km) in 1980-2004

Year	W, million tonnes	Year	W, million tonnes	Year	W, million tonnes	Year	W, million tonnes
1980	47.4	1986	19.9	1992	10.8	1998	12.3
1981	31.5	1987	23.3	1993	8.2	1999	18.9
1982	20.5	1988	41.1	1994	9.5	2000	10.1
1983	14.2	1989	12.0	1995	14.8	2001	9.1
1984	31.3	1990	5.7	1996	19.9	2002	10.7
1985	23.7	1991	41.0	1997	11.4	2003	4.4
						2004	8.2
						The 1980-2004 average:	**18.4**

The following assumptions were made to assess the sedimentation rates in the seaward access channel cutting through the sandbar section of the Bystre Branch:

- The proportion of suspended solid load received at the head of the Bystre Branch was assumed to be equal to the proportion of river flow discharged via this branch at any moment of time;
- Turbidity levels in the Chilia Branch (the 20th km) were assumed to be the same as at the head of the Bystre Branch;
- The balance of suspended solid loads at the head and mouth sections of the Bystre Branch is zero;
- The tractional sediment load at the mouth section of the Bystre Branch was assumed to be at 10% of the suspended solid load received/discharged by this branch;
- Half of the total suspended solid load received by the Bystre Branch was assumed to be deposited in the sandbar section of the branch, with 20-30% of that being deposited within the seaward access channel itself;
- The bottom sediment density in the sandbar section of the Bystre Branch is 1.1 tonne/m^3.

It should be noted that the present estimate of sedimentation rates in the seaward access channel does not take account of the sediment transport along the coastline and the impact of sea storms. Based on the above assumptions, the annual volume of sediments accumulated in the sandbar section of the Bystre Branch, can be estimated by applying the factor 0.6 to the total annual suspended solid load received/discharged by the Bystre Branch (Table 3).

Table 3. Annual Suspended Solid Load Discharged by the Bystre Branch (1980-2004)

Year	W, million tonnes	Year	W, million tonnes	Year	W, million tonnes	Year	W, million tonnes
1980	10.5	1986	4.2	1992	3.0	1998	3.1
1981	7.5	1987	5.4	1993	2.1	1999	4.2
1982	4.6	1988	9.4	1994	2.1	2000	2.8
1983	3.0	1989	3.6	1995	3.1	2001	2.9
1984	6.3	1990	1.1	1996	4.8	2002	4.1
1985	4.9	1991	11.1	1997	2.9	2003	1.4
						2004	2.6
						The 1980-2004 average:	**4.4**

The resulting estimates, converted to the volumetric units (**V**) by using the assumed bottom sediment density of 1.1 tonne/m^3, are presented in Table 4.

Table 4. Estimated Annual Sedimentation Rates in the Sandbar Section of the Bystre Branch (1980-2004, including the suspended solid transport and tractional load)

Year	V, million m^3	Year	V, million m^3	Year	V, million m^3	Year	V, million m^3
1980	5.78	1986	2.31	1992	1.65	1998	1.71
1981	4.13	1987	2.97	1993	1.16	1999	2.31
1982	2.53	1988	5.17	1994	1.16	2000	1.54
1983	1.65	1989	1.98	1995	1.71	2001	1.60
1984	3.47	1990	0.61	1996	2.64	2002	2.26
1985	2.70	1991	6.11	1997	1.60	2003	0.77
						2004	1.43
						The 1980-2004 average:	**2.42**

The results of this exercise indicate that the average annual rate of sediment deposition in the sandbar section of the Bystre Branch over the period of 1980-2004 was at about 2.5 million m^3. The ratio between the minimum and maximum sedimentation rates is 1:10, reflecting a significant variability of sediment flows in the Danube Delta. As an interesting point to note, the minimum and maximum suspended solid loads in the Chilia Branch were recorded in 1980 and 2003 respectively (Table 2), whereas the Bystre Branch received its minimum and maximum loads in 1991 and 1990 (Table 3). This inconsistency graphically illustrates the fact that the Chilia and Bystre Branch are in different development phases, where the former decreases its flow, while the latter is undergoing the activation phase.

A very preliminary character of estimates provided in Table 4 is obvious, as is the need for additional research in order to provide more reliable data, especially with respect to the spatial variability of sediment flow transport along the Bystre Branch, tractional sediment load, grain size distribution, and sedimentation/re-sedimentation processes in the sandbar section of the Bystre Branch, to take account of both river-borne and marine sediments.

A more detailed analysis of hydrological regime in 2004-2005 is provided below in order to assess the sedimentation rates in the seaward access channel. The hydrological regime of the Danube Delta during the nine months of 2005 is characterised by a lengthy and intensive high-water period in March-June, followed by three extreme rainfall flooding events in July-September (Figure 5). The total suspended solid loads carried with river flow during this period were as follows:

- Danube River (54 mile): 44.4 million tonnes;
- Chilia Arm (20 km): 20.6 million tonnes;
- Bystre Branch (head): 6.86 million tonnes.

