TECHNICAL MEMOIR FOR ENVIRONMENT PERMIT ISSUANCE

I. INTRODUCTION

The section of the Danube in Romania is an important section of the Pan-European Transport Corridor number VII.

However, in the periods of summer–autumn, the water flows are considerably lowering on this river section, so that the navigation conditions are worsening very much and on the main branch of the Danube the minimum depth criteria is not met. The reasons that have created this very unfavourable situation for navigation are mainly due to morphological and hydrological phenomena.

On the other hand, bank erosion problems on the Danube Constanta canals endanger the fluent traffic along this transport corridor. Furthermore, the importance of Tulcea and Calafat ports are also called to attention due to their importance for Romania to use the Danube as transport alternative.

Preparatory studies have been carried out under the PHARE Multi Country "Study to Improve Navigation on the Danube in Bulgaria and Romania", with a Final Report dated December 1999 (Harris, 1999). This study has identified the main black spots for navigation along the Romanian and Bulgarian sections of the Danube. Technical solutions were proposed, as well as their related costs. The economic feasibility of these solutions has also been assessed.

The Ministry of Transports in Romania, supported by the European Community, has contracted a new study in 2007 to update to the present conditions the former studies. Common actions by Romania and Bulgaria are needed for the implementation of these measures.

I.1 The assignment

On 3 May 2007, the Ministry of Transports in Romania awarded the contract ‘Technical Assistance for Improvement of Navigation Conditions on the Romanian – Bulgarian common sector of the Danube and accompanying studies’, reference EUROPEAID/122137/D/SV/RO, to the Consortium Technum N.V., Trapec S.A., Tractebel Development Engineering S.A., Compagnie Nationale Du Rhone and Safege. The European Commission endorses the contract for co-financing in accordance with the limits of the Financing Memorandum ISPA measure 2005/RO/16/P/PA/002.

I.2 Aim of the study

This project is part of the more global Danube navigability project in order to improve the Pan-European Corridor no. VII as it aims to improve the navigability of the Danube River in such a way that it will answer the needs of the national transport policy of Romania as well as the countries international commitments.

To meet these requirements the project covers the following elements:

1) Feasibility Study, Environmental Impact Assessment, Terms of Reference and Cohesion Fund Application for the next phase of project development, meaning detailed design for the following sections on the Danube River:

   a. **Section I**: Iron Gate II (rkm 863) to Romanian/Bulgarian border at Calarasi – silistra (rkm 375), where previous studies have identified a number of specific navigational constraints.

   b. **Section II**: The port of Tulcea sector between nm43 (Ceatal Ismail – Braila) to nm34 (Ceatal Sf. Gheorghe – Sulina Channel), where navigation conditions are hampered by sedimentation of the harbor and a R=700m curve with limited navigation width.

   c. **Section III**: Danube – Black Sea Canal and the Port Alba – Midia Navodari Canal, where poor design/construction has resulted in stability and erosion problems of the high embankments/escarpments defining the channels and where canal infrastructure needs improvement.

2) **Section IV**: Detail Design, Works Tender Documents and Cohesion Fund Application for the extension of Calafat Port Infrastructure and systematization of the Port rail device.

In this context two mathematical models have been set-up for the stretch of the Danube River between rkm863-375 (Section I) and nm43-34 (Section II), in order to study the critical navigation conditions and provide the necessary input for the design of the river training works.

The studied Danube sector, one of the project's objectives, is mainly a sector with a natural character, with valuable natural habitats and resources. This Danube area is traditionally a valuable resource in for various beneficiaries, close to the Danube or even from farther away, by providing navigation, fishing, agriculture on the meadow etc.

II. GENERAL DATA

II.1 Name of investment objective:

The ISPA EUROPEAID/122137/D/SV/RO - "Technical assistance for improvement of conditions for navigation on the Common Romanian - Bulgarian Danube sector and further studies".

II.2 Location

In the case of section 1, which is the subject of this documentation, the location corresponds to certain critical sectors disposed on the entire sector of the Danube, located between Portile de Fier (rkm 863) and Calarasi / Silistra (rkm 375). The hydro-technical works are to be executed in the Danube riverbed.
From an administrative point of view the works are located within the following counties: Mehedinti, Dolj, Olt, Teleorman, Giurgiu, Calarasi.
The location of the critical sectors is presented in Ch. II.2.4 "list of critical sectors ", the works locations being presented in Ch. II.2.8." Critical sectors files".

II.3 Designer:

Consortium: Technum N.V. (Belgium), Trapec S.A. (Romania) and Tractebel Development Engineering SA (Belgium) with the leader Technum N.V.

II.4 Beneficiary:

Ministry of Transport of Romania, ISPA Coordination Unit, headquartered in Romania, Bucharest, sector 1, 38 Bd Dinicu Golescu.

II.5 Estimated works value

The estimated value of the works, resulted from the Feasibility Study is purely confidential, and a tender will be organized for the works execution.
In the public preliminary documents related to this project, an investment value of approximately 257,000,000 euros is estimated, this value approximately describing the scope of the project.
The amount of the investment will be assessed in the feasibility study, but the actual investment will be final only after the tender for awarding the contractor(s).

II.6 Proposed execution period

The works are to be executed during 2010 – 2015.

III. PROJECT SPECIFIC DATA

III.1. INVESTMENT OPPORTUNITY

Improving of the navigation on the Danube is one of the goals of the third conference of the Pan European Transport held in Helsinki in June 1997.
Pan European Transport Corridor VII refers to inland navigation on the Danube, the Danube Canal - Black Sea, Danube branches Chilia and Sulina, navigable waterways between the Black Sea and the Danube, canal Danube - Sava, the canal Danube - Tisa and main port facilities located on these waterways.
The project is part of the improvement of navigation on the Danube - Pan - European Corridor No. VII.

The project falls within the category of works successively carried out, started before 1900, for the maintenance of navigable waterway that allows access to vessels between the Black Sea ports and Tulcea, Galati and further upstream, to Central and Western Europe.
The project is necessary to ensure the conditions of adequate navigation on this sector of the Danube and access between the Danube River and the Black Sea and contribute to the stability of the river on some sectors, importance given by the access of the ships in ports and other uses.

The purpose of this documentation is the technical assistance to improve conditions for navigation on the Danube, on the joint Romanian – Bulgarian sector.
As a whole, the project comes to meet the national transport policy of Romania and the international agreements between the states.
The project implementation aims to ensure navigation parameters, as they were established by the Danube Convention, as these parameters are not insured for a period of 94% of the year but for a shorter period, even after the substantial increase in volumes of maintenance dredging in the recent years.
The target groups are mainly the industrial consortiums and commercial companies, which are offered improved conditions of transport, without affecting the environment.

III.2. PROJECT DESCRIPTION

III.2.1 Role and method of approaching the project

Even from the Terms of Reference phase, the project was designed to take into account the environmental protection issues and previous studies and concepts regarding the Danube development and conservation of its natural state.

The project aims to result in a reasonable balance between the right conditions for navigation on the analyzed Danube sector and preserving the natural state of the river, aiming at the rational use of a natural river, through the minimum anthropogenic interference.

Although the project starts from reasons related to navigation, all implied matters will be considered.
The Technical Assistance Project tried to minimize the need for construction works and to find an optimal balance between ensuring the depths by dredging works and proposed hydro-technical works.
The role of the project is neither to increase the parameters of the navigation channel, nor to change the course of the river, but to ensure a more stable situation and a lower degradation of the river, which should reduce the unfavorable evolution of the river during the past years.
The project does not propose large scale construction works and does not aim to enlarge the fairway, but it tries to ensure compliance with the requirements of the Danube Commission, as they have been established for several decades.

In order to identify the best options for the project, the designer has created a complex mathematical model for this sector of the Danube, in order to analyze the best technical solutions that involve minimal intervention, and the beast stable, "environmentally" friendly effects. By using the above mentioned hydrological/ morphological model, the designer tries to minimize the need for construction works proposed in the project, through analysis of combinations and mutual effects of the main proposed solutions.

The Designer consider this issue as an end in the planning and design works, so that collateral effects to be minimal, but also to fulfill the main goal of the project. One of the project issues to be considered is related to the phase of construction / implementation, which may affect the environment. In this respect, the designer will try to ensure minimal adverse effects since the design stage, asking the contractor to carry out works mainly in water (with floating equipment), so the effects will be minimal on the natural habitats and meadows.

The construction materials to be used will be mainly stone slabs of different sizes and fascines, which do not have noticeable chemical effects on water.
The main effect expected during construction will result in increasing local silt charge due to the construction works, but the magnitude of this phenomenon is expected to be much reduced as compared to the natural variations of the silt charge on the Danube. The working method and behavior of personnel, as well as the waste and waste water related issues are not significant, but must be managed properly by the construction company under the supervision of the environment authority.

The results of implementing the proposed project will contribute to a lower degradation of this sector of the Danube, less erosion, improved navigation conditions, while trying to preserve the natural state of the river.

Principles to be considered when establishing the works for improving the navigation conditions on the Romanian Danube sector:

These principles are derived from land use on this sector, from terms of protection and conservation of the environment, from the interests that Romania has regarding the use of the river water and from the obligations for the development of the national and international navigation. the most important are the following:

• The need to maintain a fairway, especially at low water when alluvial deposits occur and depth when the fairway on certain sectors falls below 2.5 m;

• At large water flows, Q> 6000 m3 / s, such intervention works in reducing the flow capacity of the river should be minimal;

• Maintenance dredging of the fairway to be reduced to a minimum volume, but as close to an economic optimal;

• The adopted constructive solutions to be flexible, to ensure a long-term stability of the works and fairway, to resist a long time to the action of currents, of waves caused by wind and ships traffic, and of ice;

• To be designed to allow their completion and extension in time, depending on the morphological evolution of the Danube riverbed;

• To meet environmental requirements, as much as possible, regarding the maintenance and development of the natural habitat of the river on flora and fauna, the living conditions of people, to allow sustainable development of the area and countries interested in navigation on the Danube.

In the terms of reference phase, special attention was given to environmental protection issues, agreements and procedures.

The European directives regarding the environmental protection have been implemented in the Romanian environmental legislation, so observing the national legal procedures for EIA also means respecting the main European regulations in this regard.

The EIA and associated public consultation are welcome and expected to find more approaches and points of view on issues related to the project, in order to identify the best ways of implementing the project, so the project can result in the best positive effects and lowest negative impact.

Improving the conditions for navigation on the sector study includes: bathymetry, studies related to changes in the river floor, a mathematical model of the river, preliminary design of infrastructure works, cost – benefit analysis, environmental impact study of the recommended solutions including public consultation.

III.2.2 Current situation on the Danube in terms of navigation (Danube sector between kmr 863 and kmr 375)

The Danube sector between Protile de Fier II (rkm 863) and Calarasi / Silistra (rkm 375) is an important sector of the Pan - European Corridor No. VII. In the EU context "Memorandum for the development of transport Pan - European corridor VII (Columbus) and taking into account the results of the third Pan European Transport Conference in Helsinki held in June 1997, the Transport Pan European Corridor VII refers to the inland

Danube navigation, the Danube - Black Sea Canal, Danube branches Chilia and Sulina, the navigation links between the Black Sea and Danube, Danube - Sava canal, the Danube - Tisa Canal and main port facilities located along these waterways.
Also, it provides the link between the Danube river and Danube Black Sea canal and the maritime Danube.

In Romania, the Danube flows on a distance of 1075 km, between Bazias (km 1075), the confluence with the river Nera, and the Black Sea (km 0). Romania has about 31% of the entire basin of the Danube 250,000 sq. km. On the 210 km, the Danube is the border between Romania and Serbia, and is arranged with the complex navigation and hydropower Portile de Fier I (km 942) and Portile de Fier II (km 863). Put into service in the years 1972 and 1990 respectively, these upstream complexes ensure a minimum depth of 3.5 m. Downstream of the complexes, the Danube flows in free conditions and there are many areas where at low waters, drainage is carried out to ensure the necessary depth for navigation.
The Danube sector which is the subject of the technical feasibility study on navigation, is comprised between sections Portile de Fier II (rkm 863) and Silistra (rkm 375), except Calafat port, which is studied separately.

Navigation on the Danube must meet the conditions provided in international shipping standards and by the Danube Commission.
Issues regarding the improvement of navigation on the Danube concern the Danube sector downstream of Iron Gates II.

From locks Portile de Fier (rkm 863) Romania, through the Ministry of Transport (MT), ensures navigation conditions also on the Bulgarian side until Somovit (rkm 608), according to the Danube Commission recommendations. The Ministry of Transport of Bulgaria has the same responsibilities as the Ministry of Transport of Romania, only on the common border sector between Somovit - Silistra / Calarasi (rkm 374). From Calarasi, the Danube flows on the Romanian sector, Romania being responsible for maintaining the conditions of navigation throughout the sector to Sulina (km 0).

Currently, the navigation conditions are unsatisfactory in this sector, especially in the months of summer and autumn when the river flow is reduced, the condition of minimum depth for navigation established by the Danube being respected for average periods about 160 days a year, periods when the depth of the navigation value decreased to 1.4 m in some critical navigation points.
On the Danube between Portile de Fier II (rkm 863) and Calarasi/Silistra (rkm 375), the design rules established by the Danube Commission recommends a fairway depth of 25 dm below the ENR. Upstream Portile de Fier I and II, recommended depth is 35 dm below the minimum level of retention of the two dams.

According to the Danube Commission recommendations, for the free flowing stretches of the Danube between rkm 1791.00 and rkm 62.97, the width of the fairway is as follows:

- On sectors with soft river bed at least 180 m;

- On sectors of rocky river bed with bottom sills at least 100 m;
- On sectors of soft river bed at least 150 m.

Thus, the recommended channel width is 180 m at ENR – 0.25m and a channel width of 150m can be considered for sections with sandbars. The channel radius of 1000m has been recommended or 750m, when unfavorable from a geomorphological point of view.

Based on recent bathymetry measurements, on the existing fairway, on field visits and discussions with the authorities, an assessment of the critical points was made. Navigation problems can occur due to several reasons. The most common are those related to insufficient depth or width of the fairway and too stressed curvature of the fairway.
The analyses of the existing water depths and fairway curvature showed a number of critical areas for navigation.
The Danube studied sector is characterized by several areas with a high instability of the riverbed (Belene, Batin and more recently, Corabia). The periods with dry years emphasizes these critical areas.

III.2.3 Assessment of current conditions

The Danube Commission adopted the reference level for finding the minimum depth of the Danube navigable channel as Etiaje Navigable et de Regularisation ENR). This level is defined for the entire length of the Danube from Kelheim in Germany to Sulina (Sulina canal) and corresponds to the water level with a 94% frequency, without ice periods.

The Consultant based the assessment of the current situation on the findings of the literature review and updated this information with field visits, meetings with several institutions and additional measurements.

The findings of the present conditions were discussed with the Client, AFDJ and several local institutions during the field trip between Gruia and Giurgiu from 2 to 4 June 2008. A document summarizing the present conditions and critical sectors for navigation was issued afterwards (Technum et al., 2008c) and a brief revision is presented in Section 3 of this report.

In addition, **Error! Reference source not found.** provides a list with cables and bridges crossing the Danube River in the area of the project (rkm863-375) and Table 2.4 shows the list of bank protections for the right bank (Bulgarian bank).

Table III-1: Cables and bridges crossing the Danube (rkm863-375)

Location	Rkm	Type	Width [m]	Clearance above HWL [m]
Iron Gate II	863.60	Road bridge	34.00	17.70
Iron Gate II	862.40	High voltage cable	-	26.00
Kozlodui	706.10	High voltage cable	-	28.00

Bechet	679.40	High voltage cable	-	25.00
Giurgiu/Rousse	488.70	Road/rail bridge	150.00	13.70

III.2.3.1 Ice conditions

The climate changes on regional and global level, the intensification of the social-economic and industrial activities, which increase the degree of water pollution, and the reduction of the lake surfaces by fencing them with dikes, influence the ice conditions and the manifestation of the winter phenomena on the Danube.

In the last years, the winter phenomenon has been reduced in intensity and amplitude. On the Danube between Gruia and Balta Ialomitei (Section 1), this phenomenon has a reduced frequency. In the last five years the winter phenomena were present only in January and February period in areas and periods with air temperatures less than –10 to -15 degrees Celsius. These phenomena were manifested as water frost on the river and island banks with reduced depths and low velocities. This type of ice, detached from the banks has been observed and registered on the hydrometric stations (INHGA, 2008). As reference for Section 1, **Error! Reference source not found.** and **Error! Reference source not found.** show the ice conditions in the last five years at Gruia and Corabia.

Table III-2: Ice conditions at Gruia (2002-2006) (Source: INHGA, 2008)

Year	**Duration in days**				
	Bank ice	**Flowing ice**		**Ice dam**	**Total winter phenomenon**
		Often > 50 % from the river bed width	**Rare < 50% from the river bed width**		
2002	-	-	-	-	-
2003	-	-	-	-	-
2004	-	-	-	-	-
2005	-	-	-	-	-
2006	4	3	7	-	10 (Bank ice-ice formation overlying)

Table III-3: Ice conditions at Corabia (2002-2006) (Source: INHGA, 2008)

Year	**Duration in days**				
	Bank ice	**Flowing ice**		**Ice dam**	**Total winter phenomen on**
		Often > 50 % from the river bed width	**Rare < 50% from the river bed width**		
2002	-	-	-	-	-

2003	-	-	-	-	-
2004	-	-	-	-	-
2005	9	3	6		9 (Bank ice-ice formation overlying)
2006	-	-	-	-	-

Table III-4: List of bank protections on the right bank (Bulgarian bank)

From km	to km	Location	Type
833.700		Novo selo	Quaywall
828.000		Florentin	Quaywall
819.000			Quaywall
810.800	808.500		Quaywall
794.000	793.300	Vidin	Quaywall
792.700	792.300	Vidin	Quaywall
791.500	789.300	Vidin	Quaywall
788.200	788.000	Vidin	Quaywall
788.000	786.000	Vidin	Quaywall
785.300	785.100	Vidin	Quaywall
765.500	775.300		Quaywall
774.000	773.200		Quaywall
770.800			Quaywall
744.000	742.000	Lom	Quaywall
734.000		Linovo	Quaywall
724.000			Quaywall
722.000	712.000		BG Riverbank Protection
704.000		Kozlodui	Quaywall
686.000	685.800		BG Riverbank Protection
684.300	677.700	Oryahovo	Quaywall
676.000		Oryahovo	Quaywall
661.500		Ostrov	Quaywall
641.000	640.800	Baikal	Quaywall
635.500			Quaywall
625.000		Zagrazhden	Quaywall
608.000	600.500	Somovit	Quaywall
599.300	596.000	Nikopol	Quaywall
558.700	556.900		BG Riverbank Protection
550.200	550.100		Quaywall
539.000	530.000		BG Riverbank Protection
520.000	516.000		BG Riverbank Protection
510.000		Pirgovo	Quaywall
500.000	492.600	Ruse	Quaywall
491.400	491.000	Ruse	Quaywall
490.000	489.000		BG Riverbank Protection
488.000	487.000	Ruse	Quaywall
486.500	486.200		Quaywall
484.900	483.800		Quaywall
482.900			Quaywall
465.900		Ryahovo	Quaywall
454.000	450.000		BG Riverbank Protection
433.500	431.500	Tutrakan	Quaywall
414.000		Malak Preslavets	Quaywall
403.200	402.900	Popina	Quaywall
405.300	403.200		BG Riverbank Protection
390.000	388.000		BG Riverbank Protection
382.000	375.000	Silistra	Quaywall

III.2.3.2 Topo Bathymetrical survey

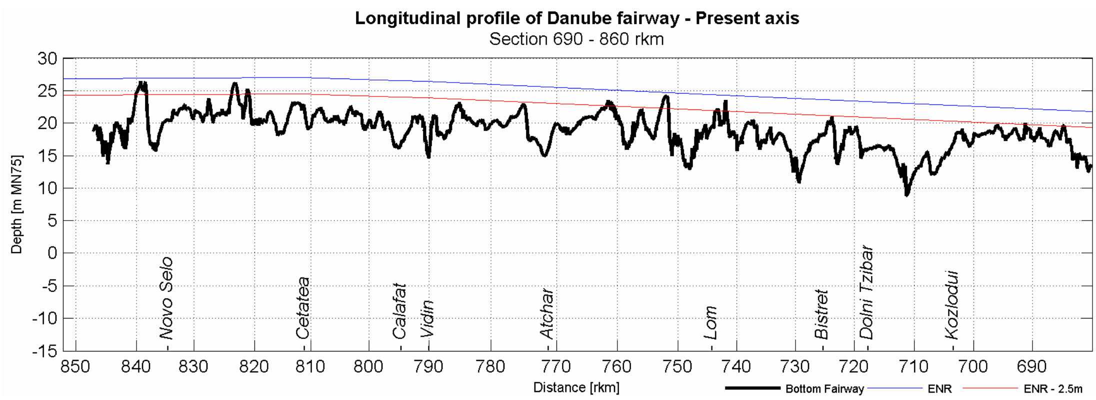
Due to high quality of the data required and the necessity of specialised equipment that guaranty the accuracy of the measurements, the Consultant subcontracted with a specialised company in this field, the Romanian Company Intergis Group, the measurements and processing of the topo-bathymetrical measurements. As preparation of these in-situ measurements, the Consultant prepared a Memo with the methodology and required accuracy to be followed during the collection of the data.

The topo bathymetrical survey was executed end 2007 begin 2008 and started with the preparation of a geodetical network that allows to georeferencing the collected data and link them to the National Romanian Reference System.

Collected data have different sources: banks and high elevations from aerophotographs, while river bathymetry from echosounder measurements. Aerophotogrpahs needed to be processed and interpreted to obtain elevations. All information is collected with GPS equipment and later georeferenced to a unique geographical reference and elevation systems. On 14 June 2007, the Consultant met with representatives of the Client in Giurgiu and chose the system Stereo 70, the National Reference System in Romania, as the standard system for the spatial information in this project. In addition, Black Sea Constanta 1975 (MN75), the Romanian National Vertical Reference System, is adopted.

Details of the topographical measurements can be read in the document: “Technical Memorandum concerning Topo-Hydrographical survey on the Danube” (Technum et al., 2008a), included in Annex 2.

Figure III-1 shows the longitudinal profile along the present navigation channel between rkm863 and rkm375 and based on the collected bathymetry data. As can be seen, the river bottom is at some locations higher than the minimum required level for navigation of ENR-2.5m, either because there is not enough depth for navigation or the river has moved its banks and the original alignment of the navigation channel is outside the present riverbanks.



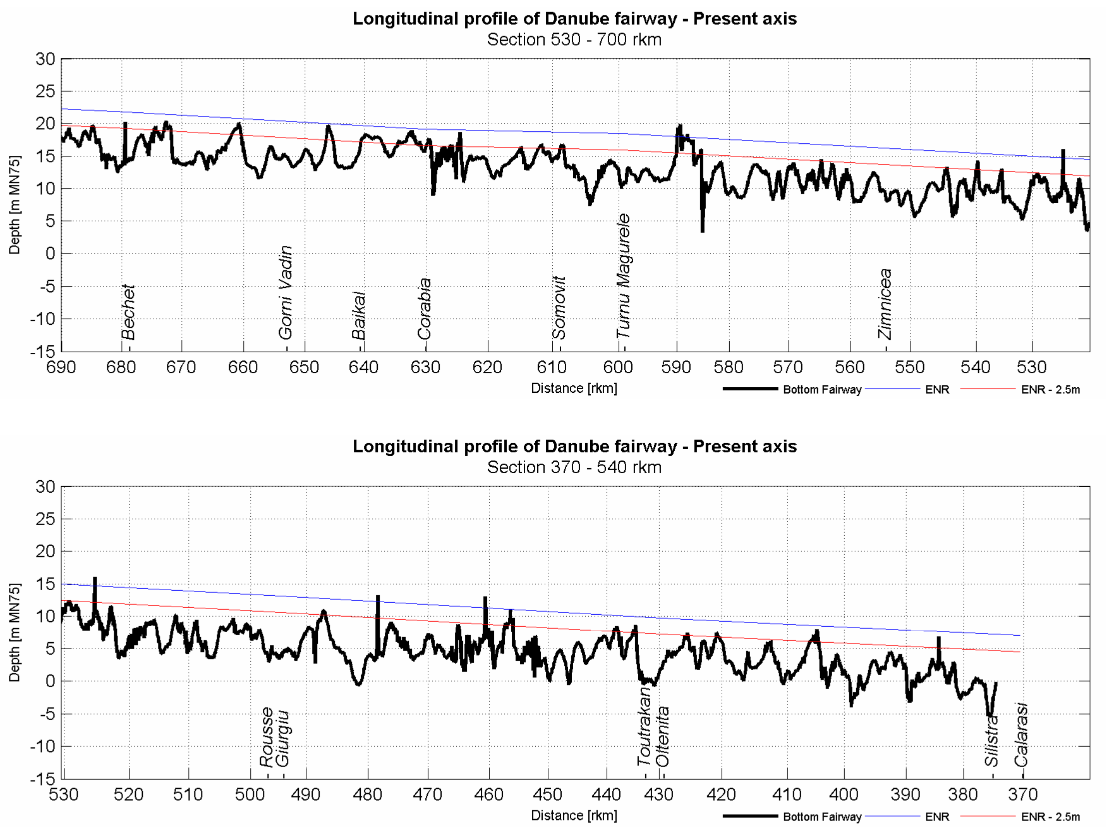


Figure III-1: Longitudinal profile along the current navigation channel rkm863-375

III.2.3.3 Hydrographical and sediment investigations

From the literature review, the Consultant had available information about historical time series of water levels at the gauge stations along the river. This information was collected from the yearbooks of the Danube Commission (Danube Commission, 1970-2006) and AFDJ Galati.

This water level information was processed and a statistical analysis of the data performed to identify tendencies of the flow and know the extreme flood and dry periods that will be used in the numerical model. **Error! Reference source not found.** lists the main gauge stations in the area of the project.

Table III-5: Water level gauges along the Danube between rkm863 and rkm375

rkm	Name of the station	Level 0 in MN75[1] [m]	Level 0 in SMNS[2] [m]	Level 0 in MN Varna[3] [m]	ENR from level 0 [m]
833.6	Novo Selo	27.0	-	27.0	1.20

[1] NM75: Black Sea Constanta 1975

[2] SMNS: Marea Neagra (Black Sea) Sulina

[3] MN Varna: Marea Neagra

795.0	Calafat	26.1	26.68	-	0.50
679.0	Bechet	21.4	22.08	-	0.42
678.0	Oriahovo	21.5	-	21.56	0.46
630.0	Corabia	18.9	20.12	-	0.23
553.7	Zimnicea	15.7	16.22	-	0.57
493.0	Giurgiu	12.7	13.06	-	0.44
430.0	Oltenita	9.6	10.01	-	0.09
370.5	Calarasi	7.0	-	-	0.00

Additional valuable information was obtained by INHGA who prepared a study contracted by the Consultant. This study compiled hydrological and sedimentological information about the Danube River and its main tributaries (INHGA, 2007). Besides, a similar study also prepared by INHGA for the previous studies between Calarasi and Braila was also available (INHGA, 2004).

Finally, the field survey of AFDJ in summer 2008 provided water and sediment samples, as well as an inventory of the bank erosion in Section I of the project (Technum et al., 2008b).

III.2.3.4 Embankment/Escarpment stability

Local erosion will occur in areas where the flow velocity is high enough to drag the available sediment out of the banks. The erosion is also related to ground water pressure and flows at certain periods of the year. Bank instability may also occur along the waterways due to navigation. To prevent instability of the banks (to protect infrastructure or keep the present conditions of the river), bank protection needs to be provided.

Simultaneously with the sediment collection campaign in July – August 2008, the Consultant made an inspection of the bank stability in the studied stretch.

The objective of the visual inspection for the banks was to determine their global state in Section I of the river. The inspection concerned the natural and protected banks.

The visual inspection reviled the following findings:

- The left bank is generally more affected by (severe) erosion than the right bank. This could be caused by the geotechnical characteristics of the embankments: the left bank of Gruia – Giurgiu section is made by meadow formations and porous rocks (clays, sands, dusts) (see Figure III-2 and Figure III-3; while the right bank is generally made of consolidated rocks (table land formations) (see Figure III-4);
- Bank erosion contributes to the riverbed sedimentation: in the bank erosion areas, the sediments collected at the river bed have the same characteristics as the soils from the banks; moreover, on some sediment samples vegetation imprints have been observed;

- There are bank protection works on the right bank (see Figure III-5 to Figure III-7), probably where erosion was occurring;
- There are also areas where the current encourages sedimentation, especially where the Danube riverbed width exceeds 1,000 – 1,200 m. These areas have been noticed on both banks and they are represented by floodable beaches (for average and high water levels of the Danube) and by islets (see Figure III-8 and Figure III-9).

Figure III-2: Left bank erosion rkm 529

Figure III-3: Left bank erosion rkm527

Figure III-4: Rocky right bank at rkm 507

Figure III-5: Right bank protection at rkm 536

Figure III-6: Right bank protection at rkm 609 (confluence with Vit river)

Figure III-7: Right bank protection at rkm 607

Figure III-8: Left bank settlement

Figure III-9: Left bank settlement rkm 630 (small island in front of Corabia port)

III.2.4 List of critical navigation sectors:

Simultaneously to the field investigations, the Consultant discussed with the local authorities and institutions responsible for the navigation on the Danube River about the difficulties for navigation in this area of the project between rkm863 and rkm375.

Based on the numerous discussions and visits to the area, the Consultant identified several locations with difficulties for navigation at present or with a history of bottleneck for navigation in the last years.

As reference, the Consultant used specifications for the maritime fairway proposed by the Danube Commission. Section 0 presents the geometrical parameters that apply to the Danube River between rkm863 and rkm375; and locations where this is not accomplished are considered critical sectors. One Critical Sector may include one or several critical points.

Harris et al. (1999) prepared the most updated and complete study available summarizing the critical sectors and problems for navigation on the Romanian – Bulgarian common sector. This was the starting point for the Consultant, who updated this study based on its new findings and discussions with the Client (Ministry of Transports) and institutions responsible for the navigation on the Danube.

The critical sectors found by the Consultant are listed in TableIII-6 and shown in Figure II-10. It is important to point out that the list of critical sectors corresponds to an exhaustive inventory of sectors reported by the Client and institutions in charge of the navigation to be studied by the Consultant. However, there are several sectors in this list that are not critical at present based on the most updated field data and engineering measures are not needed. On the other hand, the sectors at: rkm840-838, rkm813-811, rkm763-761, rkm671-669 and rkm641-634, correspond to areas with required capital dredging after the realignment of the navigation channel proposed by the Consultant.

Based on the latest bathymetry studied carried out in 2008, the Consultant prepared the ENR and checked the current navigation conditions. Out of the 33 sectors reported by the Beneficiary and by the Authorities as being critical sectors, 21 require improvement engineering measures, namely the execution of specific hydro-technical works according to the characteristics of each critical sector.

The Consultant has prepared a complete document with its findings and a discussion about the critical sectors for navigation entitled: "Description of the problems for navigation in Section I, rkm863-375" (Technum et al., 2008c).

This document has been regularly updated accordingly during the execution of the study when new information is obtained, analysis of the present conditions is made and discussions and conclusions with the Client are made.

For facility in the analysis, the document is organised by critical sectors with a "Critical Sector Card" per location. Each Critical Sector Card summarizes the main information regarding the difficulties for navigation at present and alternative development strategies.

Therefore, we reiterate that the following table includes the 38 critical sectors reported in the previous studies (Harris et al. etc.) and by the authorities (AFDJ - Galati, APPD - Russe etc.).

The engineering measures are to be applied on 21 sectors, out of the 38 total.