As can be seen from the above, the suspended solid load received/discharged by the Bystre Branch over the first nine months of 2005 was at about 85% of the total suspended solid load transported with the river flow via this branch over the past three year (2002-2004).

Table 5 provides data on the yearly distribution pattern of suspended solid load received by the Bystre Branch in 2004 and 2005. These data indicate that the 2004 suspended solid load transported via the Bystre Branch was at 2.6 million tonnes. After the completion of Phase 1 of the Danube-Black Sea Navigation Route, the total suspended solid load transported with the river flow via the Bystre Branch over the period of September through December 2004 was 0.6 million tonnes, with the major proportion of this load accounted for by the autumn high-water period in November-December.

Table 5. Monthly Distribution Pattern of Suspended Solid Load Received by the Bystre Branch in 2004 – 2005 (million tonnes)

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
2004	**0.07**	**0.16**	**0.25**	**0.62**	**0.43**	**0.21**	**0.09**	**0.19**	**0.05**	**0.07**	**0.34**	**0.14**	**2.62**
2005	**0.07**	**0.34**	**0.56**	**1.34**	**0.94**	**0.49**	**1.07**	**0.96**	**1.06**	**-**	**-**	**-**	**-**

The 2005 suspended solid transport regime of the Bystre Branch features the abnormal distribution of suspended solid load from month to month. The spring/summer high-water period (March–June) accounted for 3.36 million tonnes of suspended solids. During the following three months of 2005 (July–September, i.e. the period when the suspended solid transport in the Danube Delta used to be at minimum (Figure 2)), the total suspended solid flow in the Bystre Branch was 3.09 million tonnes, which is higher than the annual total for the previous year.

Taking account of the above assumptions, the total volume of river-borne sediments, deposited in the seaward access channel of the Danube-Black Sea Navigation Route over March through September 2005, may range between 0.8 to 1.2 million m^3. The estimated rate of sediment accumulation in the seaward access channel over the previous six months (i.e. after the completion of Phase 1) is 0.10–0.15 million m^3.