TableIII-6: List of critical sectors previously presented and reported for the Danube navigation (rkm 863 - rkm 375)

Nr. crt.	Rkm	Location name	Critical sector at present
Sectoare critice in prezent			
1	**rkm 825 – 819**	**Salcia**	**Yes**
2	**rkm 804 – 797**	**Basarabi**	**Yes**
3	**rkm 787 – 781**	**Bogdan / Seceanu Island**	**Yes**
4	**rkm 768 – 764**	**Artchar**	**Yes**
5	**rkm 760 – 755**	**Pietrisul Island**	**Yes**
6	**rkm 754-748**	**Nebuiona Island**	**Yes**
7	**rkm 745 – 735**	**Lom – Linovo Island**	**Yes**
8	**rkm 728 – 721**	**Archar Outlet - Alimanu**	**Yes**
9	**rkm 679 – 673**	**Carabulea: Bechet / Oriahovo**	**Yes**
10	**rkm 633 – 625**	**Corabia – Baloiu branch (Bulgaria)**	**Yes**
11	**rkm 615 – 607**	**Kalnovats**	**Yes**
12	**rkm 591 - 581+500**	**Lakat / Paletz Island**	**Yes**
13	**rkm 577 – 560**	**Belene Island upstream**	**Yes**
14	**rkm 548 – 540**	**Vardim Island**	**Yes**
15	**rkm 540 – 536**	**Gaska – Vardim Island**	**Yes**
16	**rkm 530 - 515**	**Batin Island - Stilpiste**	**Yes**
17	**rkm 512 – 504**	**Kama and Dinu Islands**	**Yes**
18	**rkm 490 - 486+500**	**Giurgiu**	**Yes**
19	**rkm 470 – 467**	**Lungu Island**	**Yes**
20	**rkm 426 – 420**	**Kosui**	**Yes**
21	**rkm 400 – 399**	**Varasti Island**	**Yes**
Sectoare ne-critice in prezent			
22	rkm 840 – 838	-	No
23	rkm 813 – 811	-	No
24	rkm 763 – 761	-	No
25	rkm 705+300 – 696	Kozlodui and Kopanita Islands	No
26	rkm 671 – 669	-	No
27	rkm 668 – 666	Ostrov	No
28	rkm 641 – 634	-	No
29	rkm 557 – 553	Zimnicea / Svistov	No
30	rkm 500 – 497	Slobozia	No
31	rkm 481 – 478	Ostrovul Alek	No
32	rkm 477 – 473	Gostinu Island	No
33	rkm 467 – 450	Mishka Island	No
34	rkm 441 – 435	Radetzki Island	No
35	rkm 415 – 410	Albina	No
36	rkm 409 – 400	Popina	No
37	rkm 395 – 390	Vetren	No
38	rkm 386 – 382	Chayka Island	No

In the maps of the Critical Sector Cards are included the following layers:

- Abscissa of the fairway, rkm;
- Navigation channel;
- Contour line at ENR;
- Contour line at ENR-2.5m: bathymetry above this line in the fairway hampers navigation;

- Dredging areas (> -2.50m ENR);
- Measures: bottom sills, groins, bank protection;
- Sturgeon spawing sites;
- Natura 2000 areas (RAMSAR, SPA, SCI);
- Depth with respect to the ENR line [m].

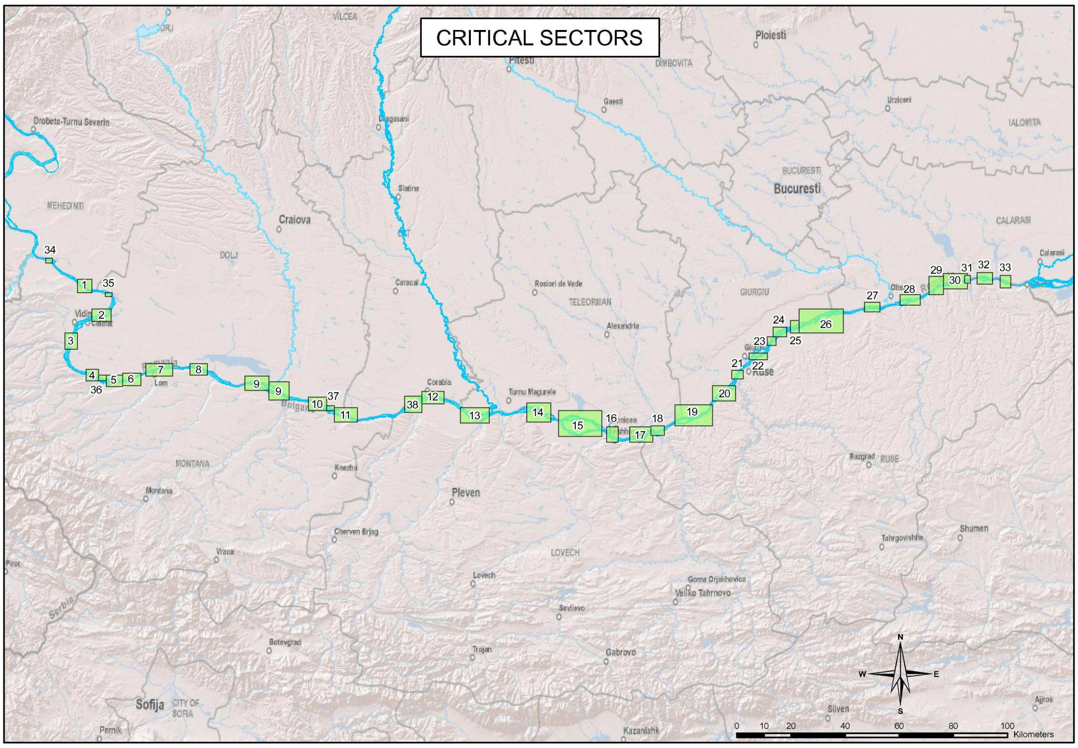


Figure II-10: Critical Sectors for Navigation on the Danube between rkm863 and rkm375

III.2.5 Scenarios for addressing the constraints

The sectors difficult for navigation that do not follow the recommendations of the Danube Commission were studied with the assistance of a numerical model; and several development strategies were included in the model simulations. These possible strategies are presented as scenarios. These scenarios will be the basis of discussion of the Client and the Steering Committee of the project to adopt the necessary works for the improvement of the navigation conditions.

Methodology

The analysis of the scenarios has been based on expert judgement and computations with the assistance of a 2D numerical model for the simulation of the hydrodynamic and sediment transport conditions of the Danube River at this location.

The numerical model is the keystone for the analysis of the hydrodynamics and sediment transport of the river. Figure III-10 shows a plan view of the model grid at one of the critical sectors.

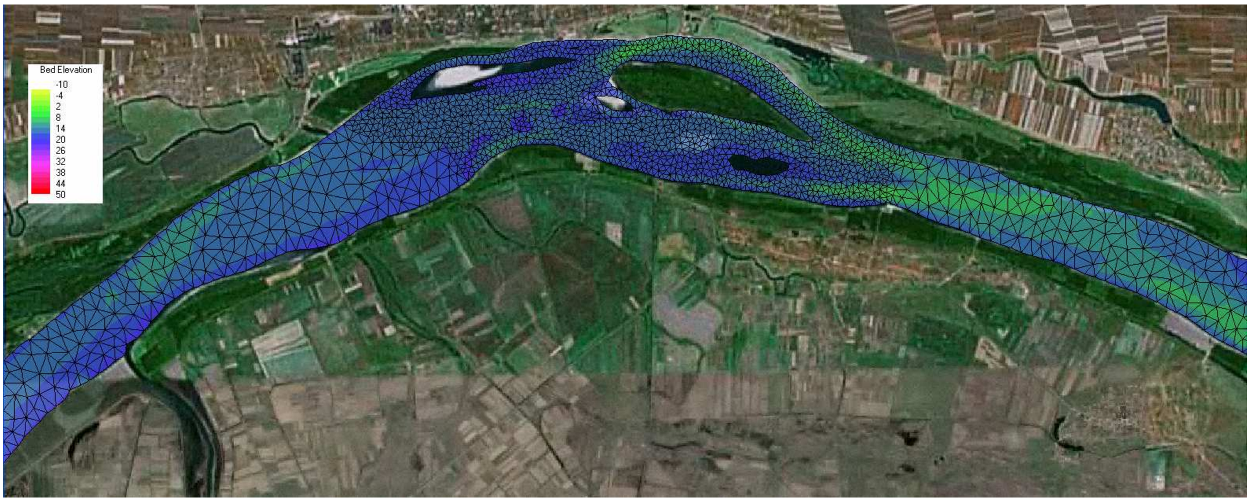


Figure III-10: Model grid and bathymetry at rkm630-620 (Aerial picture from Google.com).

As it has been mentioned before, some locations although they do not present problems for navigation at present, they have also been studied with the numerical model observing the integrity of the whole system.

For each of the Scenarios, the Consultant proposes strategies to be further evaluated together with the Client during the feasibility study. The proposed strategies include mainly common measures used in river engineering for this type of situations, such as:

- Constriction of the width, aimed particularly at low water conditions thereby increasing the available depth of the river. The construction of groins, redirection of flow, partial closure of secondary branches of the river and bank protection can achieve the river constriction.
- Capital dredging to obtain the minimum required depth of the navigation channel with a maintenance dredging. The maintenance dredging measure would be of a recurrent

nature as shallow and narrow sections are expected to reappear specially after high water periods.

- A combination of river constriction works, and capital and maintenance dredging.

Based on the updated list of navigation constraints presented in Section 3, seven scenarios were distinguished: the present conditions and six scenarios with alternative development strategies for the improvement of the navigation conditions. The scenarios vary on the proposed measures to be implemented.

All modelled scenarios are based on the Autonomous Scenario (AS) plus some additional measures described below. In all scenarios a maintenance dredging is needed. The AS corresponds to the present conditions and is used as qualitative and quantitative reference for all the other scenarios. **Error! Reference source not found.**II-7 presents a summary of the scenarios and their measures. The description of each scenario follows below.

Table II-7: Summary of the scenarios and their measures

Scenario / Measure	AS	BS	NOS	EDS	TWS	GS	MS
Realignment of the navigation channel	-	X	X	X	X	X	X
Dredge navigation channel to level ENR-2.5m	-	-	X	-	-	-	-
Dredge navigation channel to level ENR-3.0m	-	X	-	-	X	X	X
Dredge navigation channel to level ENR-3.5m	-	-	-	X	-	-	-
Training works	-	-	-	-	X	X	X

III.2.5.1 The Autonomous Scenario (AS)

The Autonomous Scenario corresponds to the present conditions. The numerical model for this scenario reproduces satisfactorily the measurements and in-situ observations (Technum et al., 2008d and 2008e).

The river is dynamic with zones of erosion and deposition changing constantly. The evaluation of this scenario was based on the latest bathymetry of 2008 collected for this study. Besides, the Consultant based its analysis of the fairway in the last digital version of the axis of the navigation channel supplied by AFDJ in August 2008. It is important to note that at some locations the supplied navigation channel does not coincide with the river bathymetry, mainly because the banks of the river have had a morphological evolution and moved. The local authorities have been updating the location of the buoys in a pragmatic way to ensure navigation.

The total volume that needs to be dredged following this fairway and for the minimum depth of ENR-2.5m for navigation is 5.1 million m^3. As will be seen in the Basic Scenario, a just realignment of the navigation channel based on the latest bathymetry and following the deeper areas reduces this volume in more than half.

III.2.5.2 Basic Scenario (BS)

The Basic Scenario (BS) includes the minimum measures to be implemented in order to comply with the adapted specifications of the Danube Commission for the maritime fairway in this sector of the river.

The following measures are included in this scenario:

- Realignment of the navigation channel at some locations towards deeper areas;
- Dredged navigation channel with a bottom width of 180m to a depth of ENR-2.5m and foresee an overdepth of 0.50m as buffer in the maintenance-dredging program.

The results of the numerical model show that the flow conditions remain basically the same with respect to the AS.

Because there are no engineering measures that partially control the morphological changes of the river, this scenario would require higher volumes of maintenance dredging than today.

III.2.5.3 No Overdepth Scenario (NOS)

This scenario differs with respect to the BS in the depth to be dredged. The over depth of 0.50m proposed in the BS is not included in this scenario. The no overdepth implies a more rigorous and regular maintenance dredging.

The following measures are included in this scenario:

- Realignment of the navigation channel at some locations towards deeper areas;
- Dredged navigation channel with a bottom width of 180m to a depth of ENR-2.5m and no dredging overdepth foreseen.

III.2.5.4 Enhanced Depth Scenario (EDS)

The EDS is a third alternative of dredging level together with the BS and the NOS. In this scenario a depth of 3.0m plus an overdepth of 0.50m is foreseen. The objective of this scenario is to evaluate if allowing a bigger draft for navigation will make more feasible the project, specially from the economical point of view.

The following measures are included in this scenario:

- Realignment of the navigation channel at some locations towards deeper areas;
- Dredged navigation channel with a bottom width of 180m to a depth of ENR-3.0m and foresee an overdepth of 0.50m as buffer in the maintenance-dredging program.

III.2.5.5 Training Works Scenario (TWS)

In order to improve the flow conditions (increase water depths locally) and partially control the morphological changes of the river (which would reduce deposition in the fairway), additional engineering measures are proposed in this TWS.

The following measures are included in this scenario:

- Realignment of the navigation channel at some locations towards deeper areas;

- Dredged navigation channel with a bottom width of 180m to a depth of ENR-2.5m and foresee an overdepth of 0.50m as buffer in the maintenance-dredging program;

Engineering measures such as groins, chevrons, bottom sills and bank protection, to partially and locally stabilize the morphological changes of the river if needed. To concentrate the effect of the structures mainly during low flow periods, the top of the bottom sill corresponds to ENR, and ENR+2.2m for groins and chevrons.

The proposed structures for this scenario have been adopted after several simulations using different shapes, locations, lengths, orientation and quantity of structures in the area.

III.2.5.6 Minimum Scenario (MS)

This scenario is a simplified version of the TWS with a reduced number of engineering measures only at the locations where it is urgently needed.

The following measures are included in this scenario:

- Realignment of the navigation channel at some locations towards deeper areas;
- Dredged navigation channel with a reduced bottom width of 150m to a depth of ENR-2.5m and no overdepth foreseen;
- A reduced number of engineering measures with respect to the TWS.

III.2.5.7 Improved Engineering Works Scenario (EES)

This scenario gives priority to the environmental issues, being based on the measures proposed by TWS and giving increased values to the environmental works. The selection and design of each measure is based on several criteria:

- Use of as less material as possible, natural materials as much as possible;
- Small structures preferred to big structures;
- Two partial bed sills are preferred rather than a single classic one, for improving the connection between the two branches;
- Influence of ratio deep water/shallow water as reduced as possible, without or with a very small connection between the bank and the big structures;
- Maximum reduction of the dredging volume, with use of dredged material;
- Works execution phasing, for a significant impact decrease.

III.2.5.8 Green Scenario (GS)

As many sites are protected by the European laws regarding nature and considering the objectives of the European water networks Directive (WDF), for the green scenario (GES) the works must be proposed in this sense. The proposed measures must be designed as complex measures which would increase the sites value and would improve the navigation conditions. These objectives may be accomplished by increasing the structural diversity and by protecting and restoring the sites (SPA and SCI). The criteria of this scenario are based on the previous scenario (EES), but consider the following:

- Measures for restoring the habitats by increasing the habitat's specificity. To this end, the navigation measures must serve the natural quality. The structural measures are possible, but they must function as a habitat and must look natural;
- The restoration measures must be taken considering the relation between the river, banks and land;

- The ecological and technical sustainability is important;
- The natural dynamic of the river is restored if possible (settlement, erosions etc). Natural materials are used where possible;
- Reducing, as much as possible, the dredging volume; Use of dredged material for creating and increasing the structural diversity;
- The measures have the role of keeping a favorable conservation and the ecologic integrity within the Natura 2000 sites network at a European level. The measures do not oppose to a possible increase of the probability of enriching the objectives of the Water Directive until 2015 for the Danube river;
- Works execution phasing, for a significant impact decrease, applied to each intervention.

The arched groins are preferred to groins if less material (non-natural) may be used and the diversity may increase.

Environmental considerations

With regard to the environmental considerations for the proposal on the structural measures for improving the navigability on the Danube River, both legislative preconditions and best practice guidelines are taken into account. Paragraph 0 describes in more details what standards will be used. The majority of the information is based on several national and international documents describing the legislative and good practice framework, such as:

- Good practice in managing the ecological impacts of hydropower schemes; flood protection works; and works designed to facilitate navigation under the Water Framework Directive (EU activity papers WFD & Hydromorphology Technical and Case studies documents); Joint Statement on Guiding Principles for the development of Inland Navigation and Environmental Protection in the Danube River Basin;
- EU Water Framework Directive, Birds and Habitats Directive, Bern Convention, …

For the Danube River and all surface water bodies the overall aim of the Water Framework Directive (WFD) is to prevent deterioration of the status of all bodies of surface water. The WFD classification scheme for water quality includes five status categories: high, good, moderate, poor and bad. Under the WFD, all bodies of surface water have to achieve by 2015 a “good ecological status” and “good surface water chemical status”. The Danube River is provisionally identified as a heavily modified water body, resulting in the objective to reach a “good ecological potential”. The requirements defined in the final definition of the type of water body of the Danube sets the main assessment approach in studying the feasibility of possible measures for improving the navigability on the Danube in all stretches.

III.2.5.9 Geometrical specifications of the maritime fairway

For the Danube River between Iron Gate II and Calarasi, the Danube Commission recommends a minimum channel depth of 0.25m below the reference level ENR. Upstream of the Iron Gates I and II, the recommended water depths are 0.35 m below the minimum retention levels of the 2 respective dams.

According to the Danube Commission recommendations, for the free flowing stretches of the Danube between rkm 1791.00 and rkm 62.97, the width of the fairway is as follows:

- On sectors with soft river bed at least 180 m;
- On sectors of rocky river bed with bottom sills at least 100 m;
- On sectors of soft river bed at least 150 m.

Thus, the recommended channel width is 180 m at ENR – 0.25m and a channel width of 150m can be considered for sections with sandbars. The channel radius of 1000m has been recomended, or 750m, when unfavourable from a geomorphological point of view.

An area where this is not accomplished is considered a critical sector.

The Consultant is based on the axis of the navigation channel supplied by AFDJ and proposes a new axis taking into account the bathymetry measured in 2007-2008.

III.2.5.10 Etiage Navigable et de Régularisation (ENR)

Within the International Danube Commission the reference level adopted to determine the minimum depth of the Danube navigation channel is the "*Etiage Navigable et de Régularisation*" (ENR). This level is defined for the entire navigable length of the Danube from Regensburg in Germany to Sulina in the Danube delta and corresponds to the water level with an exceedance frequency of 94%.

In the maritime Danube (Tulcea area, Section II of this project) the minimum draft is ENR-7.3m; in the fluvial Danube (rkm863-375, Section I of this project) the minimum draft is ENR-2.5m.

III.2.5.11 General principles of preliminary proposed strategies

This section presents a brief overview and some considerations of the training works used in river engineering nowadays and in this project.

The alternative development strategies would in principle be constriction of the river width and dredging.

The aim of the reduction of the river width is to increase the available depth of the river or increase or redirect the flow velocities and reduce sedimentation in areas where the river shows this tendency.

The construction of groins, redirection of flow, partial closure of secondary branches of the river and bank protection can improve navigation conditions.

III.2.6 Description of proposed works

This section presents a brief general image and a few considerations on the hydro-technical works currently used and proposed for this project.
The development strategy is mainly based on implementing engineering measures and dredging.
Apart from these, the ecologic solutions play an important role in selecting the measures to be implemented.

III.2.6.1 Groins/ Directional groins

Groins are wall-like structures placed in a river and extending from one bank. They are usually at a depth that is normally covered by the water, but they may be exposed at extreme low water levels. Groins are used to divert the flow of water (directional groins) and to manage sediment distribution (constrict the flow and reduce the river cross section at wide areas). They are usually used to improve a navigation channel.

The required constriction of the channel has to result from computations with the mathematical model. From this constriction, the length of each of the groins can be calculated by using the available cross section profiles.

The required distance between the groins is a very difficult parameter to calculate. Usually it is based on the consultants experience with designing similar structures. The preferred distance between two groins is based on the criterion that the resulting flow lines in the main branch/navigation channel are more or less parallel, making navigation easy. This is realised if one stable eddy occurs between the groins.

Influencing the active river cross sections, as groins do, can have a significant impact on morphological processes and bottom levels in a navigation channel. But these processes can also create erosion near the structures. Bottom protections are therefore required on both upstream and downstream sides of the works, and the length of the protection depends on the expected velocities and turbulences that will create the erosion.

The construction of the groin is schematically shown in FigureII-12 and consists of a core of quarry run and a protective layer of stones (e.g. 50-150 kg). The slope is around 1V:3H upstream of the structure and 1V:2H downstream. The groin is constructed usually from land using dump trucks. The width of the crest is around 5.0 m.

Design of parallel guiding walls is similar to the groin structures. Differences result from the absence of an up- and downstream side of the structure and consequent symmetrical design of slopes on both sides of the structures.

Ice loads on the structures should be included in the cross-section design, while the groins are usually inclined in downstream direction, to facilitate ice-discharge by the river.

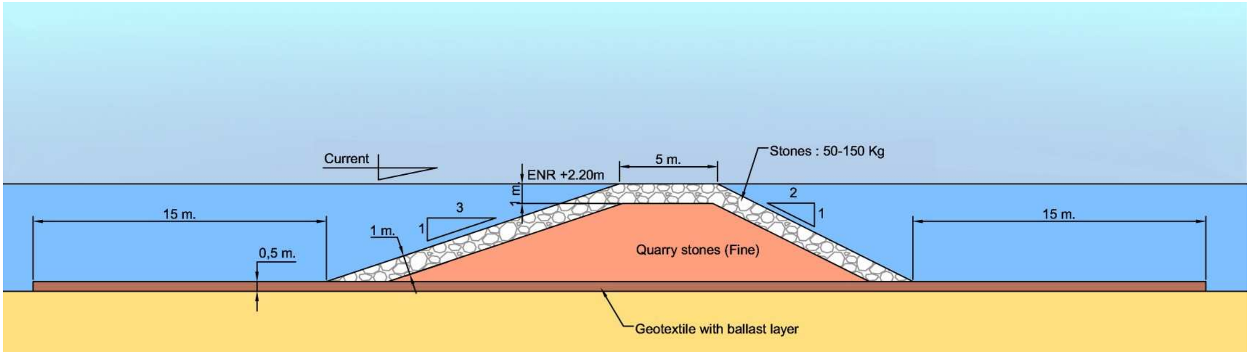


Figure II-12: Schematisation of a groin

A special type of wall structures is the called “Chevrons”. They are arch-shaped structures placed in a river, off the bank. The open end of the arch faces downstream, with its crown or arch facing upstream against the river's flow. They may be visible at lower river stages but are submerged at higher stages. In addition to direction flow and energy to either side to improve navigation, they also create a wide range of aquatic habitats. They are particularly useful for reducing point sedimentation and thus, requirements for dredging (US Army Corps of Engineers, 2008).

Figure II-13: Example of Chevrons (Source: US Army Corps of Engineers, 2008)

III.2.6.2 Bottom sills

Bottom sills are submerged structures at secondary river branches that consist of a core of quarry run and a protective layer of stones. The aim of the bottom sills is to divert the river discharge to the main branch where the navigation channel is located. The crest level of these sills will be ENR so that the flow redistribution occurs mainly only during low water periods. The sills usually have culverts, pipes or a level crest reduction at the center in order to refresh continuously the water in the side branch.

A typical cross section of a bottom sill is shown in FigureII-14. At both sides of the bottom sill is required bottom protection to prevent scour around the sills, especially important on the downstream side, where strong currents may create large scour holes in absence of bottom protection.

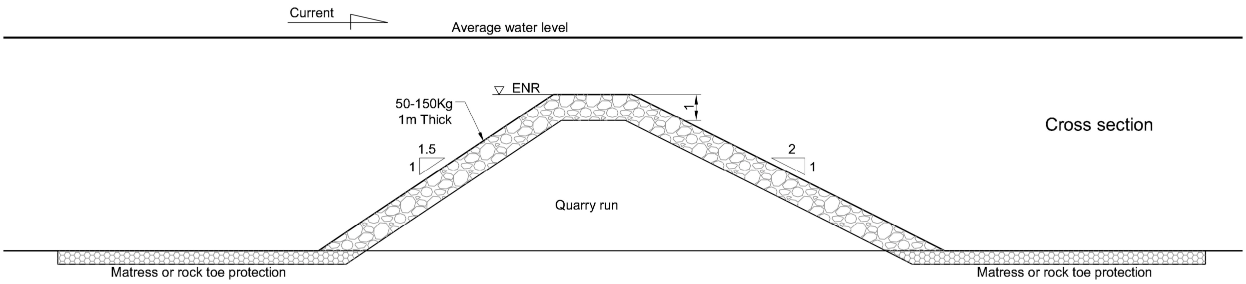


Figure II-14: Schematisation of a bottom sill (cross and longitudinal sections)

III.2.6.3 Bank protection

Bank protection structures are used to control bank erosion due to the water flow. They can be made of rock and concrete, or with natural materials such as wood or vegetation. These structures do not affect the flow conditions, but help to reduce the amount of sediment entering the river and its morphological changes. A typical bank protection is shown in Figure III-11.

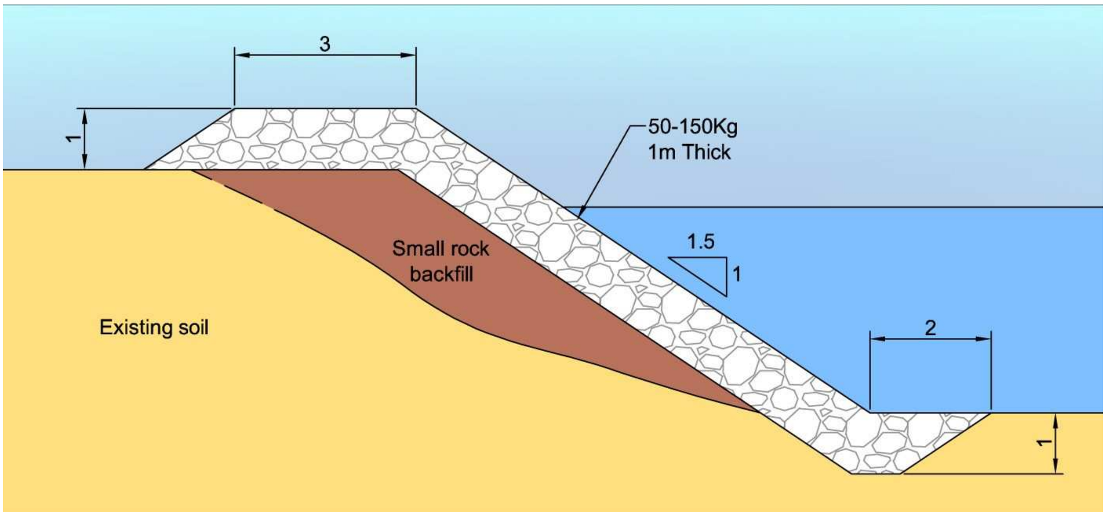


Figure III-11: Schematisation of a bank protection

From an environmental point of view, such structures may not be desirable. Especially river banks are often rich in natural life, and have to be treated with care. Therefore, the option of applying environmentally friendly bank protection should be open.

Although bank erosion is a natural process, it can also be induced due to the constriction of the river width, increasing locally flow velocities. And this result in increased flow velocities may in turn cause the local scour and erosion. Bank protection will be provided at locations where flow velocities increase more than 15% relative to the present situation.

III.2.6.4 Dredging

Dredging is an important activity within the framework of this project because of its cost impact and the necessity to include a maintenance dredging plan in order to assure the long-term conservation of the navigability conditions of the river during coming dry seasons.

During the feasibility study special considerations have to be paid to the environmental consequences of dredging and dumping operations.

The Most Appropriate Dredging Equipment

As far as the dredging equipment is concerned the main determining elements for the selection of the best equipment are:

- The soil characteristics: the dredging activities in the area of the harbour, i.e. the capital dredging needed to deepen the navigation channel as well as the maintenance dredging activities, are considered relatively easy as the bottom material is of alluvial origin, rather recently settled and without any cementation;
- The distance between the dredging and disposal sites: The distance between the proposed dredging and dumping areas is less than 10 km. Hopper transport is selected as the most appropriate because of its flexibility to adapt the actual dumping locations following the monitoring program during execution;
- The available water depth: this is a limiting condition for the selection of the appropriate equipment;
- Resuspension risk: this will be the main item to judge the feasibility of the different dredging methods. This impact will be lowest with trailing suction hopper dredgers.

In addition, the selection of the most appropriate dredging technique will be based on the following elements:

- Volume to be dredged;
- Type of material (clay, silt, sand, rock);
- Maximum execution period;
- Potential dumping area;
- Distance between the dredging location and the dumping area;
- Water depth at the dredging and dumping sites;
- Locally available equipment.

The following dredging techniques will be considered as a possibility for the execution of the dredging works:

- Trailing suction hopper dredger (TSHD): this is a normal ship with a suction pipe alongside. The suction pipe acts as a big vacuum cleaner and the excavated material is stored in the hopper (hold on board the ship). Once the ship is filled, it will navigate to the dumping area where some bottom doors are opened and the excavated soil falls on the bottom. The TSHD can only dredge soft soil (silt or sand) and needs sufficient water depth on both the dredging and dumping area. This dredger does not need anchors and is very convenient for maintenance dredging works, provided sufficient water depth is available (min. 4 meters) and an underwater disposal site can be found at less than 30 km from the dredging site;
- Bucket line dredger (BLD): this is a pontoon equipped with an endless chain of buckets excavating and lifting the material of the river bottom. The pontoon swings over the dredging area by means of an anchor system. It can dredge a fair range of different soils (silt to compacted sand and clay) with a very good accuracy. The production level is limited compared to TSHD and CSD. This type of dredger is in use on the Danube at this moment;
- Cutter suction dredger (CSD): this is a stationary dredger able to dredge a wide range of different soils (from silt to soft rock) and pump the dredged material either to its final destination or to a transport ship or barge. A CSD has no on board loading facilities. CSDs exist in many different sizes, ranging in dredging depth and installed power on

the cutter head. The fact that this type of dredger needs one anchoring system is the most important inconvenience when dredging navigation channels;

- Back-hoe/dredger (BHD): this is a hydraulic crane mounted on a spud pontoon. The crane excavates the material and loads the excavated material in a barge for transport. The BHD can dredge a wide range of different soils (from silt to soft rock) but the production level is limited. As the spud pontoon is fixed, it is a hindrance to navigation in the channel; however to a lesser extend than the BLD or CSD. This dredger is very convenient for accurate dredging such as removal of local spots or foundation excavation. It can be combined with blasting actions for hard rock;
- Grab - Dredger (GD): this is a cable crane equipped with a large grab on a pontoon. The grab is lowered to the river bottom to excavate and then raised. The material is deposited in barges for further transport. This GD is only suitable for soft material and the production capacity is limited. In case of contaminated material specially designed grabs are used to limit environmental effects.

The Dumping Sites

Two major options for the disposal of the dredged material will be considered during the feasibility study. These are located either in the river or on land. Both options have advantages and disadvantages that can differ depending on the characteristics of the material to be dredged.

As far as the cost and the environmental impact are concerned, it is important to select the most appropriate dumping locations. This selection procedure is based on the following guidelines:

- The distance between the dredging and dumping locations has to be as short as possible for economical reasons;
- The distance between the dumping area and environmentally vulnerable sites has to be as long as possible in order to avoid excessive suspended sediment content at the vulnerable sites due to the dumping activities;
- The transport mode depends heavily on the transport distance (for short distances pipeline transport can be used; for longer distances barge transport will be necessary);
- The grain size of the dredged material has a large influence on the quantity of suspended sediments generated in a certain dredging project;
- Any contaminant content can heavily reduce the dumping possibilities of dredged material.

The selection of the most appropriate option for disposal locations has to be done based on a detailed evaluation of the environmental impact and the costs for each of the options.