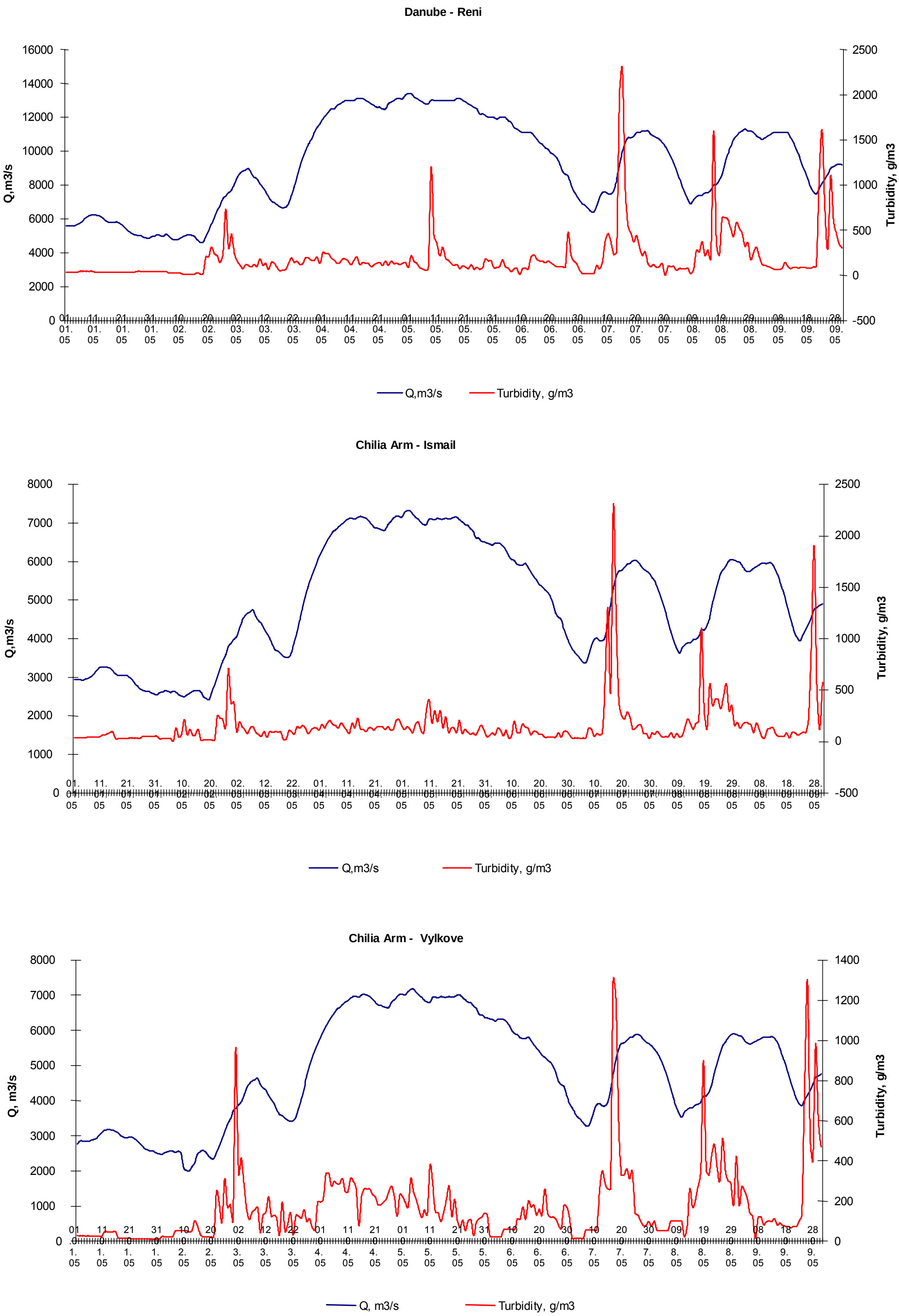

Figure 5. Daily Discharges and Turbidity Levels near Reni (Danube), Ismail (Chilia Arm) and Vylkove (Chilia Arm) in January–September 2005

Findings and Recommendations

1. Under natural flow conditions, the average sediment load received at the head of the Danube Delta was over 60 million tonnes per year. Currently, as a result of construction of major reservoirs in the Danube Basin, the sediment flow has reduced by over 2-fold.
2. The multi-year variability of suspended solid flow remains high even in the conditions of severe anthropogenic pressures.
3. The yearly variability of sediment flow is significantly stronger than that of river flow, with water turbidity peaks being directly associated with the extreme flooding events in the Lower Danube Basin.
4. The proportion of suspended solid load received by the Chilia Delta branches is considered to be equal to the proportion of river flow discharged via this branch during any hydrological phase.
5. Various estimates put the tractional sediment load at some 3-4% to 15-20%. For the assessment of sedimentation rates in the Danube–Black Sea Navigation Route, the tractional sediment load was assumed to be 1/10 of the total suspended solid load.
6. There is an obvious settled trend in the spatial and temporal variability of grain size distribution of suspended solids and bottom sediments, depending on the hydrological phase and in the downstream direction.
7. The bottom sediment density decreases from 1,600 to 1,100 kg/m^3 as one moves in the downstream direction.
8. Up to 10% of the total annual suspended solid load accounted for by the Chilia Arm is accumulated in the river section between the Ismailsky Chatal and Vylkove.
9. Based on the key assumptions, the average annual volume of sediments deposited in the sandbar section of the Bystre Branch over 1980–2004 is about 2.5 million m^3 per year, with the minimum annual volume of 0.6 million m^3 (1990) and maximum annual volume of 6.11 million m^3 (1991).
10. A preliminary estimate puts the annual rate of sediment deposition in the seaward access channel to 20-30% of the total volume of sediments deposited in the sandbar section of the Bystre Branch.
11. The hydrological regime of the Danube Delta during the nine months of 2005 is characterised by a lengthy and intensive high-water period in March-June, followed by three extreme rainfall flooding events in July-September.
12. The suspended solid load received/discharged by the Bystre Branch over the first nine months of 2005 was at about 85% of the total suspended solid load transported with the river flow via this branch over the past three year (2002-2004).
13. The 2005 suspended solid transport regime of the Bystre Branch features the abnormal distribution of suspended solid load from month to month.
14. The estimated volume of river-borne sediments, deposited in the seaward access channel of the Danube-Black Sea Navigation Route in 2005 is between 0.8 to 1.2 million m^3.
15. Additional specialised research programme is required to provide a more reliable estimate of sedimentation rates in the dredged sections of the Chilia and Bystre arms. The following hydrological aspects need to be addressed:
    - Detailed study of turbidity levels along the Bystre Branch;
    - More precise estimate of tractional sediment load for the Bystre Branch;
    - Study into the grain size distribution pattern of suspended solids and bottom sediments in the Bystre Branch and its sandbar section;
    - A comprehensive study of flow velocities in the sandbar section of the Bystre Branch;
    - Analysis of marine impacts on the access channel and sandbar section of the Bystre Branch;
    - Field survey and assessment of efficiency of the protective dam;
    - Regular depth measurements in the in-stream and sandbar sections of the Danube-Black Sea Navigation Route.

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