Maintenance dredging

Once the navigation channel has been deepened it is clear that the new channel has to be maintained. One of the elements of such maintenance-dredging programme is the removal of new sedimentation in the most critical stretches of the river.

Such maintenance-dredging program has to coop with the following elements:

- Limited water depths;
- Small layer thickness;
- Different locations at important distances from each other;
- Soft, sandy material.

III.2.6.5 Environmentally friendly development strategies

Environmentally friendly development strategies aim to comply with the improvement of the navigation conditions on one side, and the European nature legislation in combination with the objectives of the WFD on the other side. The measures for each critical sector should be designed as a complex set of measures, locally increasing the natural value of the site and improving navigability.

Some impressions of possible environmentally friendly development strategies proposed in the scenarios EES and GES, are given in the following figures.

Figure 5.12: Chevron structures Carroll Island, USA (Source:US Corps of Engineers, 2008)

Figure 5.13: Groins with off – bank protection Opijnen, The Netherlands

(Source: Google.com)

Figure 5.14: Groins with side channel Gameren, The Netherlands

(Source: Google.com)

Figure 5.15: Creation of new fish foraging and nursery habitat Rhenen, The Netherlands (Source: Google.com)

Figure 5.16: L-shaped groins with island creation St. Louis, USA (Source: Google.com)

The environmentally friendly measures have three aspects:

- **Environmentally friendly timing of construction:**
  - Phasing of dredging taking into account fish spawning/migration: as dredging can cause significant of turbidity, timing of mitigation and spawning is taken into account;
  - Phasing of larger training works to reduce environmental impact: large structures if possible built in phases taking into account timing of effect on habitats and species;
  - Keep impact on deep areas as low as possible (spawning sites): dredging upstream and downstream of spawning or influence behaviour of fish.
- **Environmentally friendly structures**
- Open guiding wall or groins at river bank: groin or guiding wall has poor or no connection with river bank in order to allow water to flow between groin and bank. The height of groins and guiding walls influences the visibility of structural measures and should be therefore kept as low as possible (see Figure 5.11).

Figure 5.11: Alternative groins with poor connection with the riverbank

- Less groins but with wing: L-shaped groins instead of perpendicular straight groins. Groins change river morphology by descreasing the channel width and the surface area of the waterway. The accelerated flows at groin head develop a scour hole immediately downtream of the dike subquently with submerged bar forming. Therefore, habitat diversity is increased, providing macroinvertebrate habitat and therefore fish foraging and nursery ground (see Figure 5.12).

Figure 5.12: Aternative L-shaped groins

(source: US Corps of Engineers, 2008)

Chevrons instead of groins and guiding walls: chevrons are considered to be more environmentally friendly as they can significantly increase habitat diversity. Dredging material can be deposited behind the chevron dike, forming small islands that encourage the development of primary river ecosystem habitats. Various microorganisms tend to grow and live on these structures, providing a food source for fish and other organisms (see Figure 5.13).

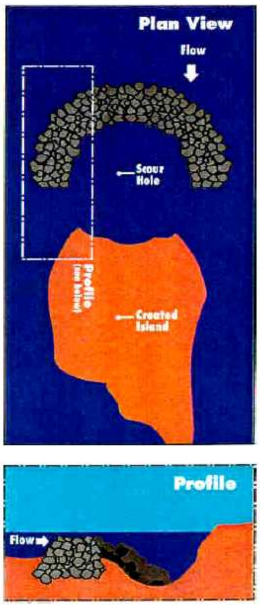


Figure 5.13: Chevrons (source:US Corps of Engineers, 2008)

Two partial bottom sills: instead of one bottom sill, two partial bottom sills are created with an opening in between, thus allowing fish migration and water passage during low run-off periods. A major point of attention is rhe water velocity through the opening that needs to be adapted to the swimming capacity of fish. Other adapted bottom sill configurations can be designed. An alternative can be to use large cubic structures in the river channel to obstruct water passage (see Figure 5.14).

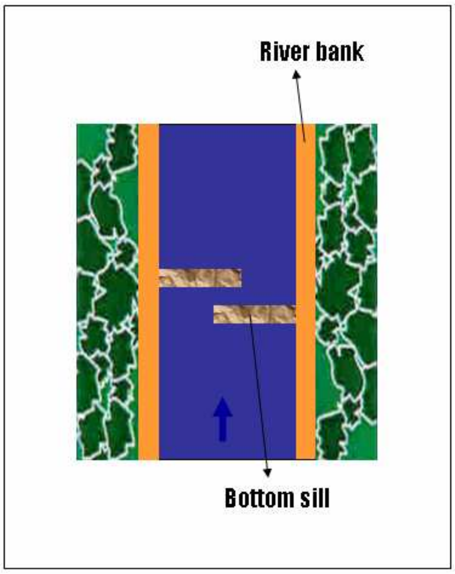


Figure 5.14: Two partial bottom sills (source:US Corps of Engineers, 2008)

- Reduce lenght of bank protection: bank protection should be kept as limited as possible as this negatively influences the structural quality of the river. Where bank protection is needed off-bank structures can be taken into consideration, creating new small side-channels protected from ship-induced wave action and creating shallow feeding and nursery grounds. Maintenance of this artificial habitat might be a concern. Many techniques exist to inplement riverbank protection with natural material, scrubs and wood debris.

- Reduce impact on the islands and protected areas: reduce length of the bank protection trying to keep equilibrium between the hard structure and the stable island configuration.

Environmntally friendly dredging

- Dredging technique should be chosen taken into account environmental effects such as turbidity and applicability on the site;
- Useful application of dredged material: dredged material is used for habitat creation and dumped in deep areas without knowledge of potential fish spawning sites. Potential dumping sites can be found at existing and degraded sand bars, or behind chevrons and groins. Dredging material can be used to enlarge or restore sand banks and islands.

Finally, as previously described, all proposed measures for the bottlenecks have to be assessed under the requirements of the Water Framework Directive. This Directive demands an immediate stand still in affecting the overall biological and physical quality of a water body and an aim for a “good ecological status/potential” (GES or GEP) by 2015.

For selection of instruments, one has to take into account that measures that do not restore the water body to GES are called mitigation measures. Measures aiming for a GES are called restoration measures. When a proposed measure is likely to affect the hydromorphological and ecological quality of the Danube, priority has to be given to measures that restore the river to the GES. If restoration is not viable, effective or possible (technically infeasible, disproportionately expensive or adverse effects on other water uses or the wider environment), alternative mitigation measures should be assessed. Such measures will have to reduce the impacts of the physical alteration in the river.

First of all, a generic list of possible measures for tackling a specific kind of bottlenecks is composed. These potential measures are defined according to a set of characteristics that can be used for the final selection of the measure (costs, ecological benefits, adverse effects, etc.). Thereafter, a bottleneck specific selection procedure is used in order to select the best measure that can be applied for solving the local problem. On the basis of the expected effects of the implementation of the measure, a list of possible restoration or mitigation measures is composed. If environmental concerns are already taken into account in the previous measure selection and if they were realistic, restoration or mitigation measures should be of minor importance. Before and after the implementation of the measure, one should be prepared to objectively monitor the environmental impact of the measure on the basis of a selected set of parameters and criteria. On the basis of this monitoring, one can evaluate the effectiveness and feasibility of the measure. This evaluation process makes it possible to take extra mitigation or restoration measures if necessary.

Before assessing the actual impact of measures on the Danube River, the final assignment of water bodies to the different ecological status/ecological potential classes (good, moderate, poor or bad) has to be made.

Intercalibration was done in all Member States in order to harmonise the understanding of ‘good ecological status or potential’ in all Member States. It is a complex task that takes into account current scientific knowledge about the structure and functioning of aquatic ecosystems, and how human activities influence them. The intercalibration gives an idea of the good ecological quality of the Danube within the assessment frame of the WFD for this project. Therefore, the sites described as High-Good or Good-Moderate quality can be used as reference situations for describing the objectives for the Danube ecological state.

III.2.7 Conclusions

The type of problems for navigation at the critical sectors in Section I of the project (between rkm863-375) are mainly shallow waters due to the natural morphological changes of the river, which reduce the minimum depth for navigation, generate bank migration (erosion of banks) and change the flow redistribution between branches.

Based on the last bathymetry surveyed in 2008, the Consultant computed the ENR and checked the navigation conditions at present. From the 33 sectors reported by the Client and the authorities as Critical Sectors for navigation, 21 require measures for their improvement. The Consultant prepared different alternative development strategies for the improvement of the navigation conditions and are presented in 6 scenarios (plus the present conditions scenario (AS) used as reference).

The first improvement is the realignment of the navigation channel towards deeper and wider areas according to the new bathymetry. The proposed new fairway complies the specifications for navigation conditions according to the Danube Commission. The realignment of the fairway reduces in half, up to 2.4 million m^3, the volume to dredge in order to obtain a fairway 180m width, with the minimum draft for navigation of ENR-2.5m and foresee an overdepth of 0.50m as buffer for the maintenance-dredging program. These two measures, realignment of the fairway and dredging, form the Basic Scenario (BS). Because no additional measures are implemented to control the morphological changes of the river in the BS, it is expected more maintenance dredging than the other scenarios with training works.

The 2D numerical model made for this project shows that the flow conditions (velocity magnitude and direction) have no significant difference in the BS with respect to the present conditions (Autonomous Scenario, AS), for which the conditions for navigation are not less favourable in the BS.

Two alternatives of the BS with different dredging depths were considered: the No Overdepth Scenario (NOS) and Enhanced Depth Scenario (ES). The NOS has a fairway with a depth of ENR-2.5m and no overdepth foreseen; while the ES has a fairway ENR-3.0m deep and foresee an overdepth of 0.50m. The motivation to include the ES is to promote bigger vessels with more benefits later in the economic analysis.

The training Works Scenario (TWS) aims to reduce partially and locally the morphological activity of the river, and enhance the hydrodynamic conditions at some locations redistributing the flow between the river branches. The strategy of the TWS is to realign the fairway,dredge where needed, propose measures to reduce the river morphological changes and slightly increase the water levels mainly during low water periods. Figure 6.1 shows model results of a longitudinal profile of a river with water levels for the present conditions (AS, blue line) and after the construction of the structures (TWS, red line) for minimum, average and maximum discharges. As can be seen, water levels are increased due the training works during low flow discharges between Corabia (km 630) and Giurgiu (km 493) with the maximum difference of around cm (maximum near Zimnicea km 554). The effect of the training works is less during average discharge and even less during high flows. Upstream Corabia and downstream Giurgiu the effect of training works is much less significant.

The results of the numeric model highlight the fact that the water level for this scenario is high in certain areas for the average flow period and also that there is a decrease of the sediment deposition in the navigation channel, as compared to SB.

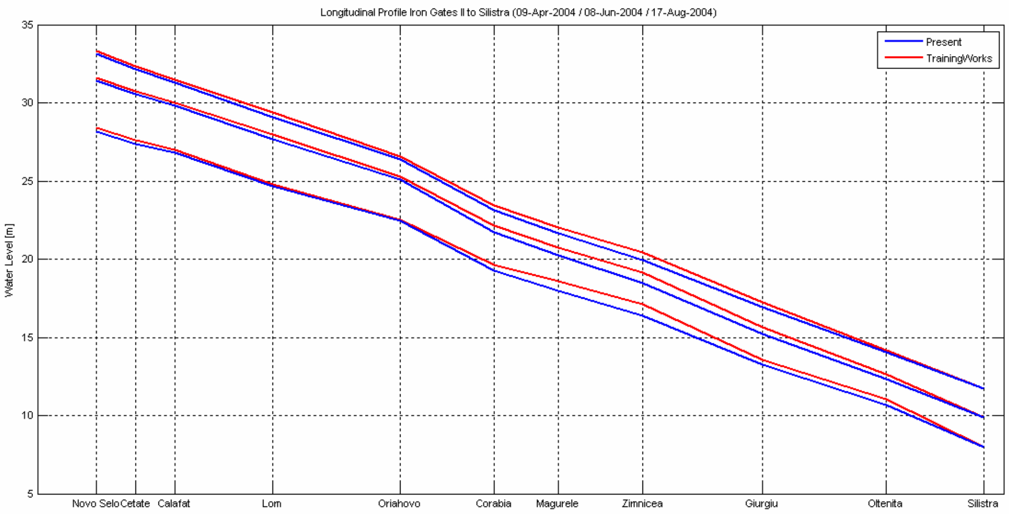


Figure III.17: Water level for scenarios: SA and SLH (TWS)

The numerical model proves the benefits of the training works from the hydrodynamic and sediment transport point of view. The measures at the critical sectors reduce sedimentation in the navigation channel and the flow at secondary branches during low flow periods.

The types of measures included in the training works are: bottom sills, groins, chevrons and bank protection. Bottom sills, where needed, are erected with their top at ENR; that means that they effectively work only during low flow periods redirecting the flow towards the main river branch where the fairway is proposed. The purpose of groins is to reduce the river cross-sections to increase flow velocities reducing sedimentation, and redirect the flow towards the main river branch. Groins are proposed with the crest at ENR+2.2m (around average flow discharge) and a slight downstream angle to reduce the effect of ice accumulation during winter periods. A special type of groins are the called chevron structures, which smoothly redirect the flow in a river bifurcation without cutting at any time the flow at the secondary branches; these type of structure has been used successfully at several locations in the world, such as in the Mississippi River.

The training works can increase the flow velocities or redirect the flow towards the banks, which might induce erosion; for this reason, bank protection is usually implemented together with the training works.

There is much discussion in the literature about the efficiency and the environmental effects of the groins. Groins are not environmental bad per se, but their design (length, direction, quantity, space between them) needs special attention and a detailed study to assure that they work properly avoiding negative effects occurred in the past in other rivers, such as sedimentation between the groins with no space for aquatic fauna and flora.

The TWS includes measures at critical sectors that need implementation in short term, and at locations that the numerical model shows tendency to sediment deposition and reduce the water depth for navigation and thus will hamper navigation. The Minimum Scenario (MS) is a short version of the TWS with only a set of measures at the priority locations. A monitoring program is proposed then to follow the evolution of the other locations and implement additional measures in a second construction phase. Having fewer measures in the MS will increase the required maintenance dredging with respect to the TWS.

Although the included measures in the TWS and MS consider environmental aspects and intend to reduce the effect in the environment with innovative structures as chevrons, they have difficulties for their full implementation due to the environmental restrictions for engineering works at some locations. The Green Scenario (GS) takes as basis the TWS which has proved its benefits in the model results, and modify some of the proposed measures with alternative structures, which although might be more expensive and eventually reduce the hydrodynamic and sediment transport efficiency, cope better with the objectives of flora and fauna protection.

Because many of the sites are protected by (European) nature legislation and in combination with the objectives of EU Water Framework Directive (WFD), a Green Engineering Scenario (GES) can be developed for these specific sites. Here, given the fact that measures for navigation are needed, all measures will be designed as a complex set of measures, locally increasing the natural value of the site and improving the navigability. This can be done with increased structural strategy for each critical sector will be unique and needs detailed study.

The river needs some degree of freedom to allowing certain dynamic equilibrium and immediate bank protection measures are not proposed (except those necessary for assuring the stability of the proposed measures), but well a monitoring program to follow the morphological evolution of the river and take actions in case it is necessary.

In all proposed scenarios the navigation conditions comply with the recommendations of the Danube Commission. Although the navigation channel needs to be realigned and flow velocities are slightly locally increased, the navigation conditions are not affected.

With respect to the ice conditions in winter, the proposed measures intend to minimize the effect of ice accumulation, but there are no measures explicitly proposed to avoid ice clogging; for this, maintenance has to be done with ice-breaking tugboats if needed.

It is also important to point out that all scenarios will need maintenance dredging strategy, the location of the dredge material and the dredging method need to be studied in more detail.

III.2.8 Critical sectors files

AS:	Autonomous scenario
BS:	Base scenario
NOS:	No additional dredging Scenario
EDS:	Improved dredging scenario
TWS:	Hydro-technical works scenario
MS:	Minimum hydro-technical works scenario
EES:	“More environmentally friendly” hydro-technical works scenario
GES:	Green scenario

1. Salcia (rkm 825-819)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	1
Location:		
Salcia		
Position:	Danube sector:	
rKm 825-819	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Navigation Directorate • Harris (1999)		
Description of the present situation:		
Upstream of the town of Iasen, at rkm 825, the river width starts to increase, which continues up to rkm 822, where the river is getting narrower again. In this section, shallow and narrow sections regularly occur due to the reducing flow velocities and hence sedimentation. Problems occur when water levels at Cetate Gauge are less than 1.5m (the zero of Cetate Gauge, at rkm 811, with respect to Black Sea Sulina is +27.786m). Left bank at rkm 822 is only 2.0 m deep at present. The exact location of the navigation bottleneck varies between rkm 825 and 822 over the years. Up to now, every now and then some maintenance dredging is carried out, which mainly aims at improving sufficient depth. The provided dredged width in the bottleneck area is some 80-100m; the width varies from 700m to 60m.		
Previous Proposed works:		
Harris (1999): To provide the most fluid and easiest navigation route along this section of the river, it is important to keep the navigation channel on the left bank. Hence, the possible navigation improvement options consist of the application of: Groins on the right bank. Four groins will be constructed at a distance of 800m in phase one. If required, another three groins will be constructed in phase two, between the phase one groins. In addition, bank protection will be required along the left bank of the river, to prevent bank erosion due to increased flow velocities directly after implementation of the training works.		
Alternative Development Strategies (Technum et al., 2008):		
The last bathymetry of 2008 shows a long shallow area towards the left bank, for which is proposed to realign the fairway towards the center of the river cross section, following the deep areas. It is proposed to control the migration of the sand bars at the left and right banks and concentrate the flow at the center of the river cross section. Proposed measures in the TWS: 3 groins, 2 chevrons, a guiding wall and bank protection. The area is morphologically active and the same measures are proposed in the MS. An option to be considered in the EES is the construction of the groins and the guiding wall detached from the banks (e.g. wing dam notching) allowing flow between the structures and the banks. Other important aspects for the EES and GES, and in general for construction:		

• Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works; • Keep impact on deep areas as low as possible (spawning sites); • Less groins but with wing (although the total length of groins might be similar, groins with wings reduce works on the river bank and diverse habitats are maintained); • Useful application of dredged material; • Reduce length of bank protection accompanied with a monitoring program in order to take actions if necessary.
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

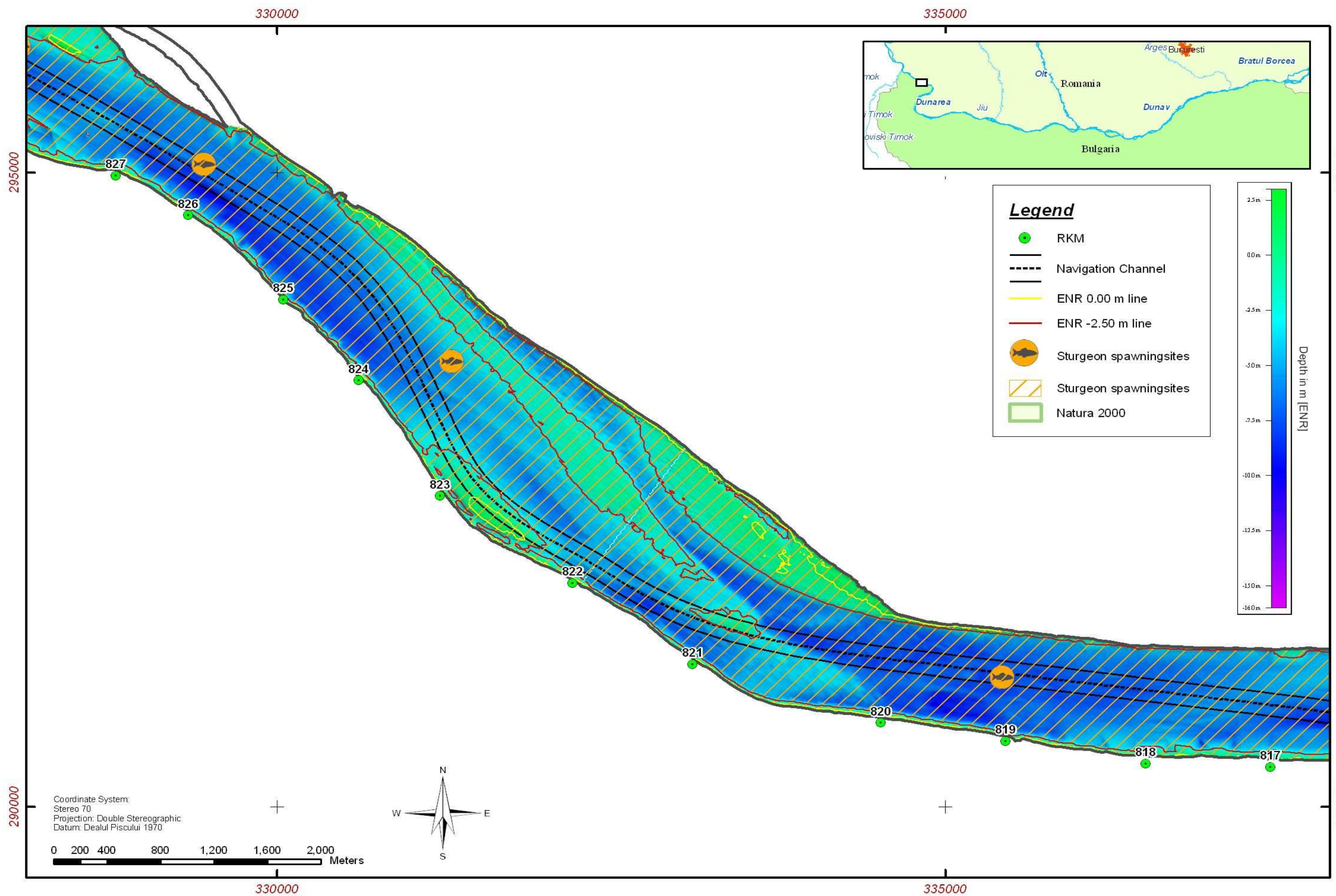


Figure 26: Salcia. Present Conditions

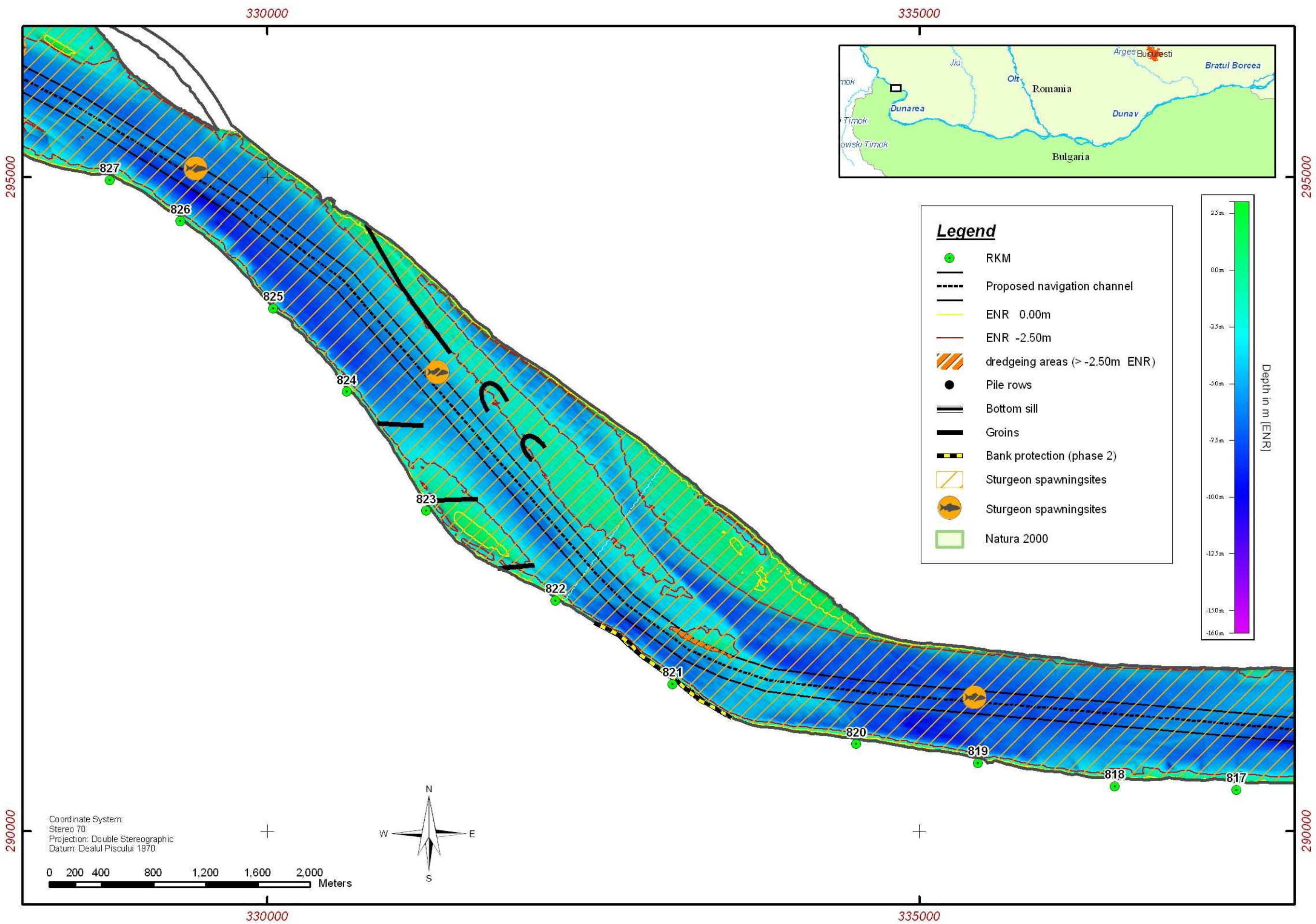


Figure 27: Salcia. Alternative Development Strategy

2.Basarabi (rkm 804-797)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	2
Location:		
Basarabi		
Position:	Danube sector:	
rKm 804-797	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• AFDJ Giurgiu		
Description of the present situation:		
The navigation is on the left branch of the Cutovo Island. The difficulty for navigation at this location is the minimum required channel width and minimum radius of curvature between rkm804-801. Although the recommended width is 180m, at this location the navigation channel is between 100-150m, which makes difficult the crossing of convoys. Ice and minimum depth are not a difficulty at this sector at present. The construction of a new bridge is starting at rkm 796 in 2008. The end of Kutovo Island at rkm 802 is having significant erosion at present. Proposed works:		
Harris (1999): None		
Alternative Development Strategies (Technum et al., 2008):		
The realignment of the fairway improves the radius of curvature. In addition, it is suggested a structure to reduce the flow discharge on the right branch and reduce sedimentation upstream of the island on the left branch. Proposed measures in the TWS: a bottom sill and its corresponding bank protection to assure its stability. The area is morphologically active and the same measure is proposed in the MS. An option to be considered in the EES is the construction of 2 partial bottom sills. Although the total length of the structures is higher, the two partial bottom sills created with an opening in between, allow fish migration and water passage during low run-off periods. A major point of attention is the water velocity through the opening that needs to be adapted to the swimming capacity of fish. Other adapted bottom sill configurations can be designed. An alternative can be to use large cubic structures in the river channel to obstruct water passage. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Keep impact on deep areas as low as possible (spawning sites); • Useful application of dredged material;		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):		

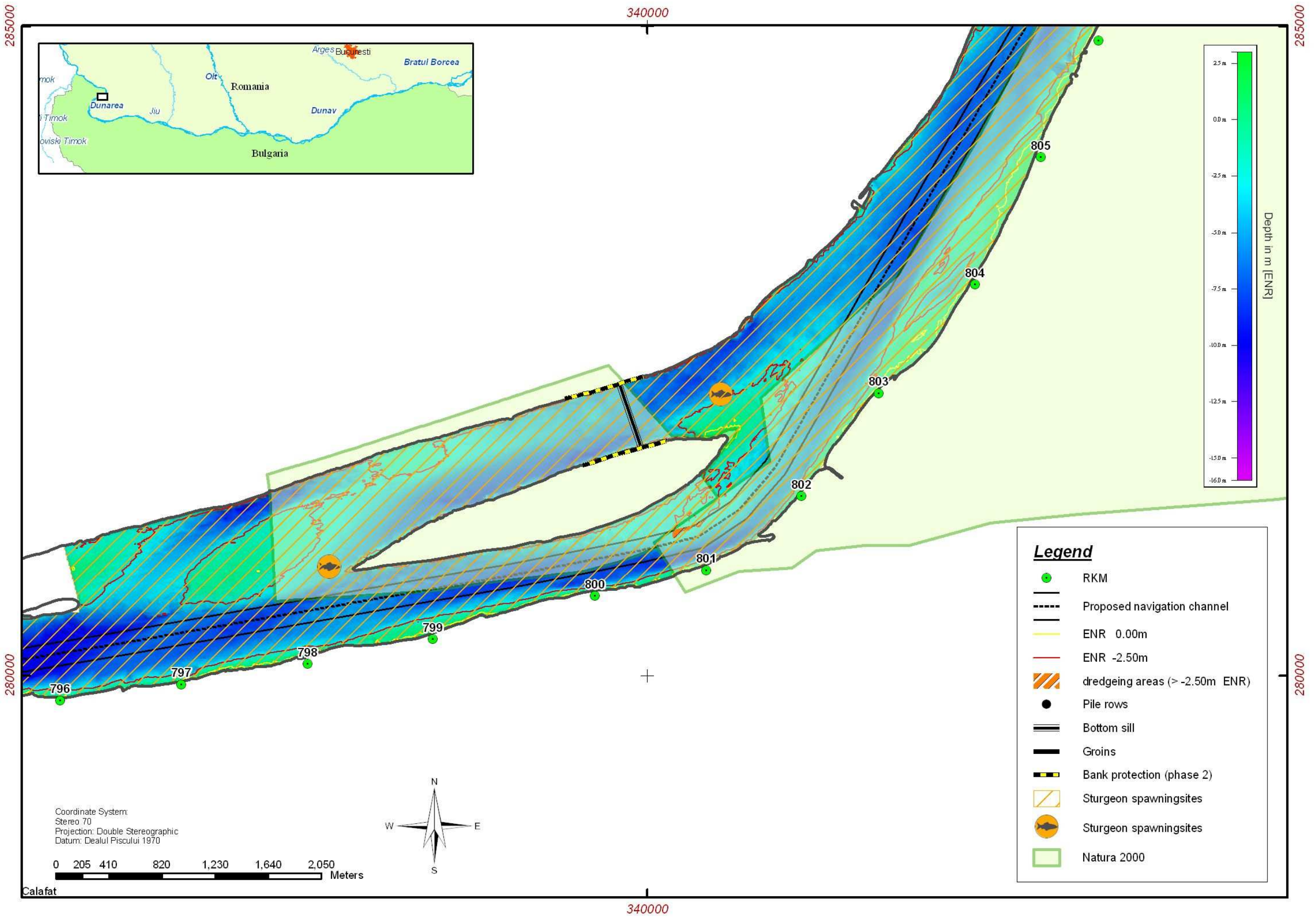


Figure 28: Basarabi Present Conditions

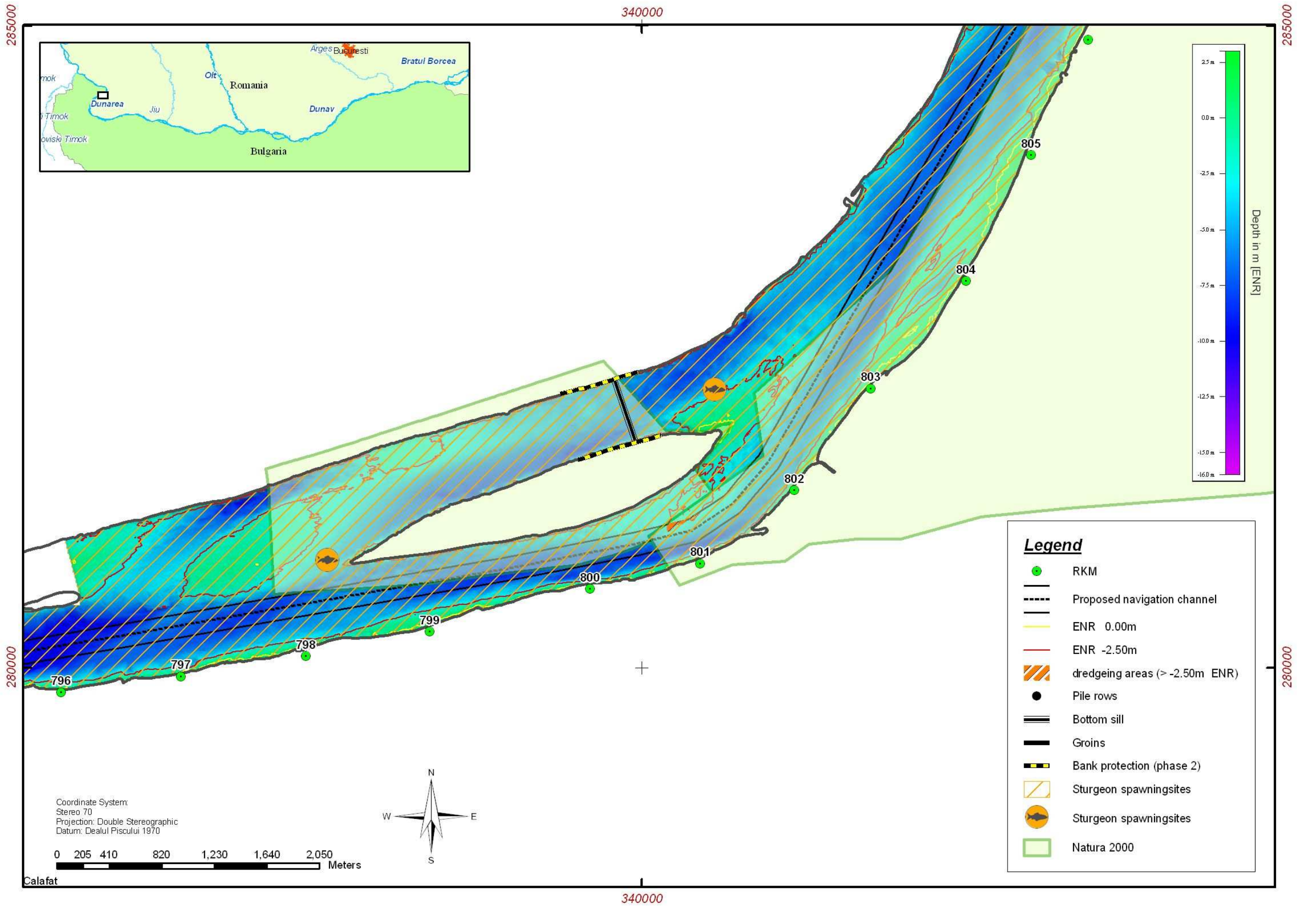


Figure 18: Basarabi Alternative Development Strategy

3.Bogdan/Seceanu Island (rkm 787-781)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	3
Location:		
Bogdan/Seceanu Island		
Position:	Danube sector:	
rKm 787-781	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Navigation Directorate • Harris (1999) • AFDJ Giurgiu		
Description of the present situation:		
The main navigation channel in on the left of the Bogdan / Seceanu Island. The right side branch attracts a substantial part of the flow and the flow velocities in the main channel are not always sufficient during low flow regimes. The navigation channel silts up slowly. A small bottleneck may occur, as the navigable depth and width are not always sufficient. The proposed solutions need to take into account two important issues: - The structures proposed on the right bank should not affect the harbour activities happening on rkm 785 (Bulgarian side). - There is a sand bar around rkm 784 on the left bank (Romanian side). This sand bar is made of gravel and is relatively stable at present. Special attention needs to be taken when adopting solutions that the possible increment of flow velocities on the left branch of Bogdan-Seceanu Island will not erode this sand bar and the sediment will deposit obstructing the navigation channel.		
Proposed works:		
Harris (1999): To remove this bottleneck, the option is to construct groins at the right bank upstream of Bogdan / Seceanu islands. Further, bank protection will be required along the Romanian left bank to prevent bank erosion due to increased flow velocities.		
Alternative Development Strategies (Technum et al., 2008):		
A combined structure of bottom sill and chevron is proposed downstream of the harbour at rkm785 (TWS). The structure will be responsible of reducing flow discharges on the secondary branch and at the same time protect the existent sand bar and island from erosion. The same measure is proposed in the MS. An option to be considered in the EES is an especial design of the bottom sill with openings that will allow fish migration and water passage during low run-off periods. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration;		

• Keep impact on deep areas as low as possible (spawning sites); • Open guiding wall at river bank; • Useful application of dredged material; • Reduce length of bank protection.
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

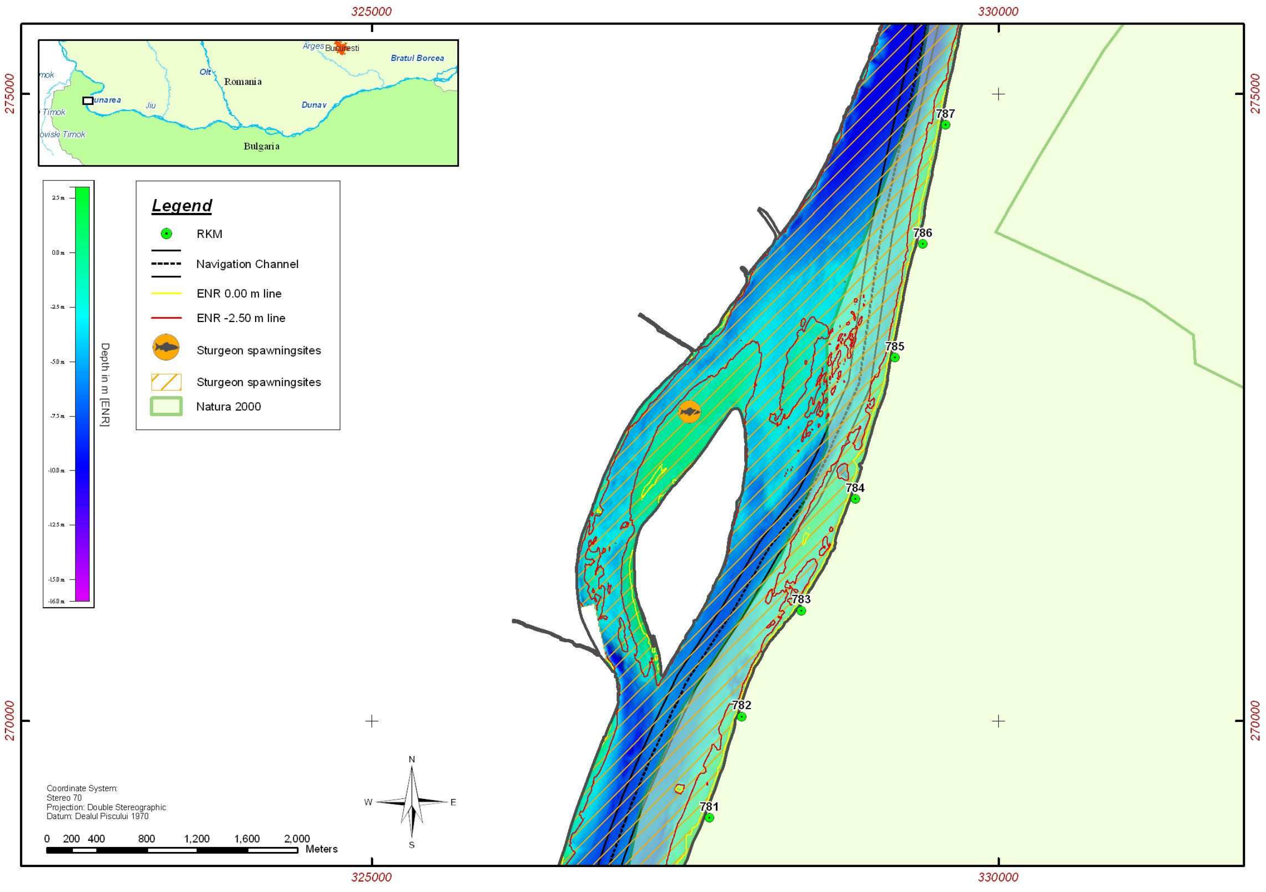


Figure 30: Bogdan Present Conditions

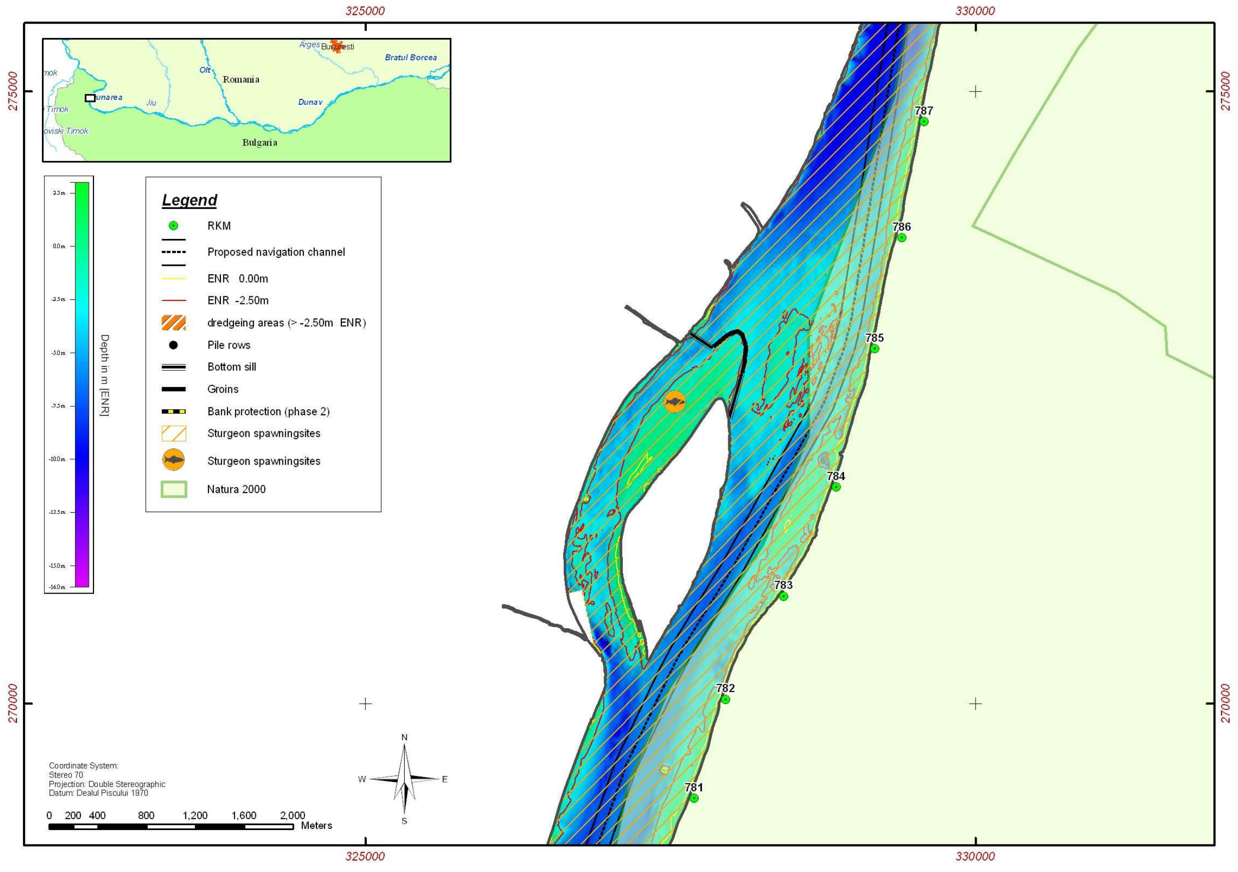


Figure 19: Bogdan Alternative Development Strategy

4. Artchar (rkm 768-764)

<table>
<tr><td rowspan="2"></td><td>Last update of this sheet:</td><td>18/09/08</td></tr>
<tr><td>Critical Sector Number:</td><td>4</td></tr>
<tr><td colspan="3">Location:</td></tr>
<tr><td colspan="3" align="center">Artchar</td></tr>
<tr><td>Position:</td><td colspan="2">Danube sector:</td></tr>
<tr><td>rKm 768-764</td><td colspan="2">Common Romanian – Bulgarian sector
rKm 610 - 845.5</td></tr>
<tr><td colspan="3">Sector for detail measurements:</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Critical point reported by:</td></tr>
<tr><td colspan="3">• AFDJ Giurgiu</td></tr>
<tr><td colspan="3">Description of the present situation:</td></tr>
<tr><td colspan="3">A narrow channel width is present at rkm 768 during low waters, which cause difficulties for navigation.
Besides, the main river branch is sedimenting and more flow is distributed towards the two other
branches (Romania and Bulgaria; Desa and Dovlek Islands respectively). Although apparently small, a possible source of sediment is the Danube tributary coming from the Bulgarian side discharging at rkm 769-768.
Maintenance of the navigation channel is necessary to assure a minimum width.</td></tr>
<tr><td colspan="3">Proposed works:</td></tr>
<tr><td colspan="3">Harris (1999):
None</td></tr>
<tr><td colspan="3">Alternative Development Strategies (Technum et al., 2008):</td></tr>
<tr><td colspan="3">This critical sector is attached to the next one (Pietrisul Island) and the proposed measures are thought to work for both critical sectors.
The proposed structures at rkm760 and rkm757 (see Critical Sector 5, Pietrisul Island) reduce the flow discharges of secondary branches. No measures are proposed between rkm768 and 764.</td></tr>
<tr><td colspan="3">Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):</td></tr>
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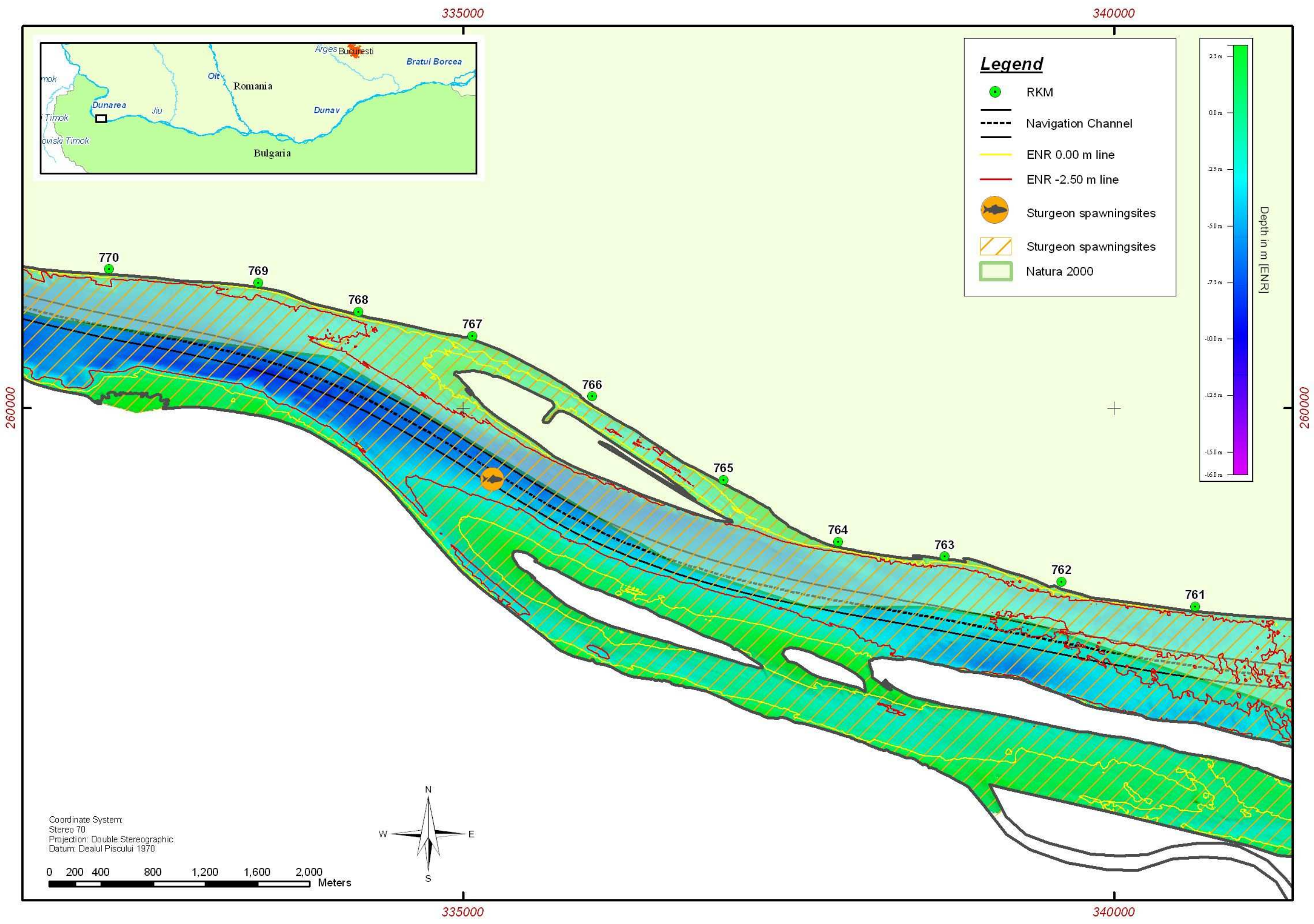

Figure 20: Artchar Present Conditions

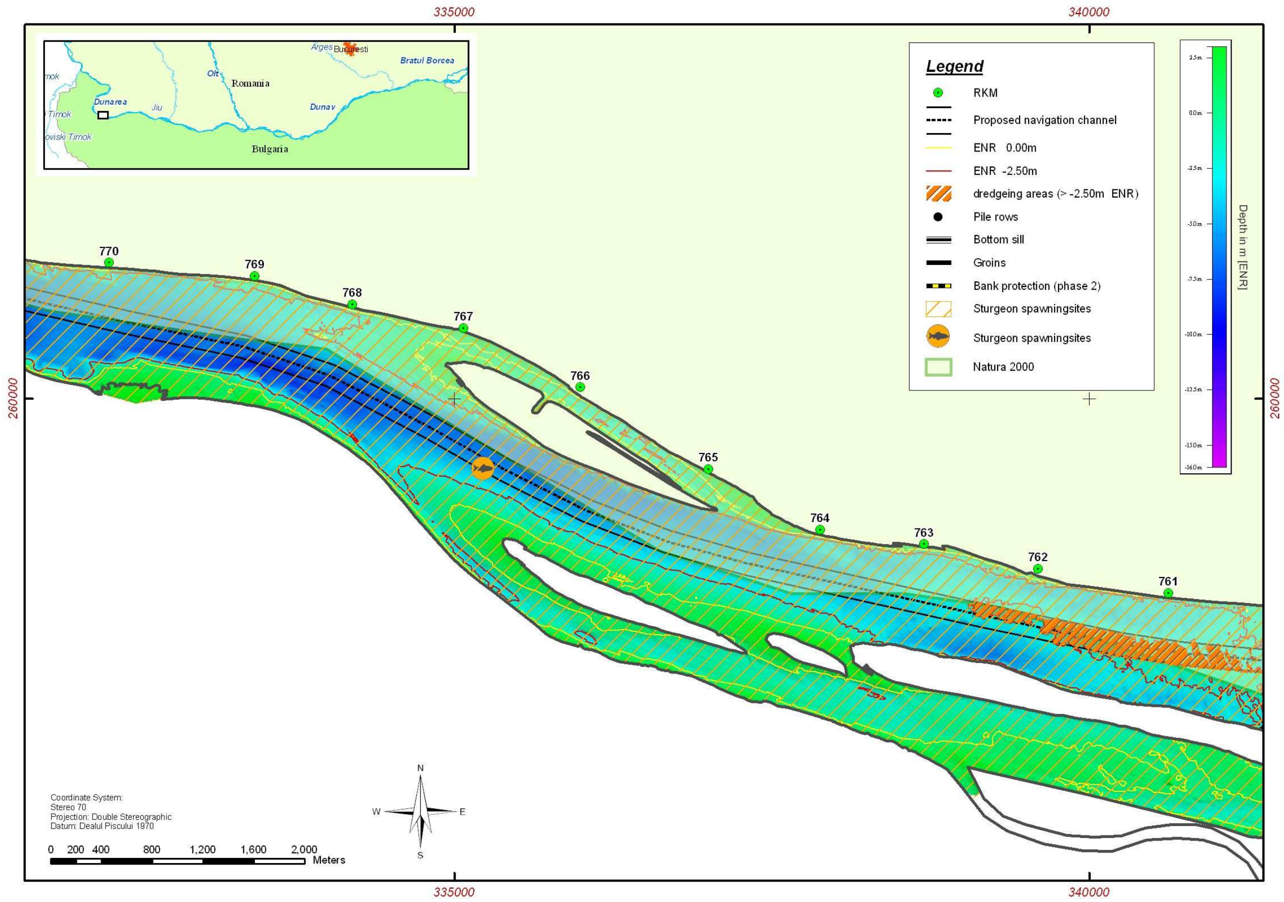

Figure 21: Artchar: Alternative Development Strategy

5. Pietrisul Island (rkm 760-755)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	5
Location:		
Pietrisul Island		
Position:	Danube sector:	
rKm 760-755	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Navigation Directorate • Harris (1999) • AFDJ Giurgiu		
Description of the present situation:		
A bottleneck used to occur regularly at Pietrisul Island. The navigation channel was on the right branch (Bulgarian side) and low flow velocities in the main channel during low flow regimes used to generate sedimentation. These low velocities were insufficient to keep naturally the channel at the required depth and width. Maintenance dredging was then carried out in the last decade, providing a navigation channel of at least 2.5m deep and some 80-100m wide. For all the above, the navigation channel has been moved to the left branch (Romania). At this branch water depths are significant deep and the only difficulty for navigation is a narrow navigation channel width of 150m. The Bulgarian bank is with gravel material and is stable, while the Pietrisul Island presents noticeable erosion at its North side and migration. The river evolution shows a widening of the Romanian branch, which tends to favour the improvement of the present navigation channel on this branch.		
Proposed works:		
Harris (1999): Regarding the Pietrisul Island, the main option is to close the side branch north by means of a bottom sill at rkm759. Bank protection may be required along the Bulgarian and Romanian banks in case bank erosion due to increased flow velocities at the islands becomes too strong.		
Alternative Development Strategies (Technum et al., 2008):		
A capital dredging and realignment of the fairway are needed to assure navigation on the left branch. Due to the fact that the morphological evolution of the river in the last years shows a widening of the Romanian branch (left branch), it is recommended to keep the navigation channel in that branch. The structures at rkm760 (groin) and rkm757 (bottom sill) in the TWS will reduce the flow discharge in the secondary branches. The area is morphologically active and the same measure is proposed in the MS. An option to be considered in the EES is the construction of 2 partial bottom sills. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works; • Keep impact on deep areas as low as possible (spawning sites);		

• Open guiding wall at river bank; • Useful application of dredged material; • Look for alternative measure for the guiding wall at rkm 760, to avoid sedimentation at the spawning site and reduce impact on island (protected area).
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

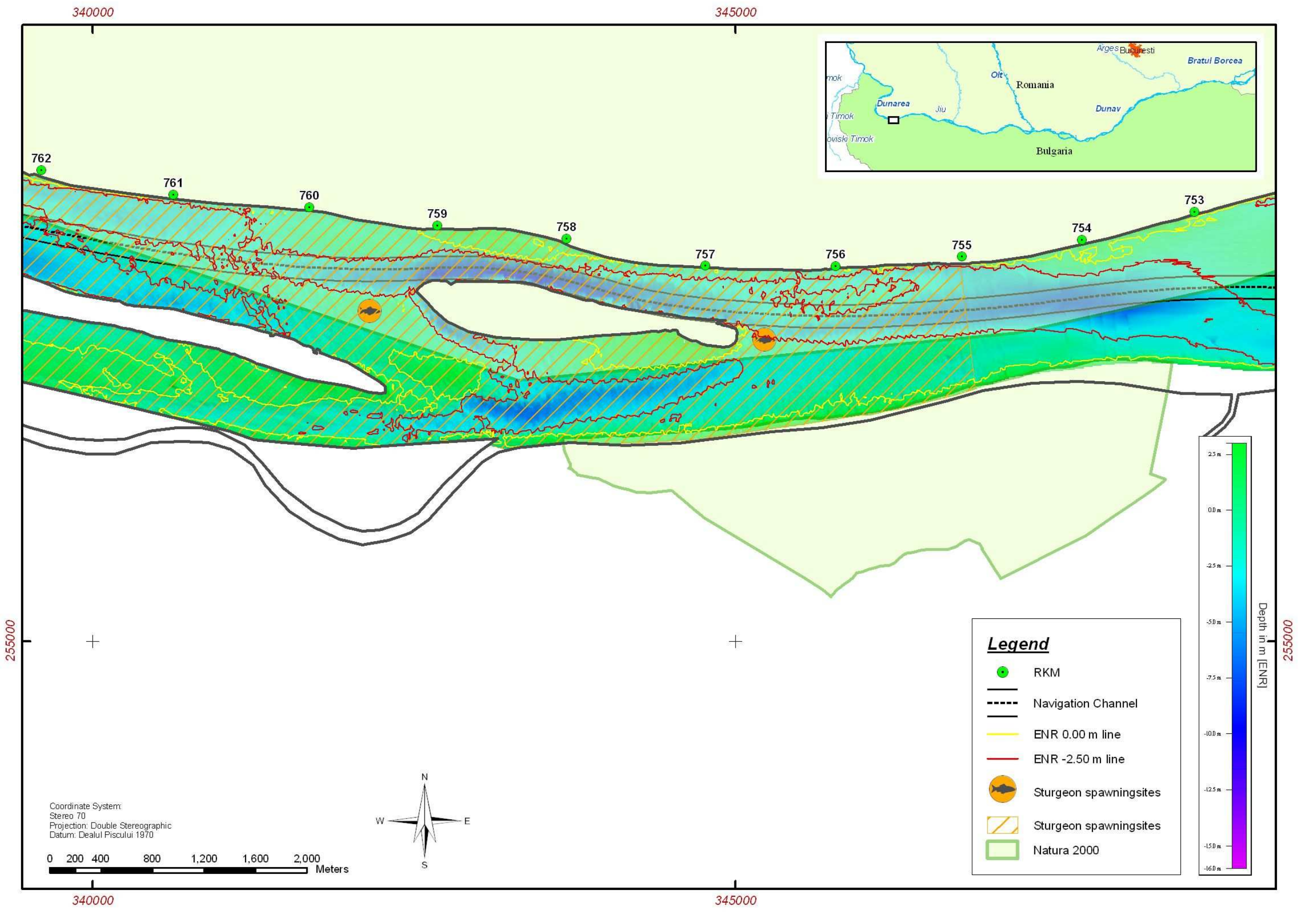

Figure 22: Pietrisul Island Present Conditions

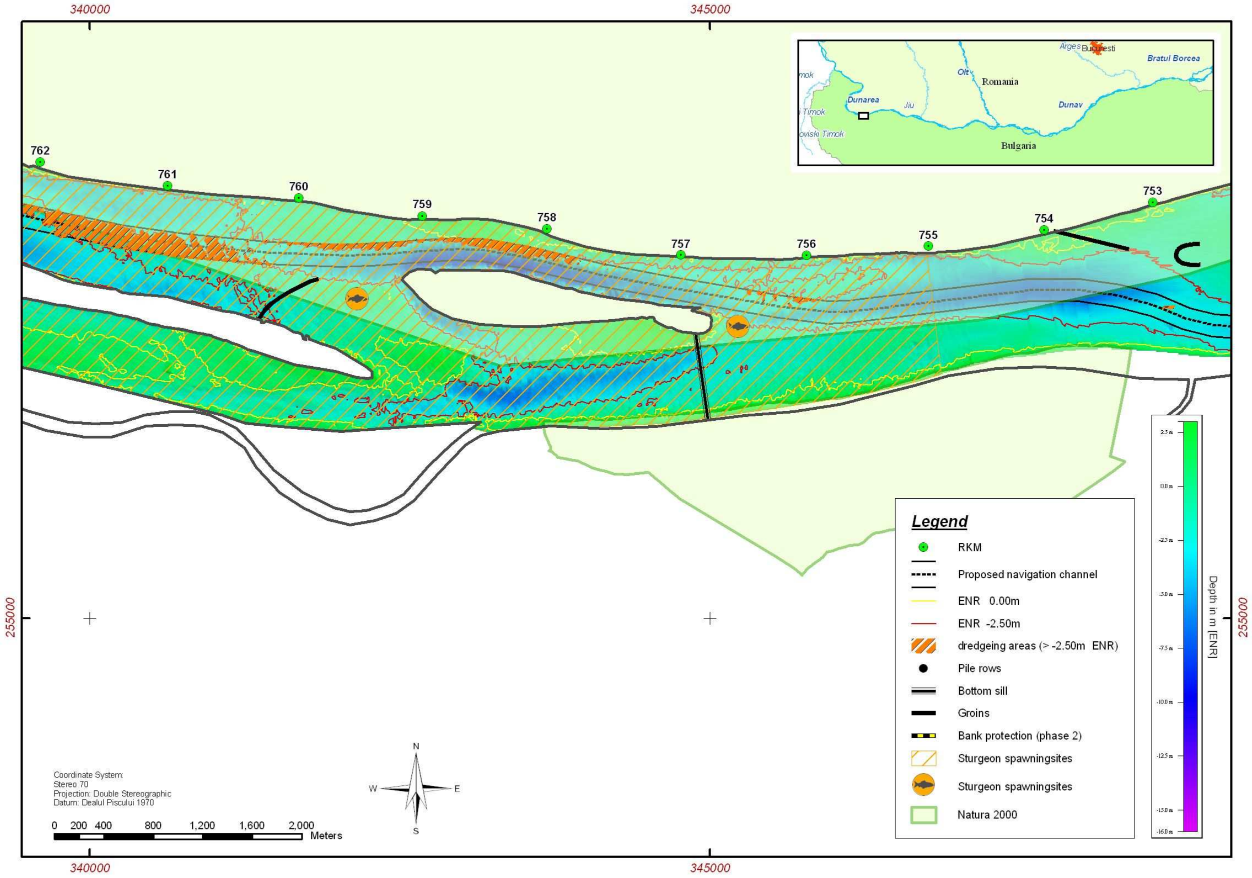

Figure 23: Pietrisul Island Alternative Development Strategy

6. Nebuna Island (rkm 754-748)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	6
Location:		
Nebuna Island		
Position:	Danube sector:	
rKm 760-755	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Navigation Directorate • Harris (1999) • AFDJ Giurgiu		
Description of the present situation:		
At rkm 753-750 the navigation channel is towards the Bulgarian bank due to the Nebuna Island and low water depths nearby. This causes that the minimum radius of curvature is not complied.		
Proposed works:		
Harris (1999): None		
Alternative Development Strategies (Technum et al., 2008):		
It is proposed the realignment of the navigation channel: to comply with the minimum radius of curvature and at the same time keeps dredging volumes to the minimum. In addition a groin and 2 chevrons are proposed in the TWS to redirect the flow towards the right branch, increasing velocities and reducing sediment deposition in the navigation channel. The area is morphologically active and the same measure is proposed in the MS. Other important aspects for the EES and GES, and in general for construction: • Phasing of large training works; • Keep impact on deep areas as low as possible; • Open guiding wall at river bank;		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):		

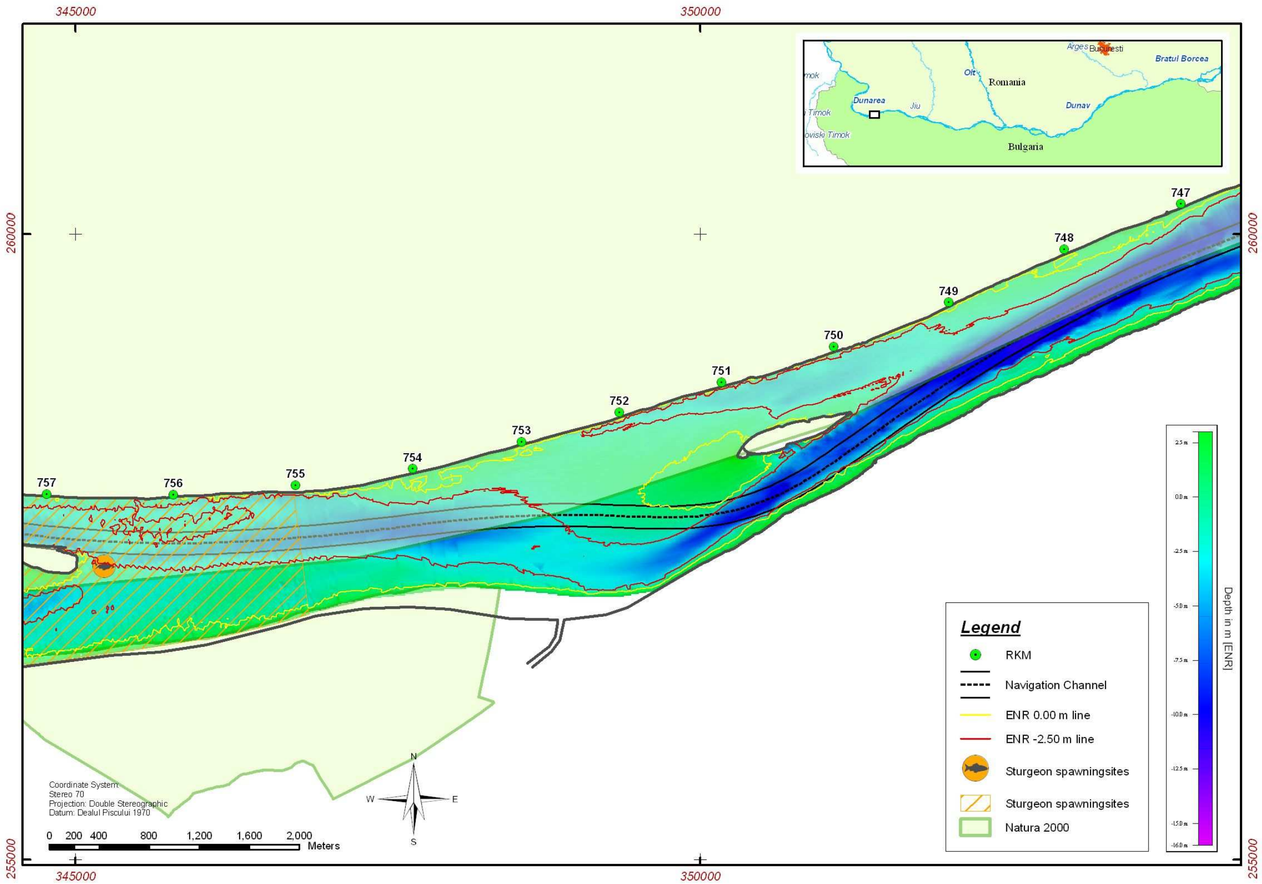

Figure 24: Nebuna Island Present Conditions

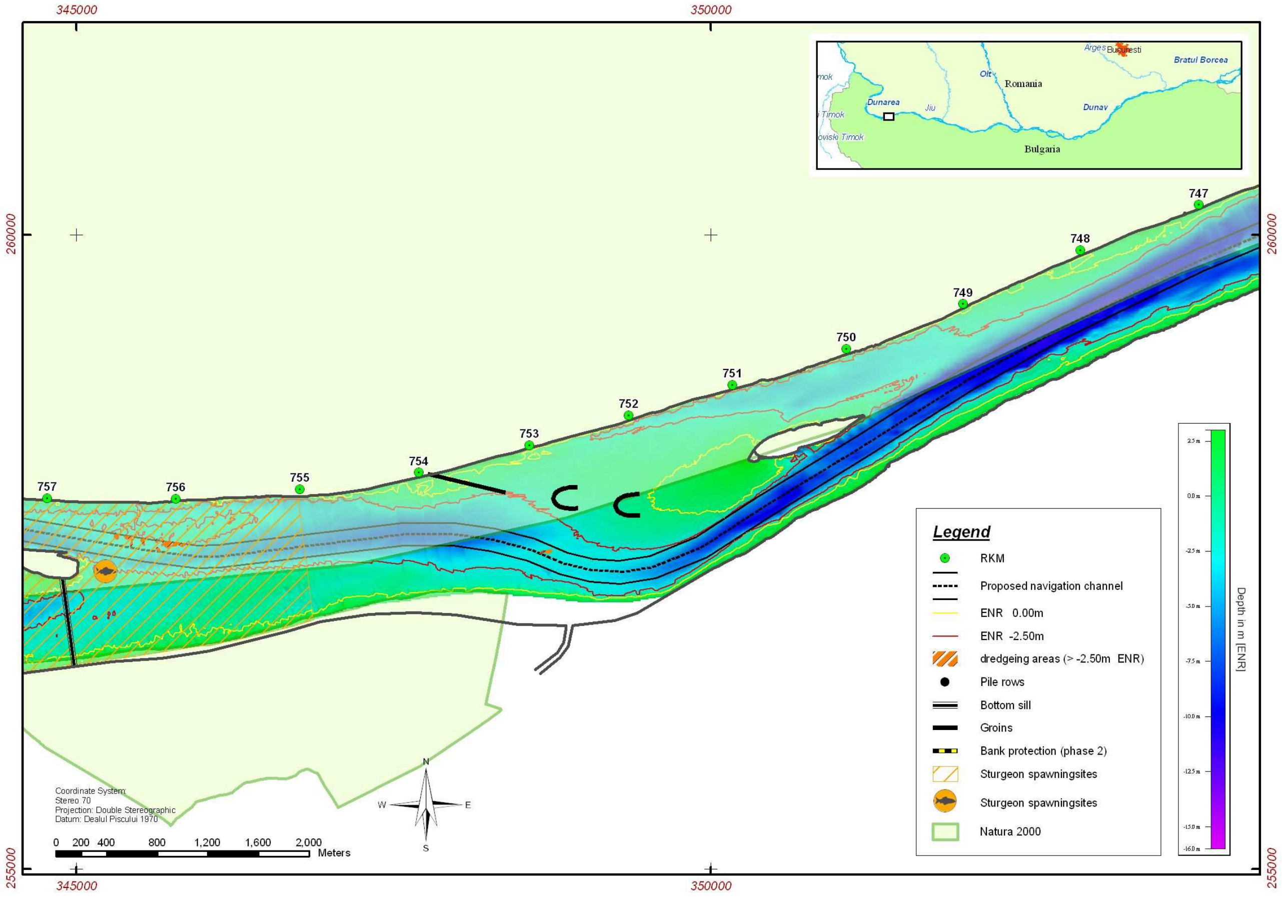

Figure 25: Nebuna Island Alternative Development Strategy

7. Lom – Linovo Island (rkm 745-735)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	7
Location:		
Lom – Linovo Island		
Position:	Danube sector:	
rKm 745-735	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Navigation Directorate • AFDJ Giurgiu		
Description of the present situation:		
At this location, the river is relatively wide. Due to the decreasing in flow velocities, an emerging sand bar occurs at rkm 739-738 and the depth and width of the navigation channel do not always meet the required criteria. At the same time, the sediment discharged by the Lom River can be noticed on the bathymetry with shallower waters on the right bank near rkm 741. On the other hand, the right bank of the Danube is eroding between rkm 739-738. Another morphological active area in the sector is between rkm 744-743. At this location, the Romanian bank is having significant erosion, together with the north side of the sand bar. Although this branch of the river is not used for navigation, this branch is getting active and taking more flow; bathymetry can reach values of up to 10m deep at some locations. The south side of the sand bar is sedimenting.		
Proposed works:		
Harris (1999): To narrow the flow area and consequently increase the channel depth, it is proposed to construct two groins at the left bank upstream of Linovo Island. A bottom sill may also be envisaged.		
Alternative Development Strategies (Technum et al., 2008):		
The realignment of the fairway reduces the dredging volumes. Besides, groins and a bottom sill are proposed (TWS). The groins at the wide cross sections of the river will increase flow velocities and reduce sedimentation. The bottom sill reduces the flow discharge of the secondary branch. The area is morphologically active and the same measure is proposed in the MS. An option to be considered in the EES is the construction of 2 partial bottom sills instead of one, and L-head groins with openings at the bank. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works;		

• Keep impact on deep areas as low as possible (spawning sites); • Open guiding wall at river bank; • Less groins but with wing; • Useful application of dredged material;
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

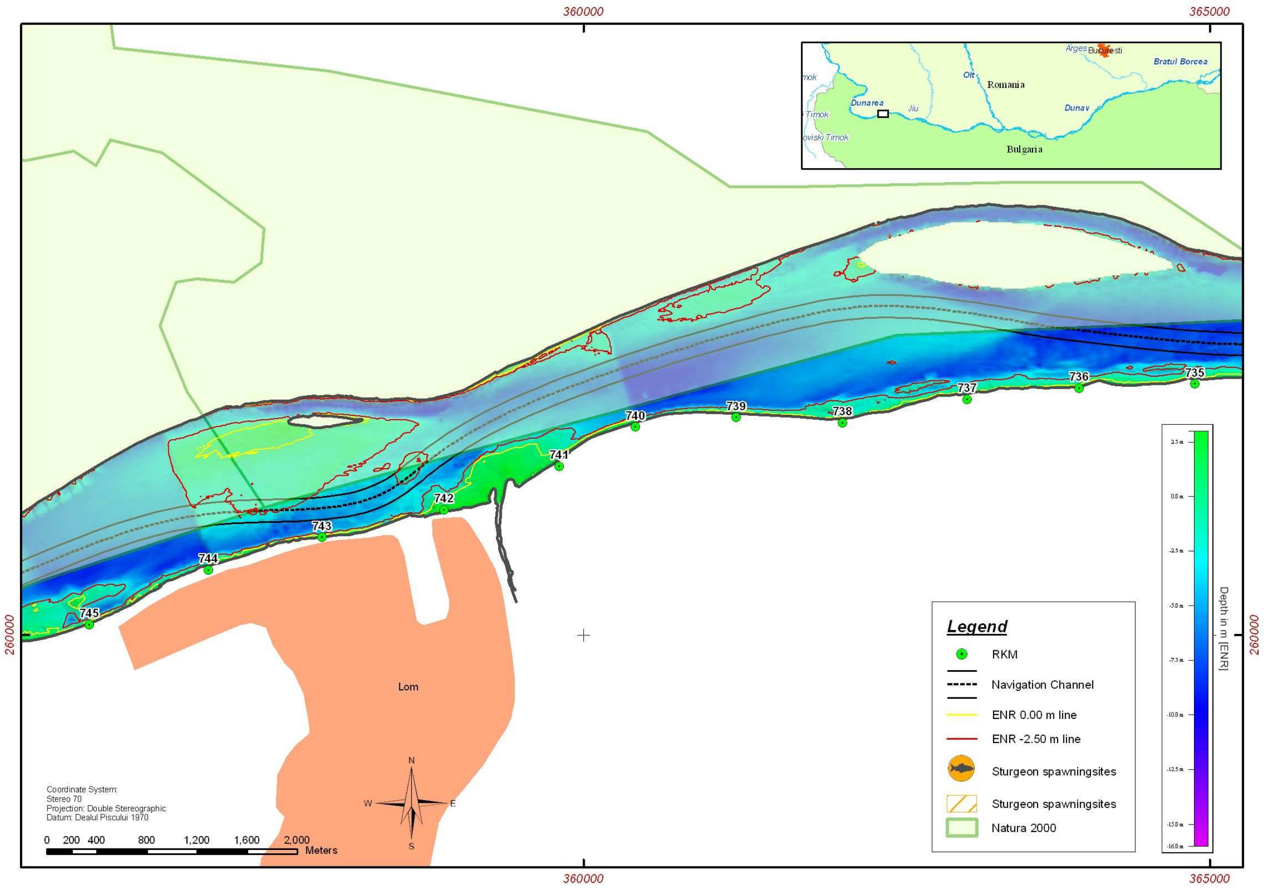

Figure 26: Lom – Linovo Island Present Conditions

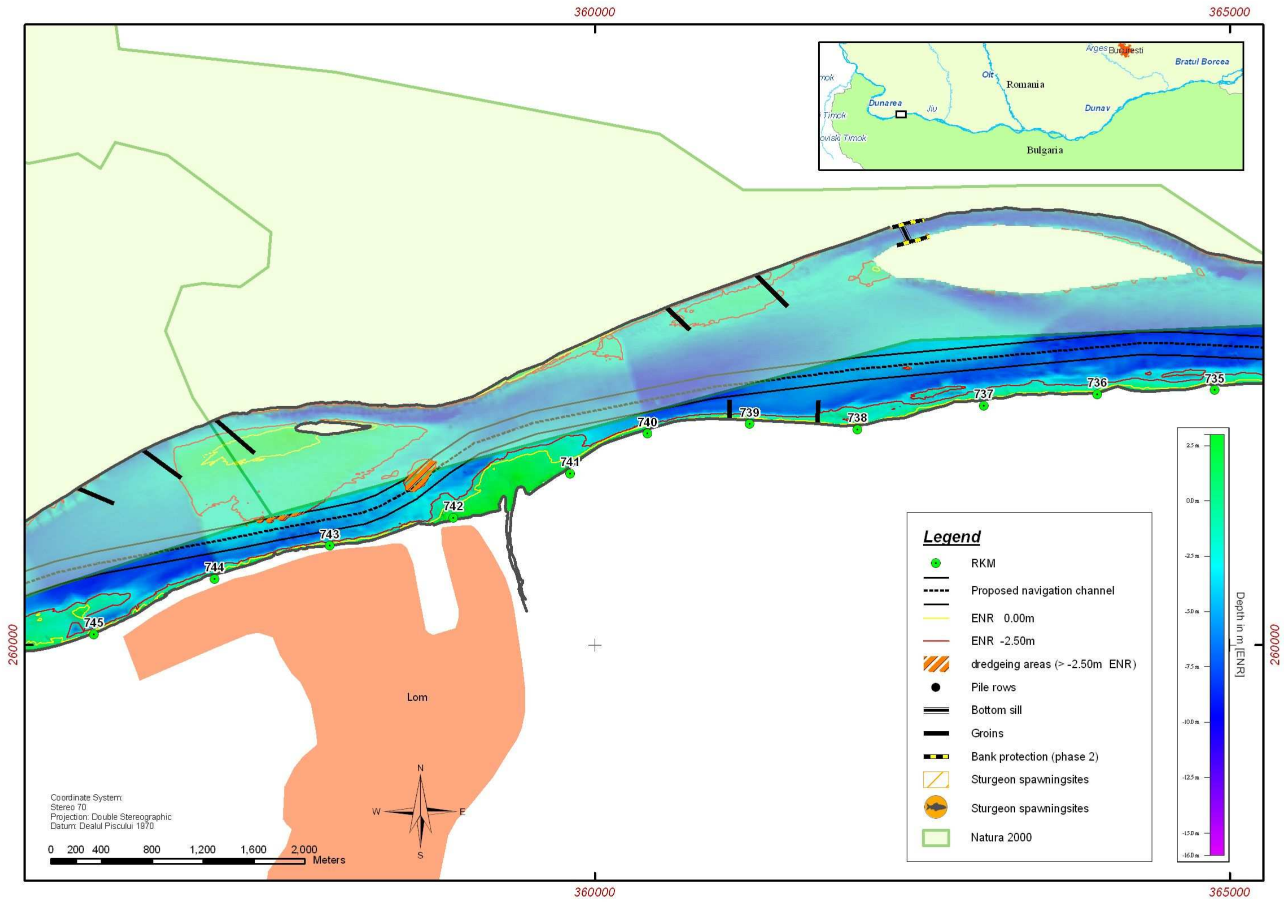

Figure 27: Lom – Linovo Island Alternative Development Strategy

8. Archar Outlet - Alimanu (rkm 728-721)

<table>
<tr><td rowspan="2"></td><td>Last update of this sheet:</td><td>18/09/08</td></tr>
<tr><td>Critical Sector Number:</td><td>8</td></tr>
<tr><td colspan="3">Location:</td></tr>
<tr><td colspan="3">Archar Outlet - Alimanu</td></tr>
<tr><td>Position:</td><td colspan="2">Danube sector:</td></tr>
<tr><td>rKm 728-721</td><td colspan="2">Common Romanian – Bulgarian sector
rKm 610 - 845.5</td></tr>
<tr><td colspan="3">Sector for detail measurements:</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Critical point reported by:</td></tr>
<tr><td colspan="3">• AFDJ Giurgiu</td></tr>
<tr><td colspan="3">Description of the present situation:</td></tr>
<tr><td colspan="3">Due to sediments in the middle of the riverbed, it is very difficult to bound the navigable channel.
The navigable depth is less than 2.5 m at some periods of the year.
The south side of the Tibar Island between rkm 719-718 has a shallow bathymetry causing the relocation of the navigation channel towards the Bulgarian bank of the river. There are robust and very long bank protection works at this location in Bulgarian territory.
There are also active sand bars in the middle of the Danube between rkm 728-721 which made move the navigation channel from the right to the left bank. Regardless the morphological changes which require monitoring and relocation of the axis of the navigation channel, there are no difficulties for navigation.</td></tr>
<tr><td colspan="3">Proposed works:</td></tr>
<tr><td colspan="3">Harris (1999):
None</td></tr>
<tr><td colspan="3">Alternative Development Strategies (Technum et al., 2008):</td></tr>
<tr><td colspan="3">There are no significant changes in the axis of the navigation channel in this area. The structures proposed in TWS aim to concentrate the flow in the center of the river and reduce sediment deposition in the navigation channel. The area is morphologically active and the same measures of the TWS are proposed in the MS.
Other important aspects for the EES and GES, and in general for construction:
• Phasing of dredging to take into account fish spawning/migration;
• Phasing of large training works;
• Keep impact on deep areas as low as possible;
• Open guiding wall at river bank;
• Less groins but with wing;
• Useful application of dredged material.</td></tr>
<tr><td colspan="3">Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):</td></tr>
</table>

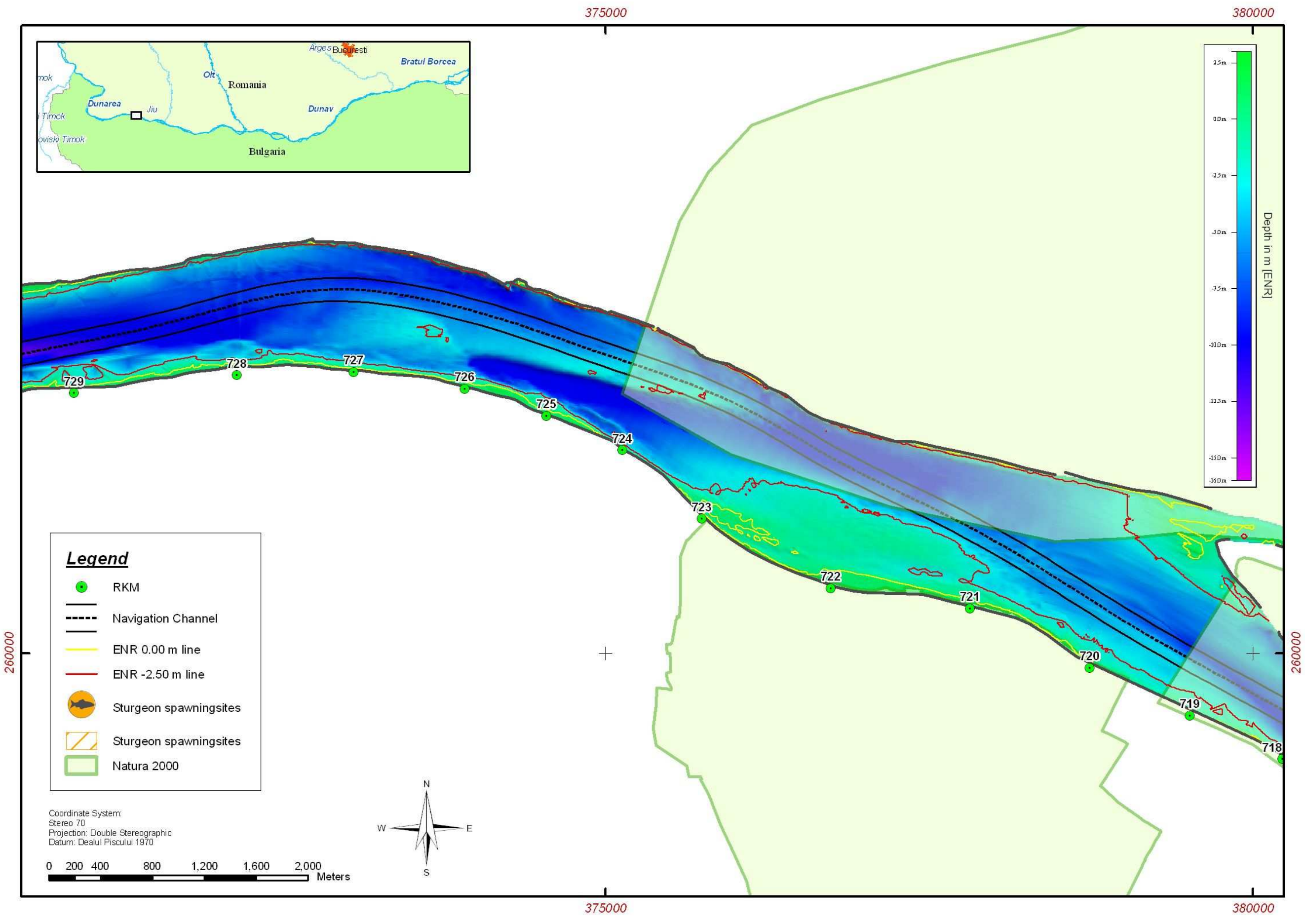

Figure 28: Archar Outlet - Alimanu Present Conditions

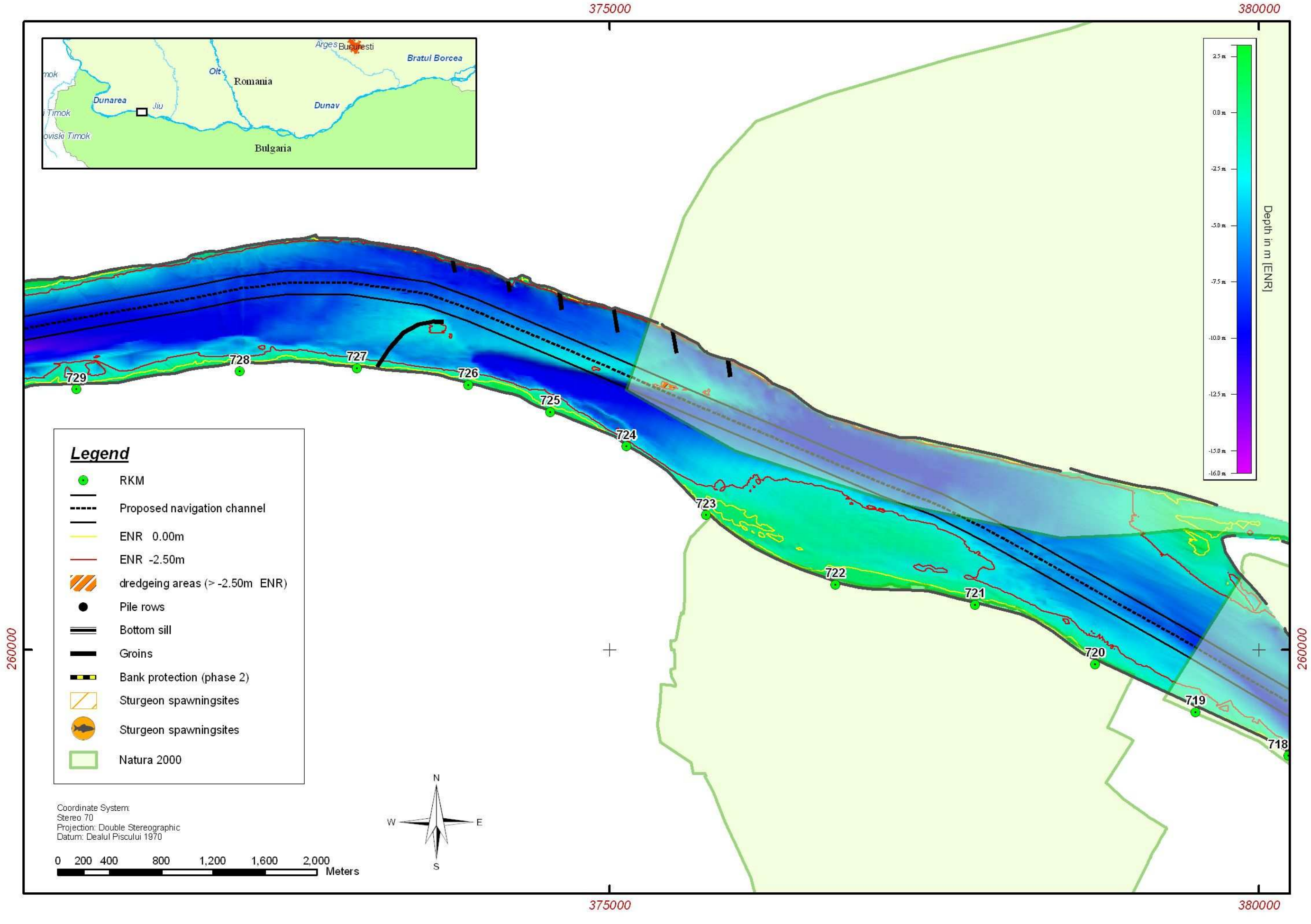

Figure 29: Archar Outlet - Alimanu Alternative Development Strategy

9. Kozlodui and Kopanita Islands (rkm 705-687)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	9
Location:		
	Kozlodui and Kopanita Islands	
Position:	Danube sector:	
rkm 705+300-696 and rkm696+700-687+400	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• AFDJ Galati		
Description of the present situation:		
Outlet of Jiu River. There are numerous islands and river bifurcations at this location. There are also sand bars at rkm 702 on Romanian side. There are no difficulties for navigation at present.		
Proposed works:		
Harris (1999): None		
Alternative Development Strategies (Technum et al., 2008):		
Regardless the numerous river branches, the last bathymetry of 2008 confirms no difficulties for navigation in the sector. Furthermore, a slight realignment of the navigation channel avoids the necessity of dredging. No measures are proposed in this area.		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):		

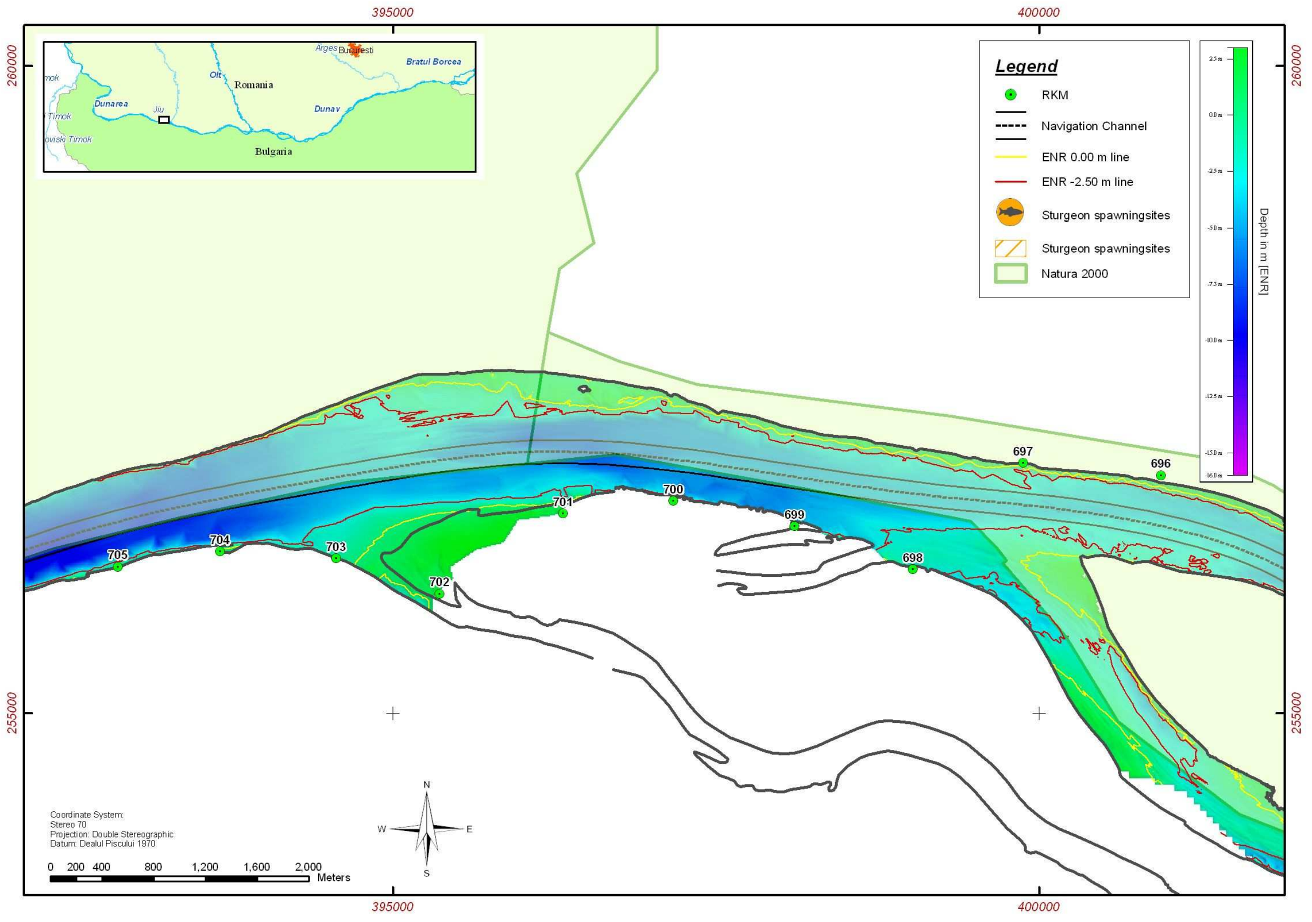

Figure 30: Kozlodui and Kopanita Islands Present Conditions A

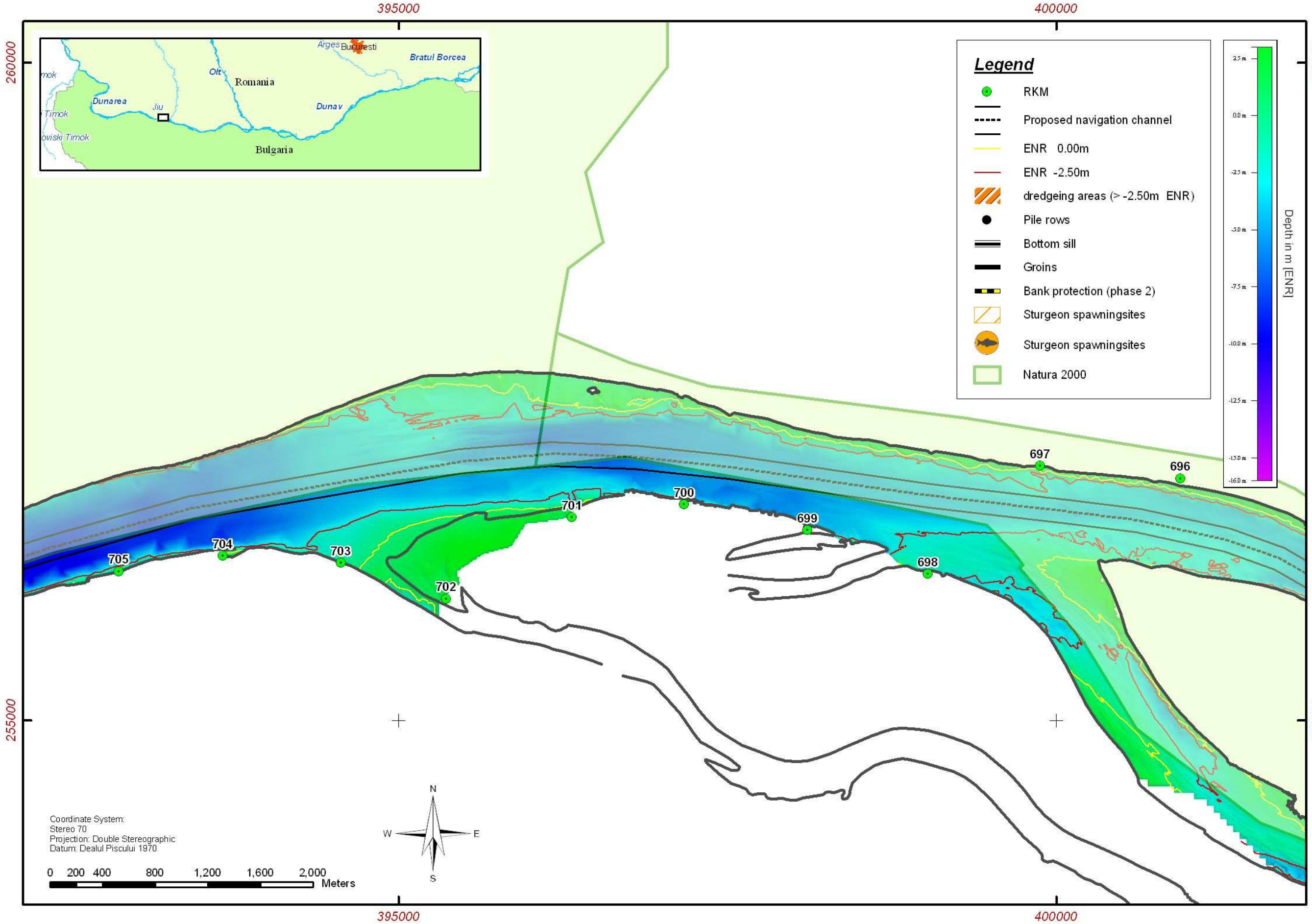

Figure 31: Kozlodui and Kopanita Islands Alternative Development Strategy A

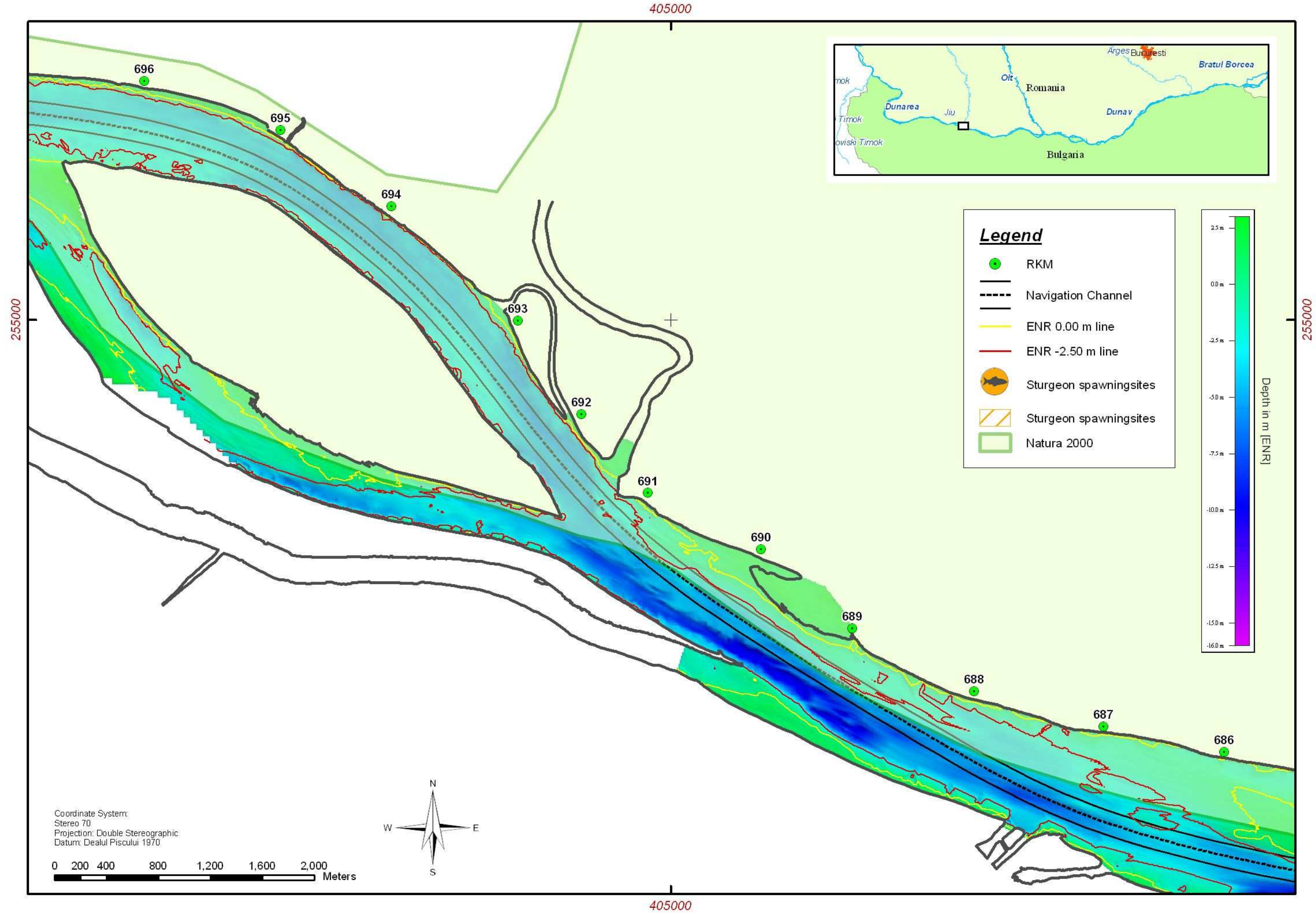

Figure 32: Kozlodui and Kopanita Islands Present Conditions B

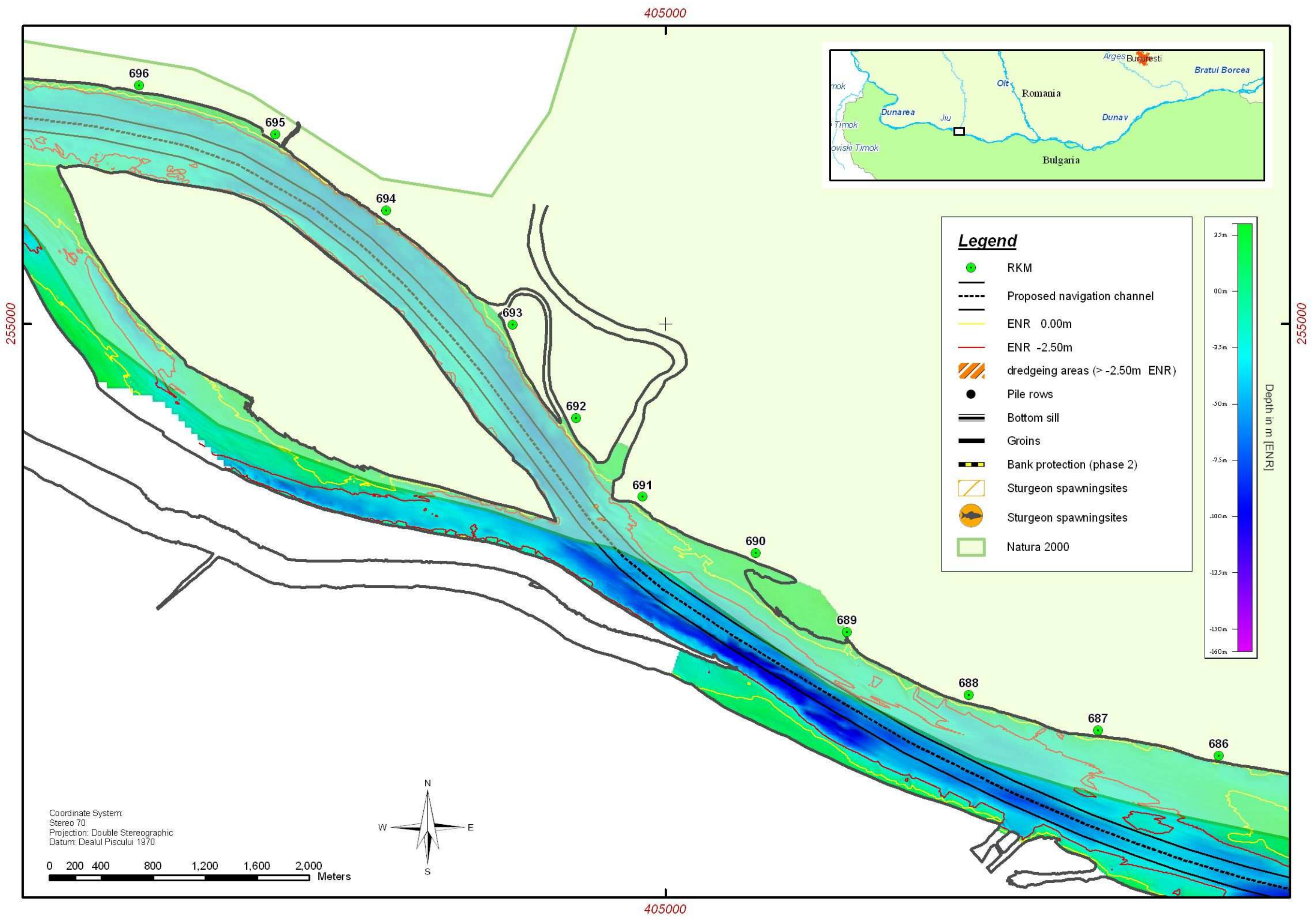

Figure 33: Kozlodui and Kopanita Islands Alternative Development Strategy B

10.Carabulea: Bechet / Oriahovo (rkm 679-673)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	10
Location:		
Carabulea: Bechet / Oriahovo		
Position:	Danube sector:	
rKm 679-673	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Navigation Directorate • Harris (1999)		
Description of the present situation:		
At this location, the Danube is wider compared to surrounding areas, resulting in decreased flow velocities and hence shallow and narrow sections regularly occurring. Flow is diverted in two branches due to a sand bar in the river emerging during low river flows. At the present the north branch has significant flow and the navigation channel has been relocated through it, due to the fact that the former navigation channel at the south branch is too shallow for navigation. Although the navigation channel has been already at the north branch for around 10 years, its width does not comply the minimum requirements of 180m and authorities responsible for navigation would like to recover the south branch for navigation. The sand bar at rkm 671-670 is morphological active and is growing upstream. Similarly, the sand bar attached to the north of Papadia Island at rkm 668 is also growing towards upstream. At rkm 687 there is a flow discharge to the Danube from a nuclear power plant in Bulgarian territory.		
Proposed works:		
Harris (1999): It is proposed to construct a groin / bottom sill in the side branch at rkm 677. If this solution would prove to be insufficient, a parallel training wall may have to be constructed on top of the mentioned sand bar.		
Alternative Development Strategies (Technum et al., 2008):		
The latest bathymetry of 2008 shows the possibility to relocate the navigation channel back to the south branch with no difficulties to comply with the required width of the navigation channel. The new fairway could be moved further to the north at rkm673, reducing the radius of curvature. The structures proposed in the TWS (one groin, two chevrons and bank protection) aim to redirect the flow towards the south branch and reduce sedimentation in it. The area is morphologically active and the same measure is proposed in the MS. Other important aspects for the EES and GES, and in general for construction:		

• Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works; • Keep impact on deep areas as low as possible; • Open guiding wall at river bank; • Useful application of dredged material; • Reduce length of bank protection.
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

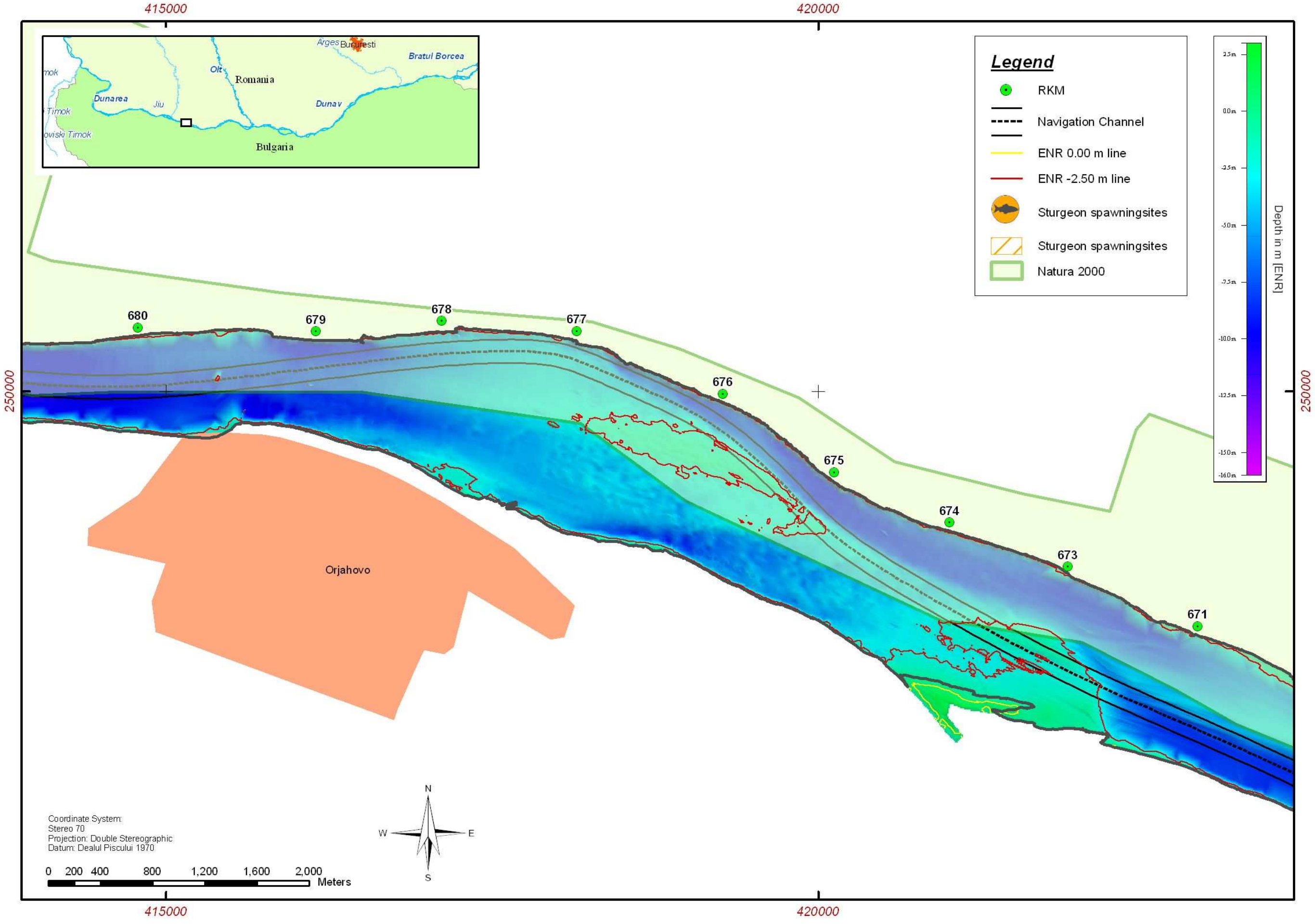

Figure 34: Carabulea: Bechet / Oriahovo Present Conditions

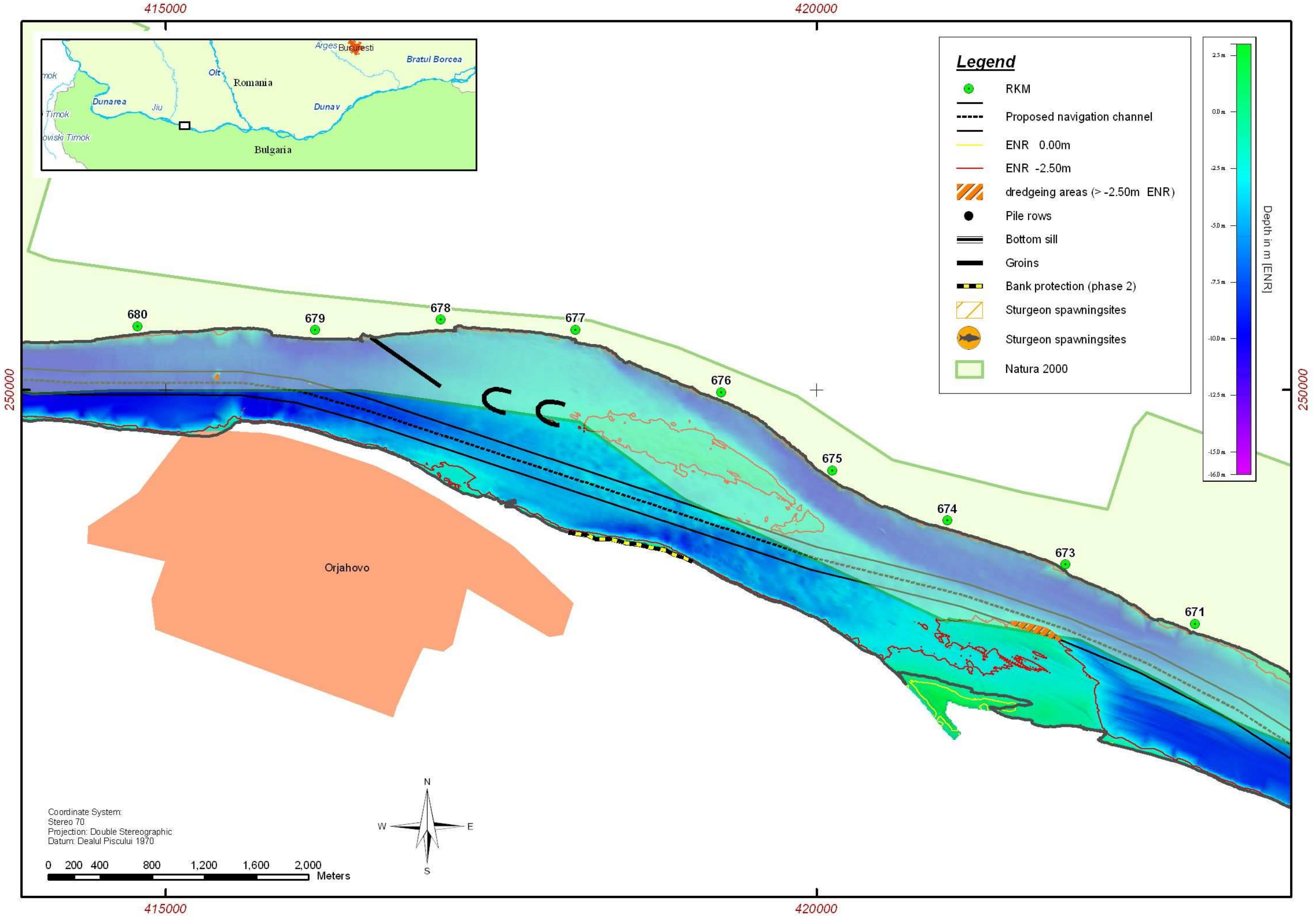

Figure 35: Carabulea: Bechet / Oriahovo Alternative Development Strategy

11. Ostrov (rkm 668-666)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	11
Location:		
Ostrov		
Position:	Danube sector:	
rKm 668-666	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Navigation Directorate		
Description of the present situation:		
Inactive critical point. There is a shipwreck at rkm 667.		
Proposed works:		
Harris (1999): Groins		
Alternative Development Strategies (Technum et al., 2008):		
The realignment of the navigation channel avoids the necessity of dredging. No measures are proposed in this area.		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):		

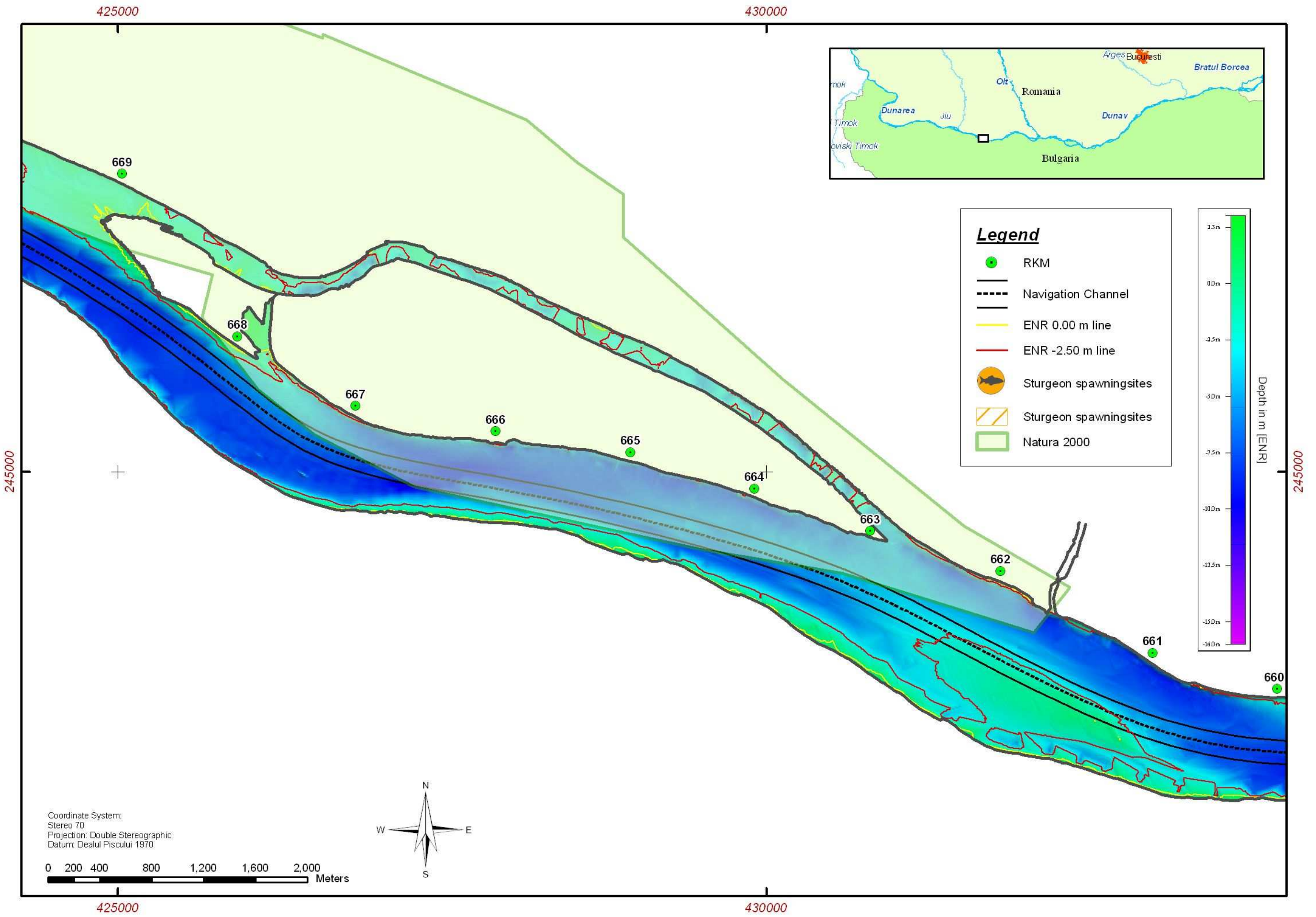

Figure 36: Ostrov Present Conditions

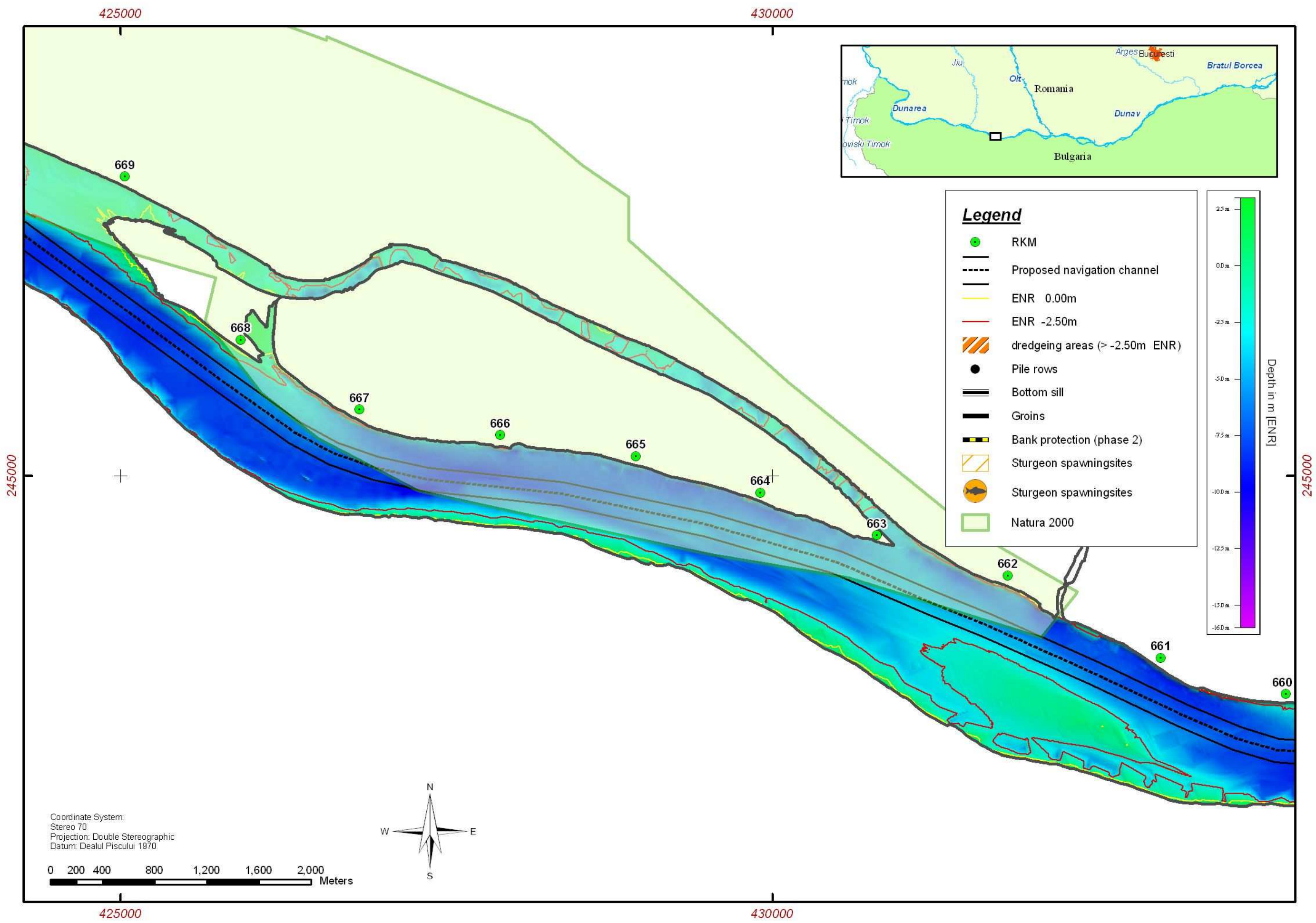

Figure 37: Ostrov Alternative Development Strategy

12. . Corabia – Baloiu branch (rkm 633-625)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	12
Location:		
Corabia – Baloiu branch (Bulgarian)		
Position:	Danube sector:	
rKm 633 – 625	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Harris (1999) • AFDJ Giurgiu		
Description of the present situation:		
At this location, the Danube has a pronounced braiding character resulting in a very large distance between both banks and a number of sand bars and small islands are present in the river. The result of this is that shallow and narrow passages regularly occur in the main navigation channel, which is along the Romanian bank. Navigation is happening at this location without problems at the moment; however, there were difficulties around two years ago with the sand bar at the beginning of the island (rkm 629) obstructing the navigation channel. The existence of rocks at the head of the island protect it from erosion and is in fact stable at the moment. The sand bar at rkm 632-631 (close to the Romanian bank) is morphological active and is moving downstream. Bulgaria has big bank protection between rkm 633-631.		
Proposed works:		
Harris (1999): It is important that the navigation channel is kept along the deeper, outer river bend at the Romanian river bank. The first option the extension of the parallel training wall from Baloiu Island, of which already one kilometre has been built. A bottom sill may also be envisaged at the Bulgarian river bank, connecting the bank with the training wall. Further, bank protection will be required on the left bank of the river to prevent bank erosion.		
Alternative Development Strategies (Technum et al., 2008):		
This is the critical sector with the highest dredging volumes (around 1 million m3 for the TWS) to obtain the required depth for navigation. The fairway is kept along the deeper branch at the Romanian river bank, and one groin and two chevrons are proposed in the TWS. These structures concentrate the flow at the center of the river and redirect it towards the left branch. Special attention should be taken during the design of the groin and chevrons to avoid the erosion of the head of island at rkm629-626 and bank protection might be necessary on the left bank in a second construction phase. The area is morphologically active and the same measures are proposed in the MS.		

Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works; • Keep impact on deep areas as low as possible; • Open guiding wall at river bank; • Useful application of dredged material; • Reduce length of bank protection.
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

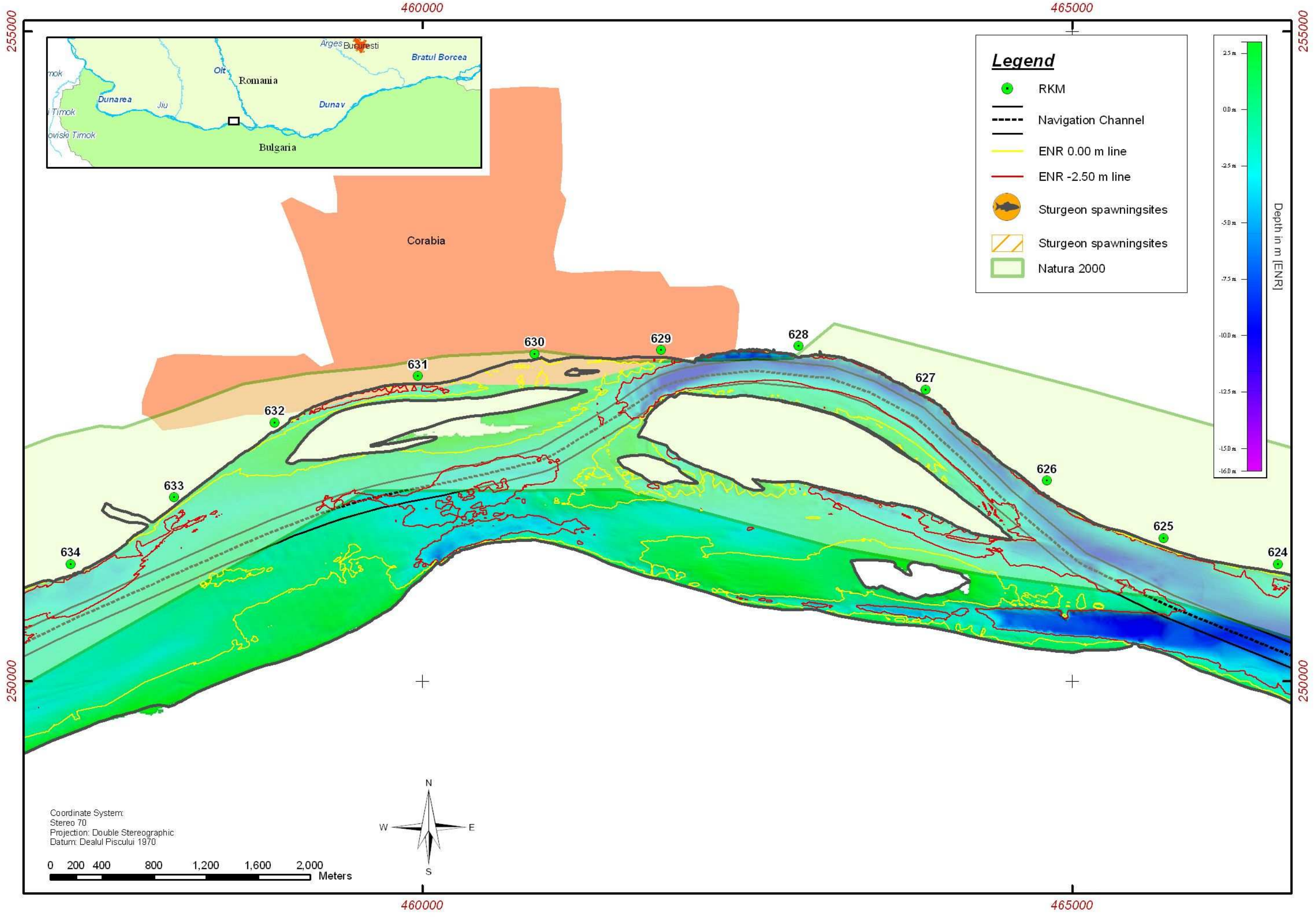

Figure 38: Corabia – Baloiu branch (Bulgarian) Present Conditions

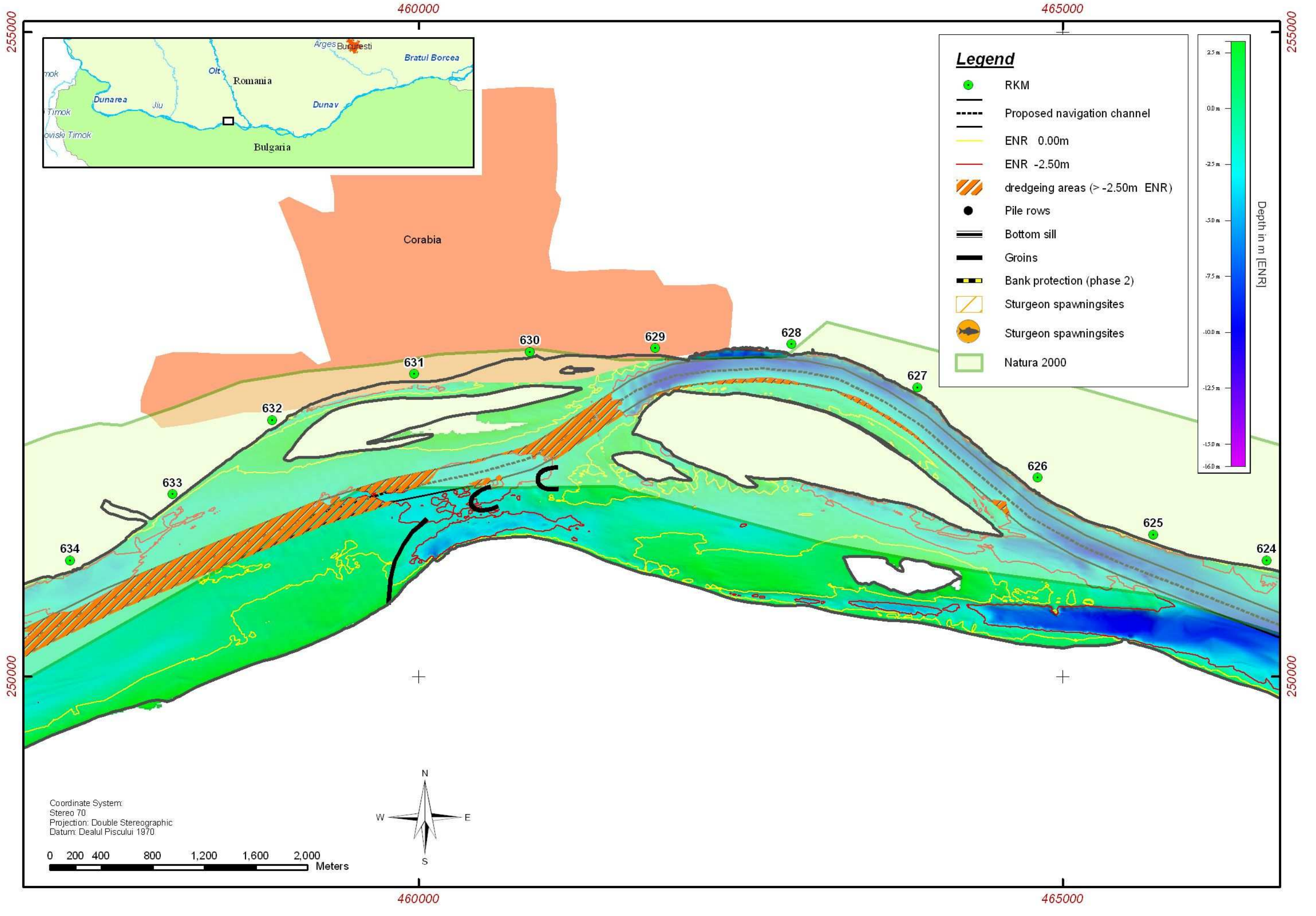

Figure 39: Corabia – Baloiu branch (Bulgarian) Alternative Development Strategy

13.Kalnovats (rkm 615-607)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	13

Location:

Kalnovats

Position:	Danube sector:
rKm 615-607	Common Romanian – Bulgarian sector rKm 610 - 845.5

Sector for detail measurements:

Critical point reported by:

- Navigation Directorate
- Harris (1999)

Description of the present situation:

The Calnovat Island divides the Danube in a main channel and a left side branch. Because the side branch attracts part of the flow, the resulting flow velocities in the main channel during low flow regimes are insufficient to continuously keep the navigation channel at the required depth and width.
The axis of the navigation channel has been moved since 5-6 years from the right side of the sand bar at rkm 611-610 to its left side between the south side of the Calnovat Island and the sand bar.
There is a sand bar forming at rkm 611 at the location of the former navigation channel.
There is also a sand bar around rkm 608 on the north side of the navigation channel.
Bulgaria has a strong bank protection along rkm 612-610.

Proposed works:

Harris (1999):
It is proposed to increase the flow in the main channel thanks to a bottom sill in the side branch north of Calnovat island.
To prevent bank erosion, protection will be required on the right bank of the river.
The width of the channel may also be constricted by goynes along the southern bank of Calnovat Island (between rkm 612 and 607) at a distance between them of 800m.

Alternative Development Strategies (Technum et al., 2008):

Dredging is needed to obtain the required depth for navigation. Besides, training works are proposed at the left bank on rkm612 to concentrate the flow in a smaller cross section and reduce the sedimentation of the sand bar in the fairway. An alternative solution, such as pile rows, is proposed in the TWS; these structures work like permeable groins reducing flow velocities nearby inducing sedimentation. The area is morphologically active and the same measures are proposed in the MS.
Other important aspects for the EES and GES, and in general for construction:

- Phasing of dredging to take into account fish spawning/migration;
- Phasing of large training works;

• Keep impact on deep areas as low as possible; • Useful application of dredged material;
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

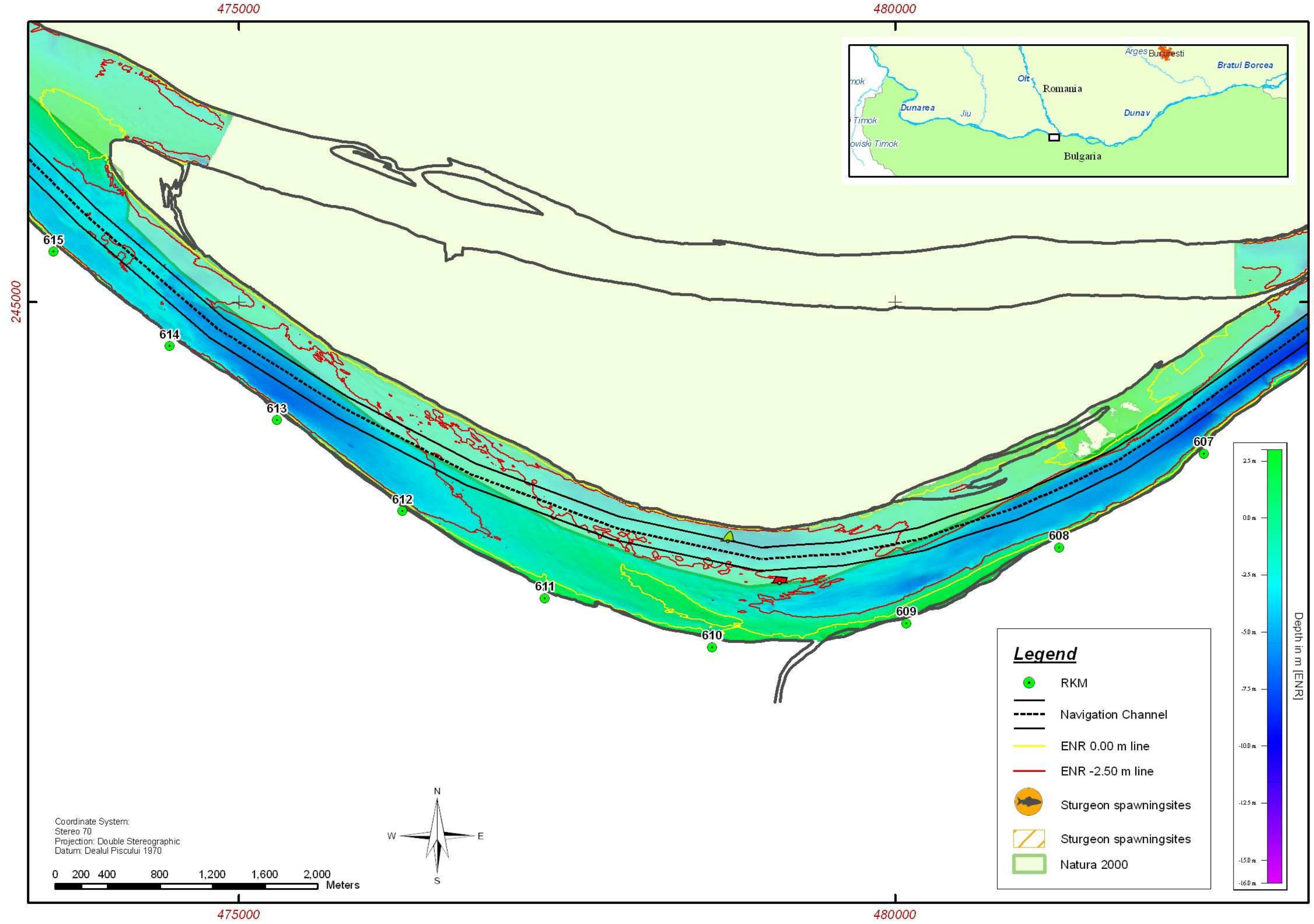

Figure 40: Kalnovats Present Conditions

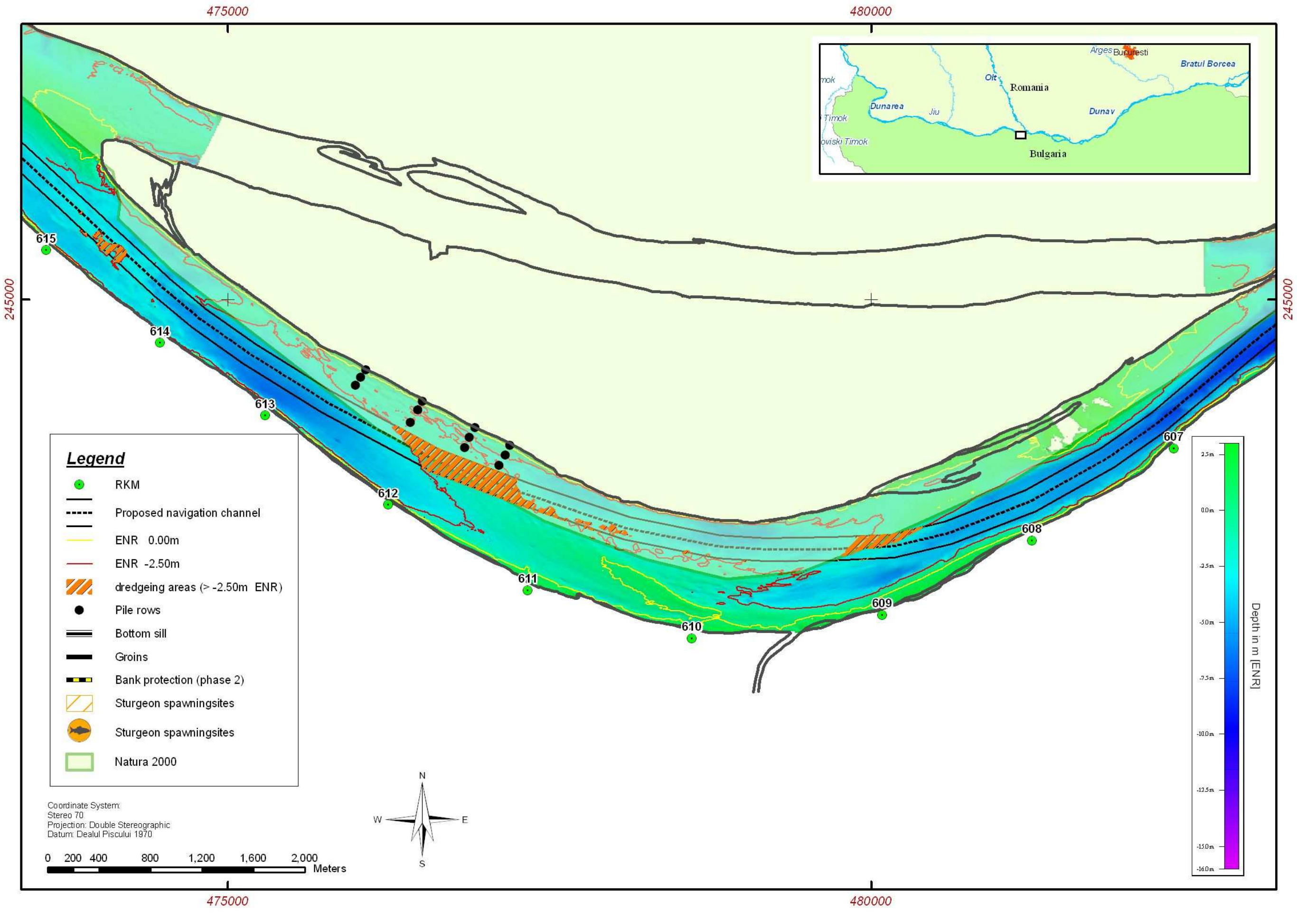

Figure 41: Kalnovats Alternative Development Strategy

14. Lakat/ Paletz Island (rkm 591-581)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	14
Location:		
Lakat/ Paletz Island		
Position:	Danube sector:	
rKm 591 – 581+500	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Navigation Directorate • Harris (1999) • APPD Ruse (Bulgaria)		
Description of the present situation:		
Navigation is restricted by the presence of a sand bars at rkm 590-589 and 586-584, which results in a shallow and narrow navigation channel. The location of the bars and islands is relatively stable. Navigation at this location has only one single navigation line. It has been noted that the navigation channel may be via the right or left branch of the Danube at Lakat Island; in fact the navigation channel was before on the Romanian branch.		
Proposed works:		
Harris (1999): The option at this location is the construction of a bottom sill in the right branch of the river at rkm 590-589. Bank protection will be required at the Romanian side.		
Alternative Development Strategies (Technum et al., 2008):		

Significant dredging volumes (around 0.6 million m3 for the TWS) are needed to obtain the required depth for navigation. The fairway is proposed on the left branch at the Romanian river bank like in the ‘90s according to the “carte de pilotage”. Besides, two bottom sills (rkm590 and rkm586) are proposed in the TWS to concentrates the flow discharge during low water periods on the main branch with the navigation channel. Bank protection upstream and downstream of the bottom sills is needed to assure the stability of the new measures. Bank protection will also be needed along the left bank once this branch receives more flow discharge due to the construction of the bottom sill. The same measures are proposed in the MS. Alternative design of the bottom sills is proposed in the EES, such as two partial bottom sills instead of one per location. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works; • Keep impact on deep areas as low as possible; • Useful application of dredged material; • Reduce length of bank protection; • No bottom sill at small branch (rkm586).
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

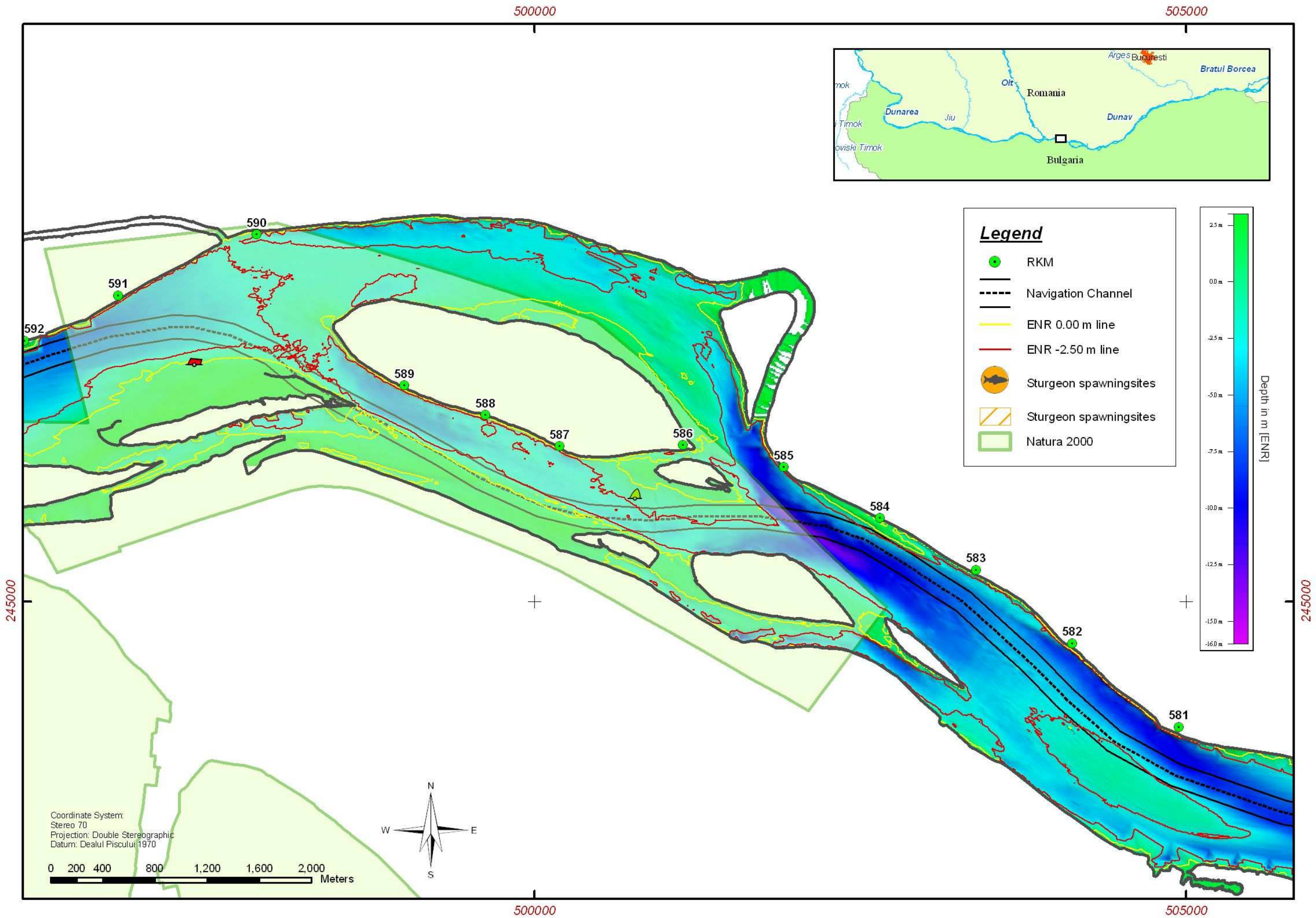

Figure 42: Lakat/ Paletz Island Present Conditions

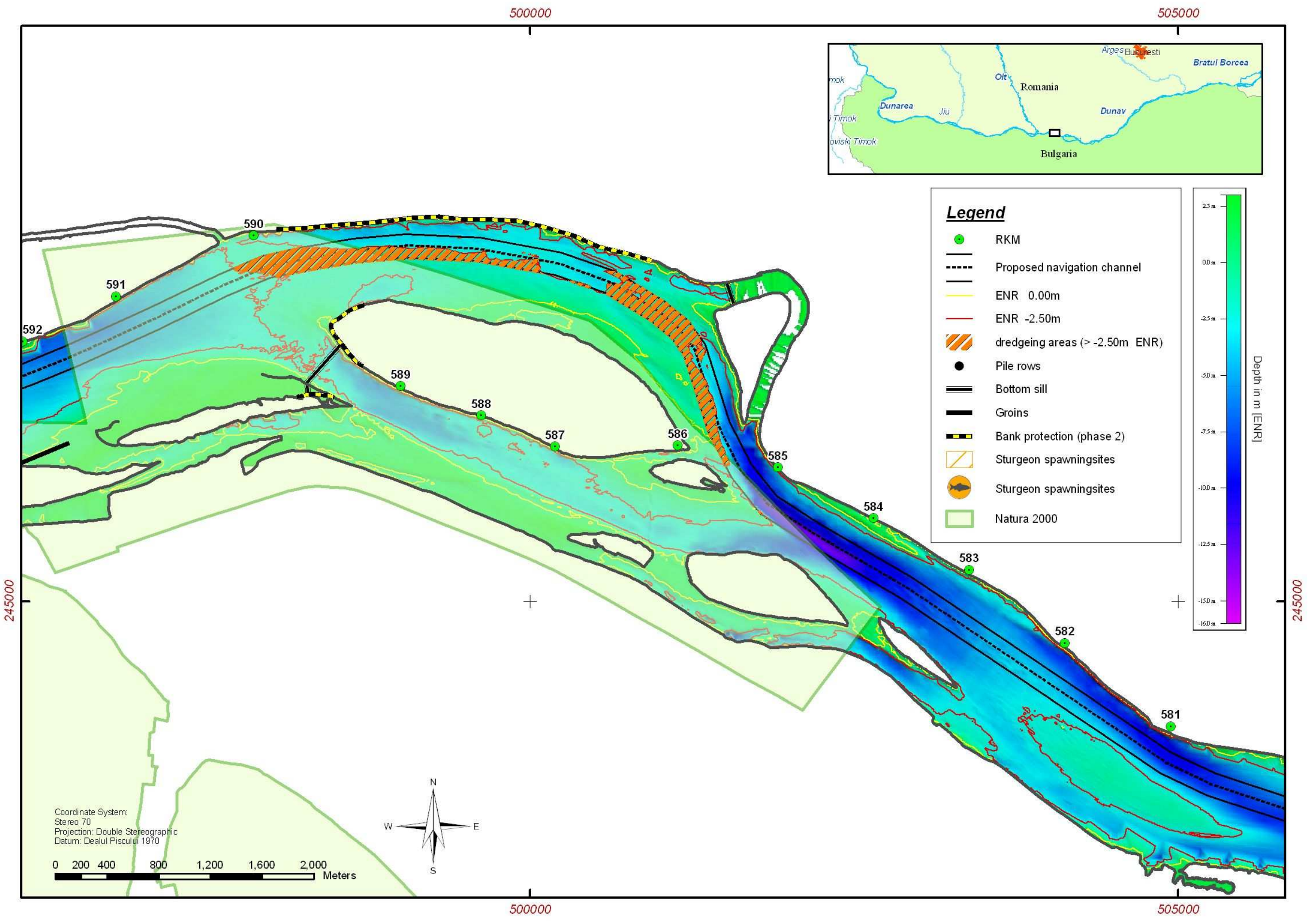

Figure 43: Lakat/ Paletz Island Alternative Development Strategy

15. Belene Island upstream (rkm 577-560)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	15
Location:		
Belene Island upstream		
Position:	Danube sector:	
rKm 577 - 560	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Navigation Directorate • Harris (1999) • APPD Ruse (Bulgaria)		
Description of the present situation:		
This passage is one of the most severe navigational bottlenecks on the Danube river in Bulgaria and Romania. The main channel has a braiding character, with a number of small islands and sand bars, which also migrate. Very shallow (water depths up to 15dm) and narrow sections occur frequently. The width at low water is restricted to only 40-60m. Only one single navigation line is applied at this island. The average duration of periods with at least available depth less than 2.5m is some 80 days with a maximum of 120 days per year. Between rkm 565-561 the navigation channel changes, and with difficulties for navigation during the low water periods (September-October). There are some wrecks at the north bank of Belene Island rkm 571. Besides, there have been already training works at this location in front of Milka Island with little effect. Sedimentation is more pronounced during low water levels. At these periods bathymetry measurements are daily to assure a safe navigation. A nuclear power plant is being built on the Bulgarian branch of Belene Island. Future training works for improvement of navigation have to take into account a minimum flow discharge on this secondary branch for use in the new electrical plant. There is already a dam for water intake in front of the nuclear plant. There is a bottom sill in the southern branch, at rkm567, with a crest level of some 16m Kronstadt level.		
Proposed works:		
Harris (1999): It is proposed to increase the crest level of the existing bottom sill to 18.8m Kronstadt level. Bank protection may be required in this branch. If this is not sufficient, additional groins may be constructed in the main channel, on the right		

bank (rkm 576-573 and rkm 568-566) and on the left bank (565-564 and 562-561).
Alternative Development Strategies (Technum et al., 2008):
Several measures are needed at this critical sector. Besides the realignment of the fairway and dredging, a set of groins, chevrons, bottom sill and bank protection are proposed in TWS. These measures aim to concentrate the flow in the center of the river cross section and reduce the dynamic morphological changes in the area. The area is morphologically active and the same measures are proposed in the MS. The measures proposed in the EES are basically the same than in the TWS, with alternative design of the training works allowing more space for flora and fauna. The significant width of the cross section of the river in this area gives valuable space for special development strategies in the GES. The selection of measures for the GES needs a more detailed study to cover the engineering and environmental aspects in an integral set of measures. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works; • Keep impact on deep areas as low as possible; • Useful application of dredged material; • Two open bottom sills instead of one; • Reduce length of bank protection;
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

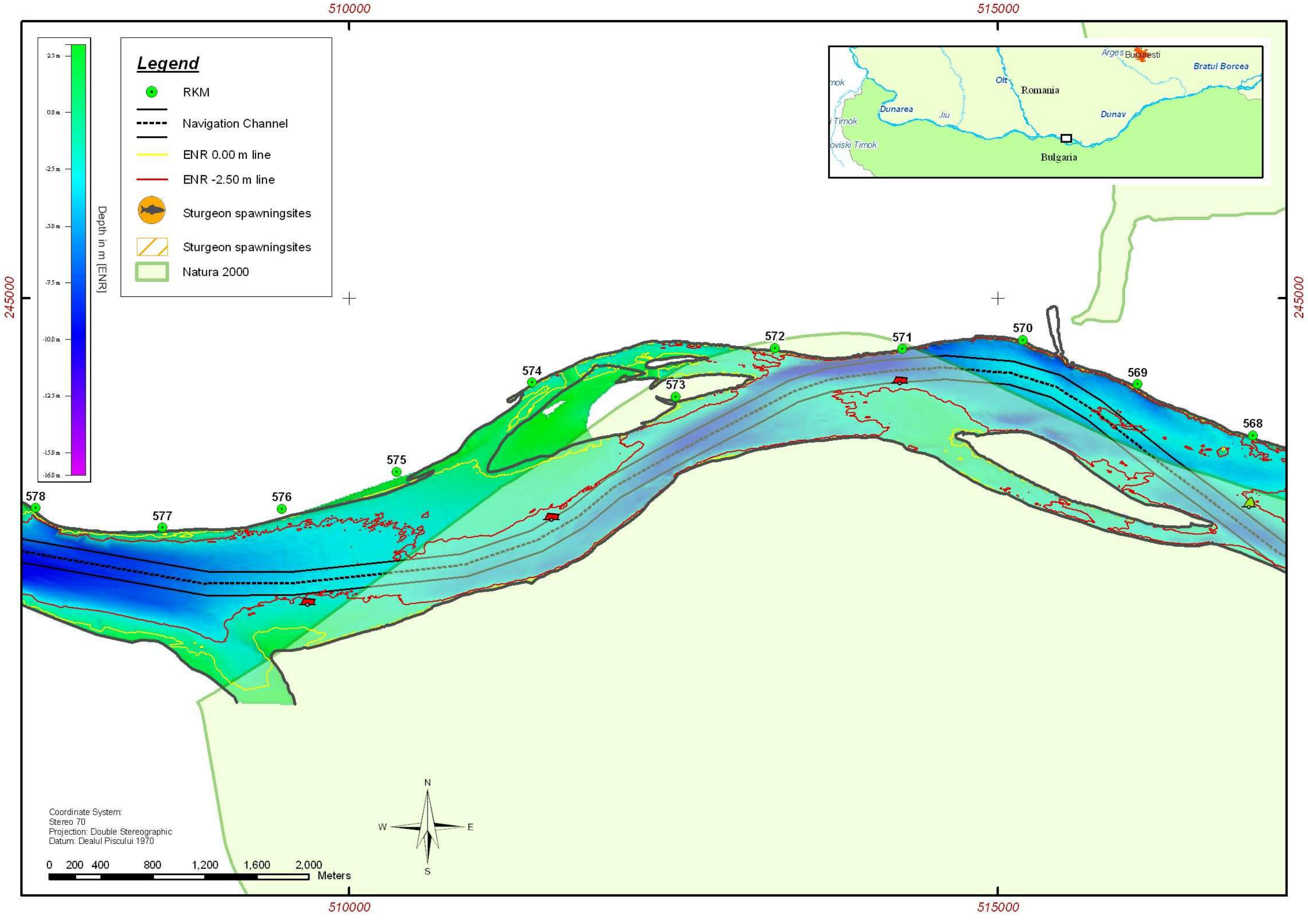

Figure 44: Belene Island upstream Present Conditions A

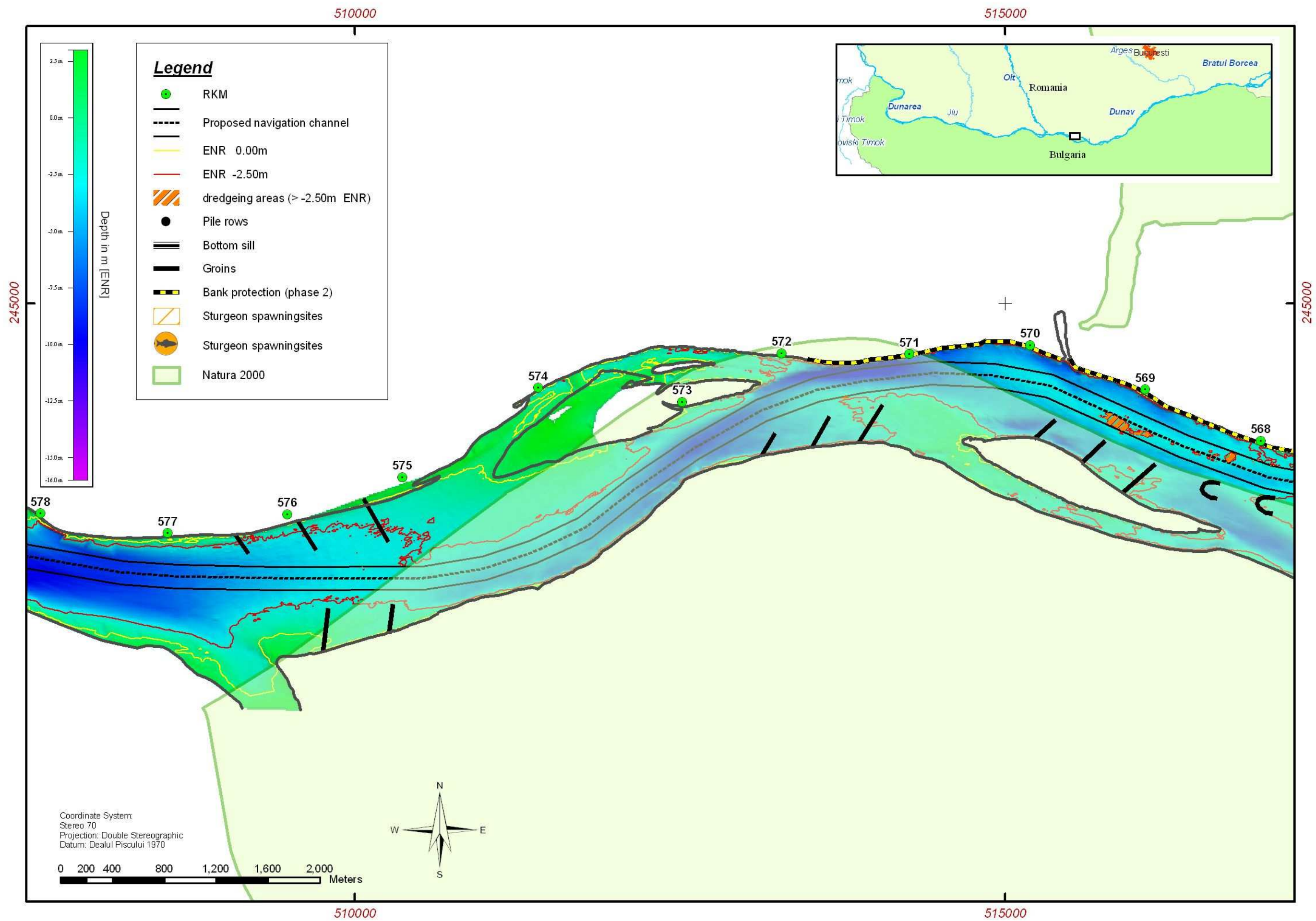

Figure 45: Belene Island upstream Alternative Development Strategy A

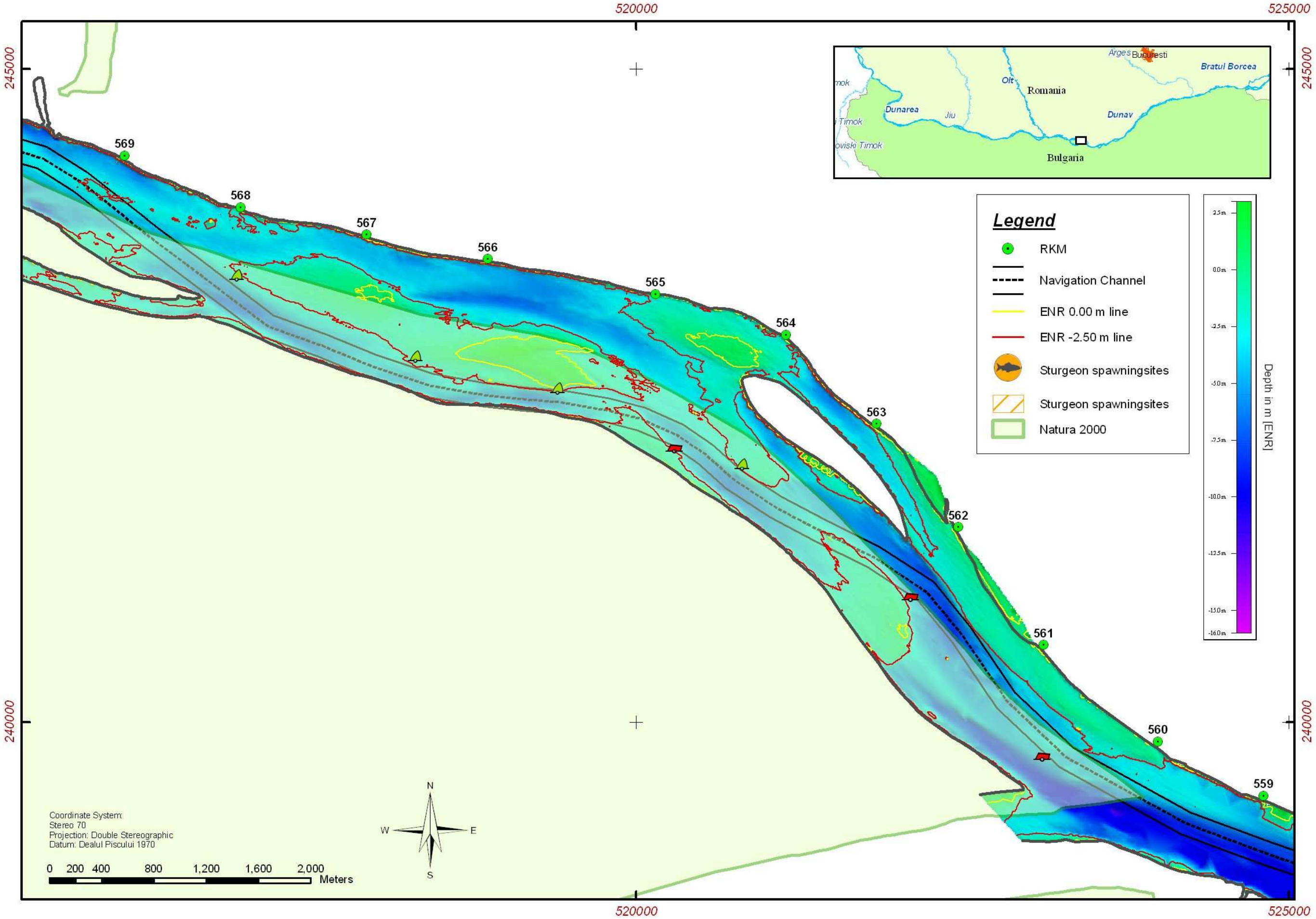

Figure 46 Belene Island upstream Present Conditions B

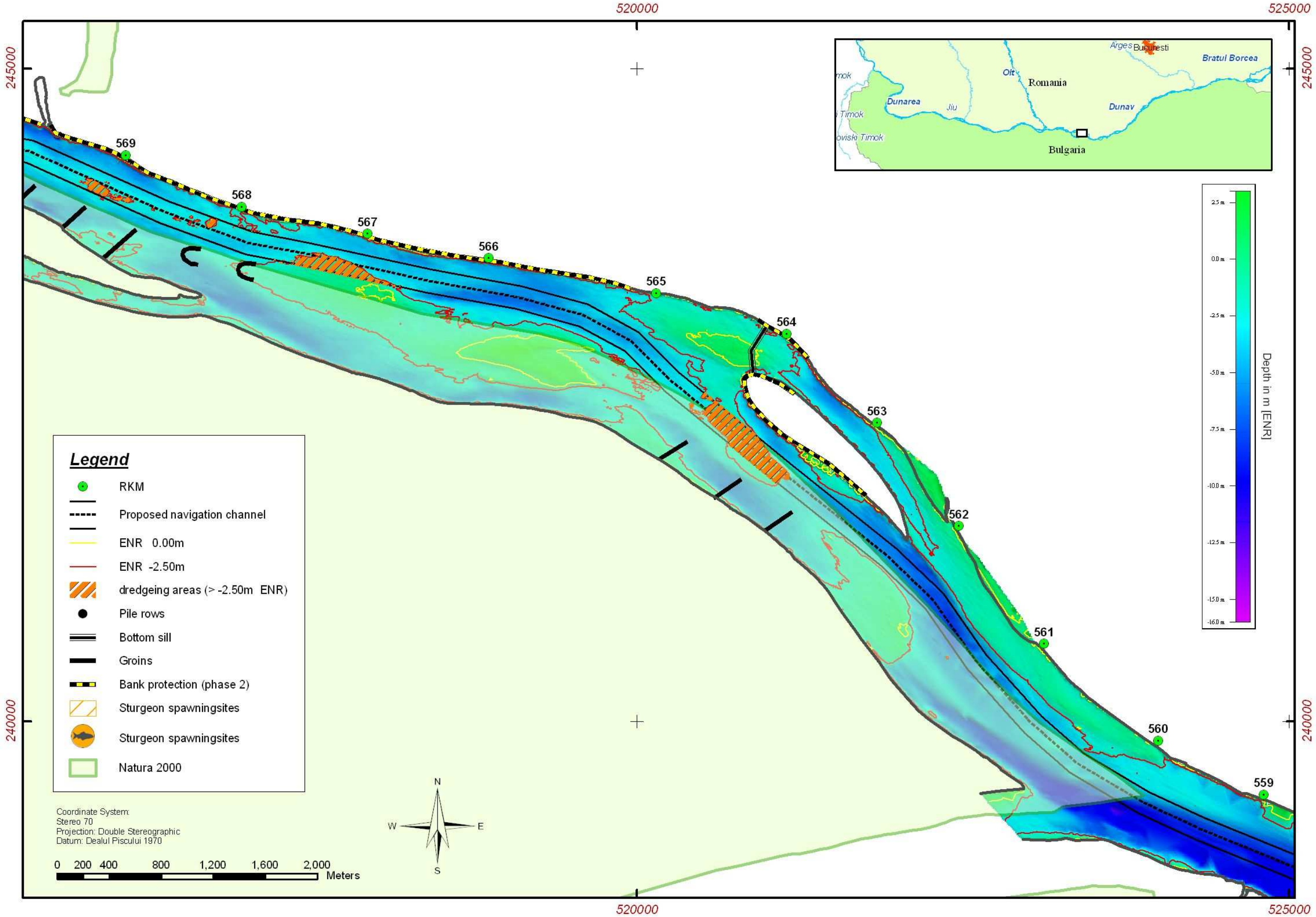

Figure 47: Belene Island upstream Alternative Development Strategy B

16. Zimnicea/Svistov (rkm 557-553)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	16
Location:		
Zimnicea/Svistov		
Position:	Danube sector:	
rKm 557 - 553	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• AFDJ Giurgiu		
Description of the present situation:		
The navigation channel varies at rkm 555 at both sides of the existent sand bar. Not really a problem for navigation.		

Proposed works:
Harris (1999):
Alternative Development Strategies (Technum et al., 2008):
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

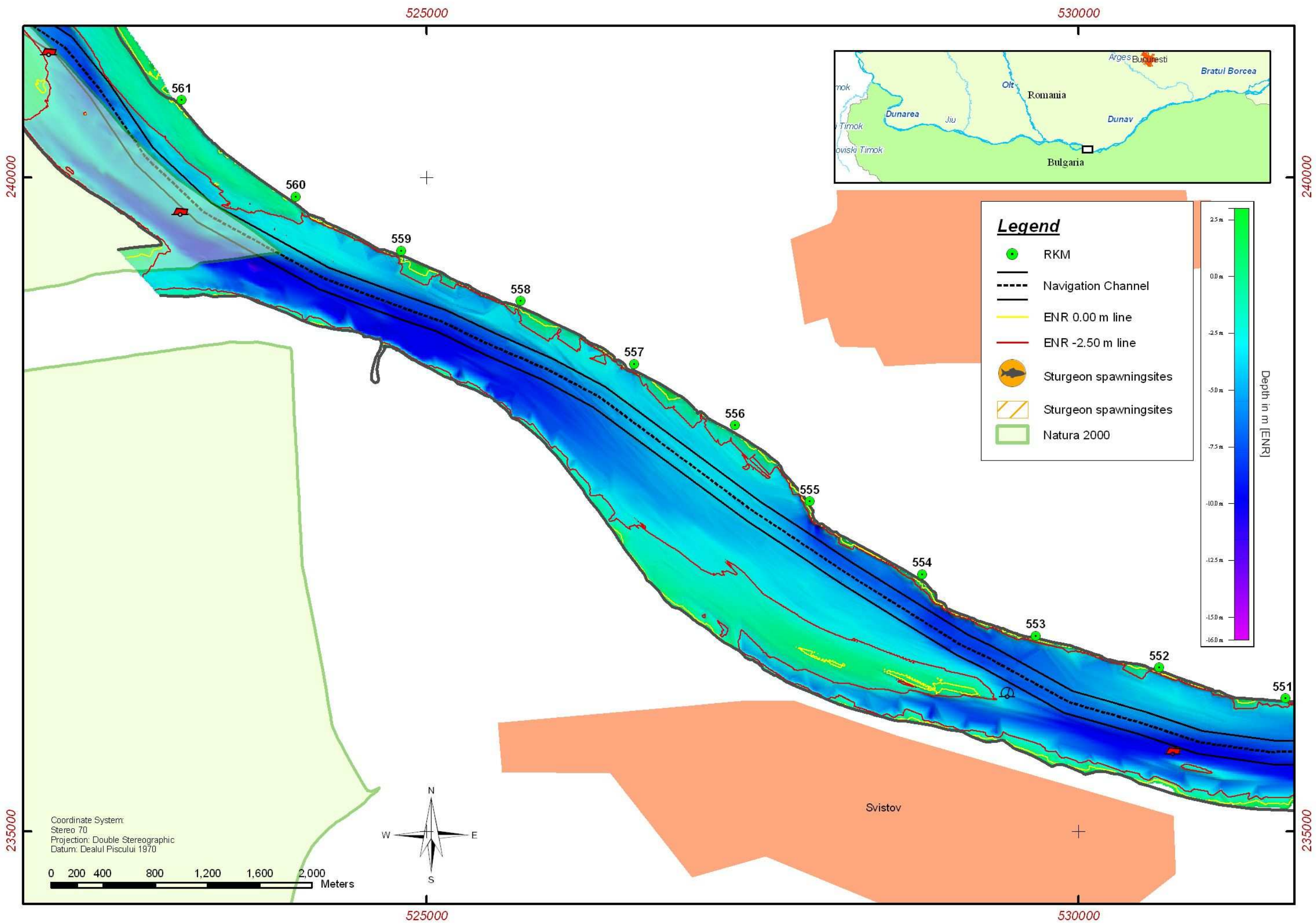

Figure 48: Zimnicea/Svistov Present Conditions

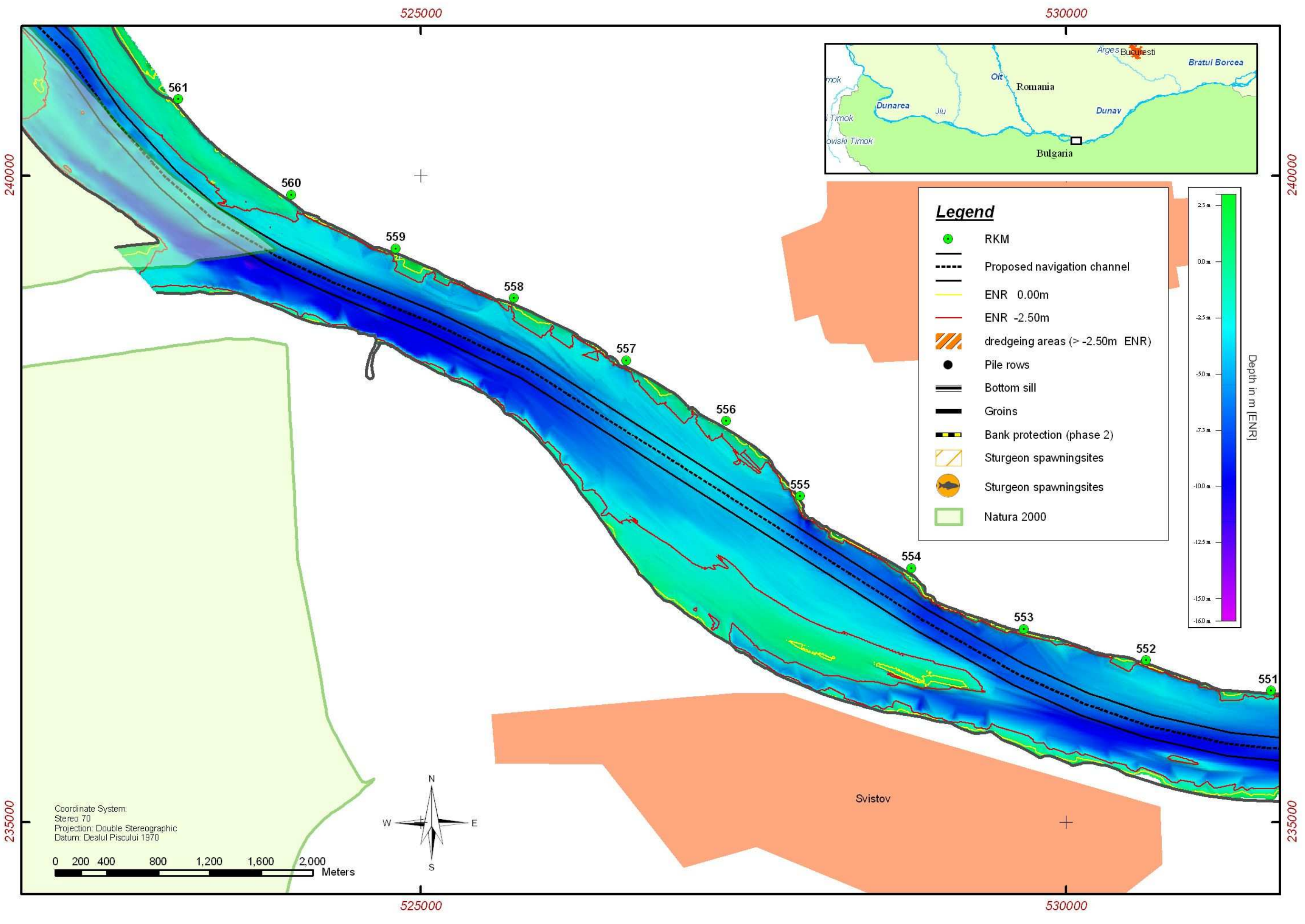

Figure 49: Zimnicea/Svistov Alternative Development Strategy

17. Vardim Island (rkm 548-540)

	Last update of this sheet:	23.06.2008
	Critical Sector Number:	17
Locatie:		
Insula Vardim		
Position:	Danube sector:	
Km 548 - 540	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector pentru masuratori detaliate:		
Sector for detail measurements:		
Harris (1999) APPD Ruse (Bulgaria) AFDJ Giurgiu		
Description of the present situation:		
As the side (South) branch is attracting quite some flow, the flow velocities in the main channel are insufficient to keep the navigation channel at the required depth and width. In addition, the width of the main channel is too large to guarantee the required navigation channel depth during low flow periods. Specific shallow water locations are at rkm 543-540. There is also sand bars migration around rkm 546 and at the Romanian bank at rkm 546-543.		
Proposed works:		
Harris (1999): It is proposed to construct a bottom sill. If it is not enough, additional measures with groins in the main channel may be considered.		

Alternatives proposed by JV Technum, Trapec, Tractebel, CNR, Safege (2008): Realignment of the navigation channel to improve the radius of curvature with dredging is proposed. The TWS includes additional measures to reduce sedimentation in the main branch: groins at both sides of the fairway (rkm546-544), 2 groins at rkm540 and a bottom sill in the secondary branch. The same measures are proposed in the MS. The measures proposed in the EES are basically the same than in the TWS, with alternative design of the training works allowing more space for flora and fauna, such as two partial bottom sills instead of one. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works; • Keep impact on deep areas as low as possible; • Useful application of dredged material; • Less groins but with wing; • Open groins at river bank; • Two partial bottom sills instead of one; • Reduce length of bank protection;
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

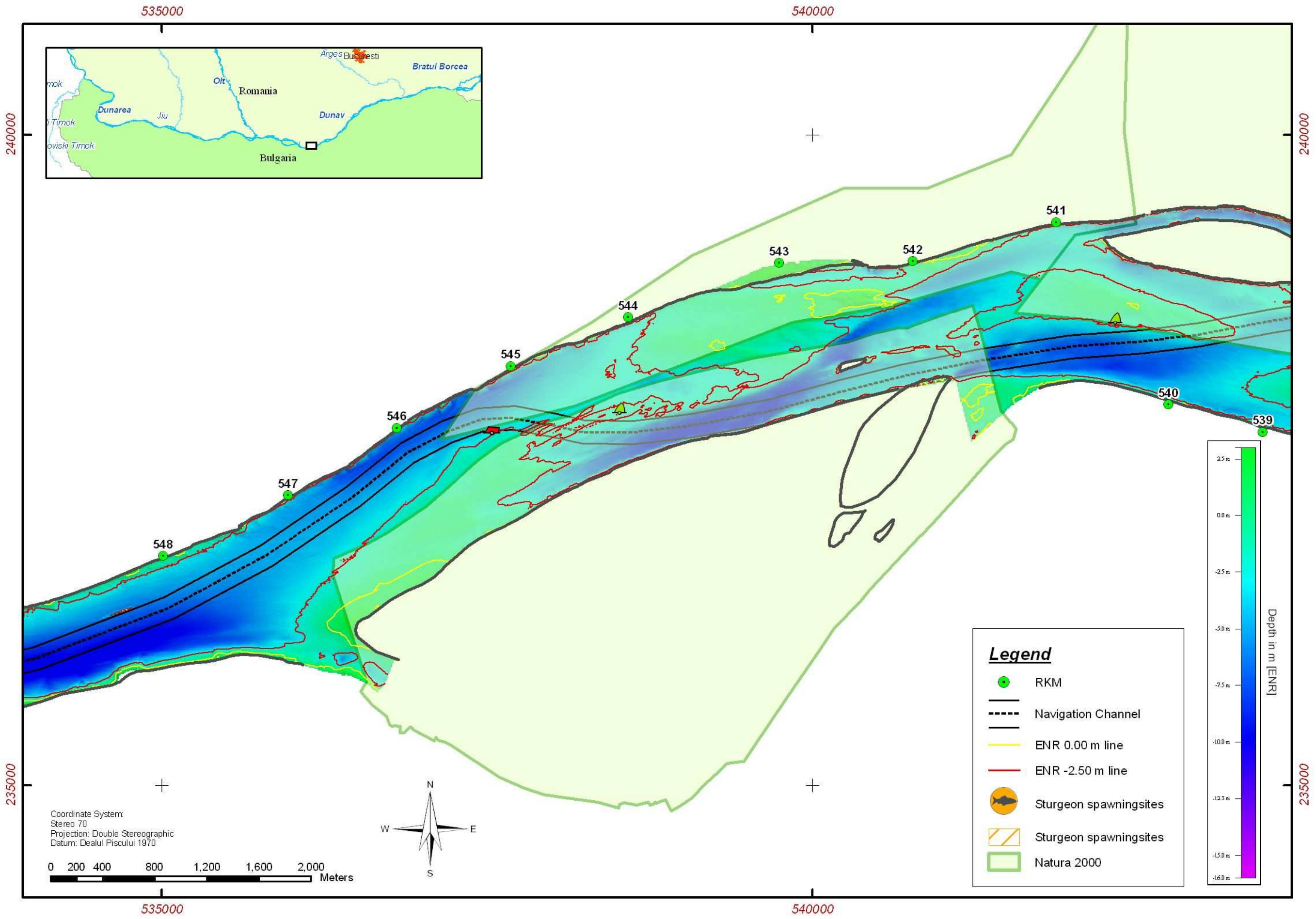

Figure 50: Vardim Island Present Conditions

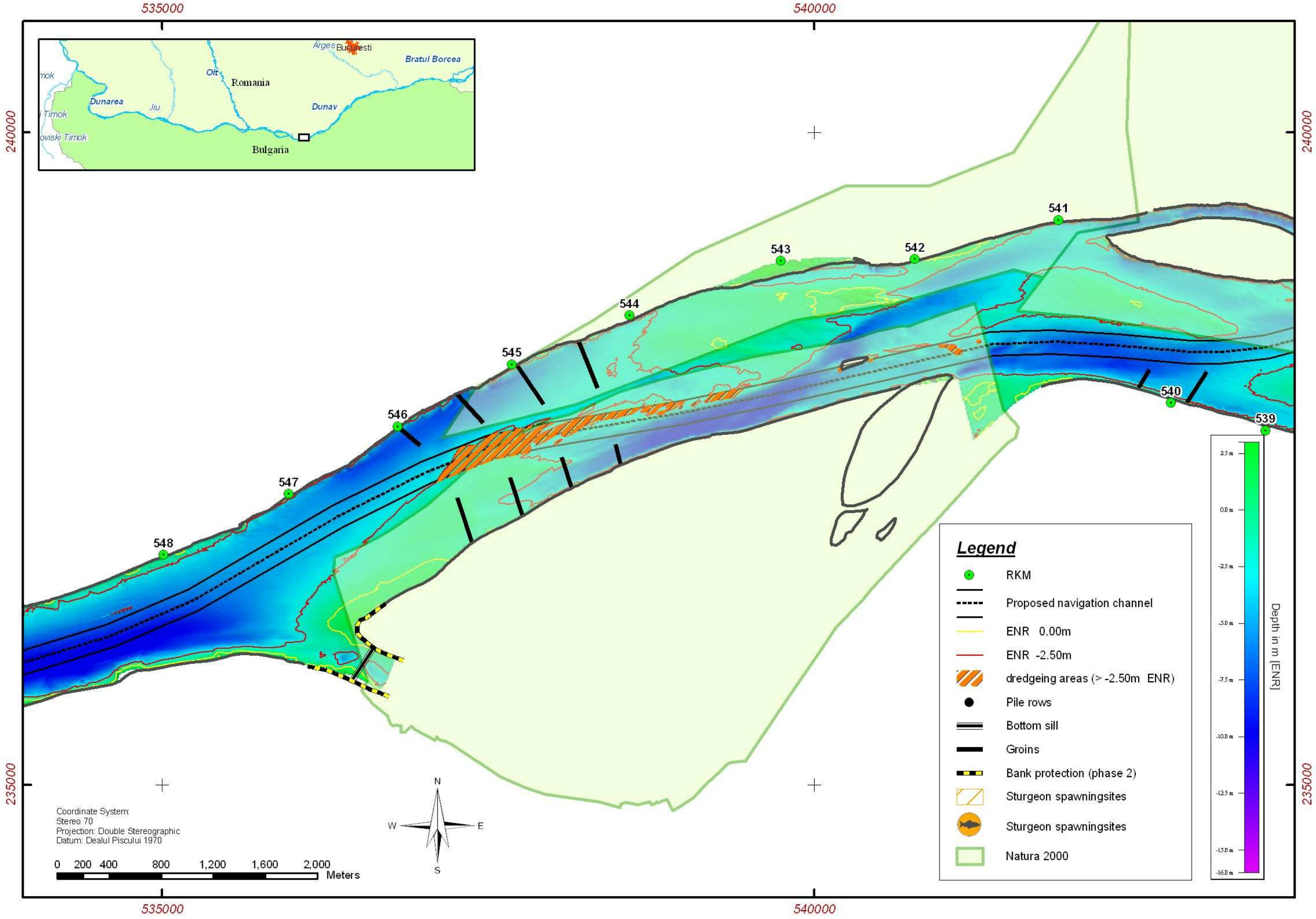

Figure 51: Vardim Island Alternative Development Strategy

18. Gaska – Vardim Island (km 540-536)

	Last update of this sheet:	23.06.2008
	Critical Sector Number:	18

Location:

Insula Gaska – Vardim

Position:	Danube sector:
Km 540 - 536	Common Romanian – Bulgarian sector rKm 610 - 845.5

Sector for detail measurements:

Critical point reported by:

AFDJ Giurgiu

Directia de Transporturi Navale

Harris (1999)

Description of the present situation:

Navigation depths may be less than 2.5m and width between 60 and 100m.

Shipwrecks.

Proposed works:

Harris (1999):
It is proposed to construct groins at rkm 538

Alternatives proposed by JV Technum, Trapec, Tractebel, CNR, Safege (2008):

The TWS proposes realignment of the navigation channel to reduce dredging volumes; besides,

groins and an additional measure (e.g. pile rows) to concentrate the main flow on the left bank and induce the sedimentation at the sector of the pile rows on the right bank.

An option to be considered in the EES is the construction of the groins detached from the banks

(e.g. wing dam notching) allowing flow between the structures and the banks.

Other important aspects for the EES and GES, and in general for construction:

- Phasing of dredging to take into account fish spawning/migration;
- Phasing of large training works;
- Keep impact on deep areas as low as possible (spawning sites);
- Useful application of dredged material;

Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

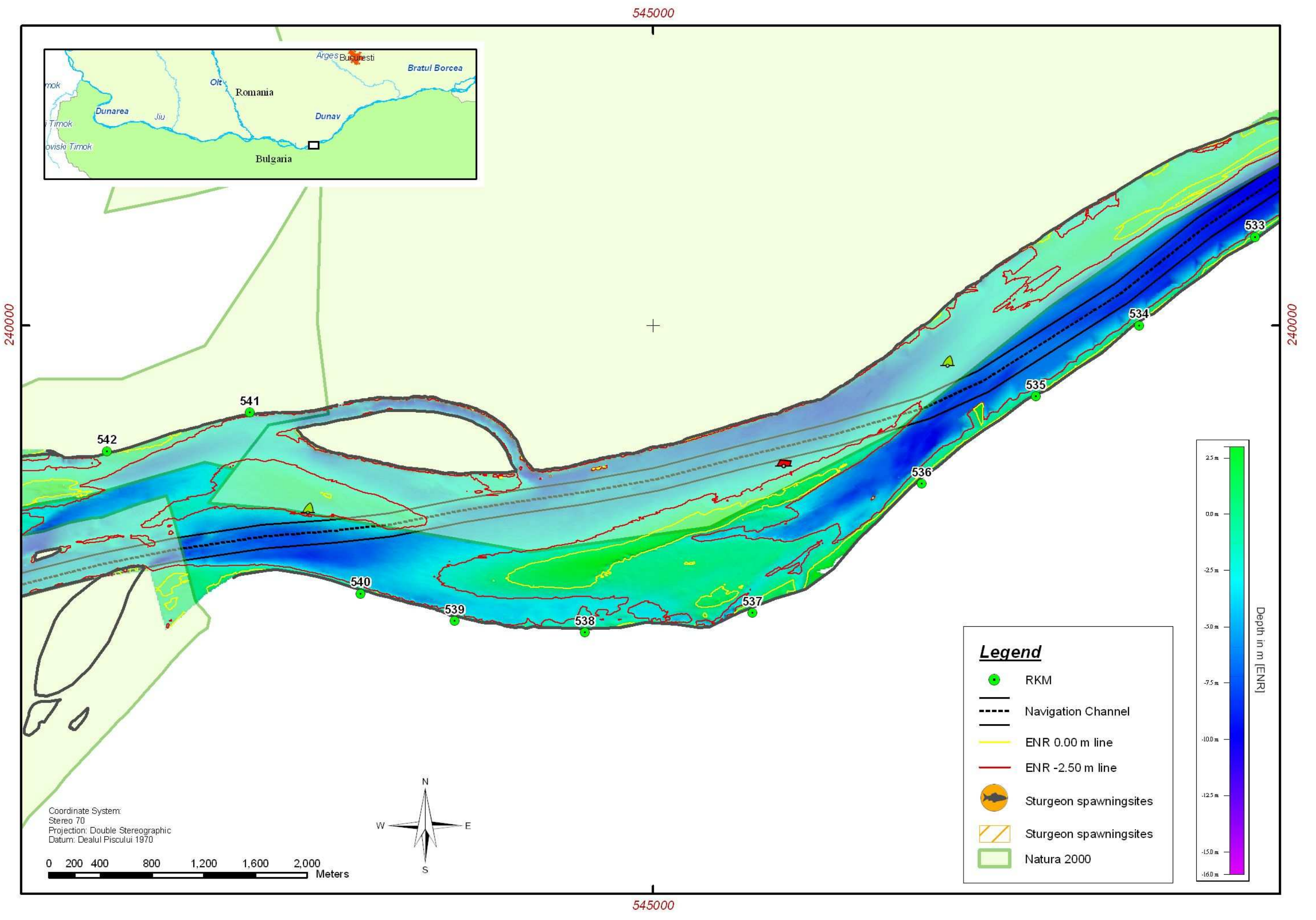

Figure 52: Gaska – Vardim Island Present Conditions

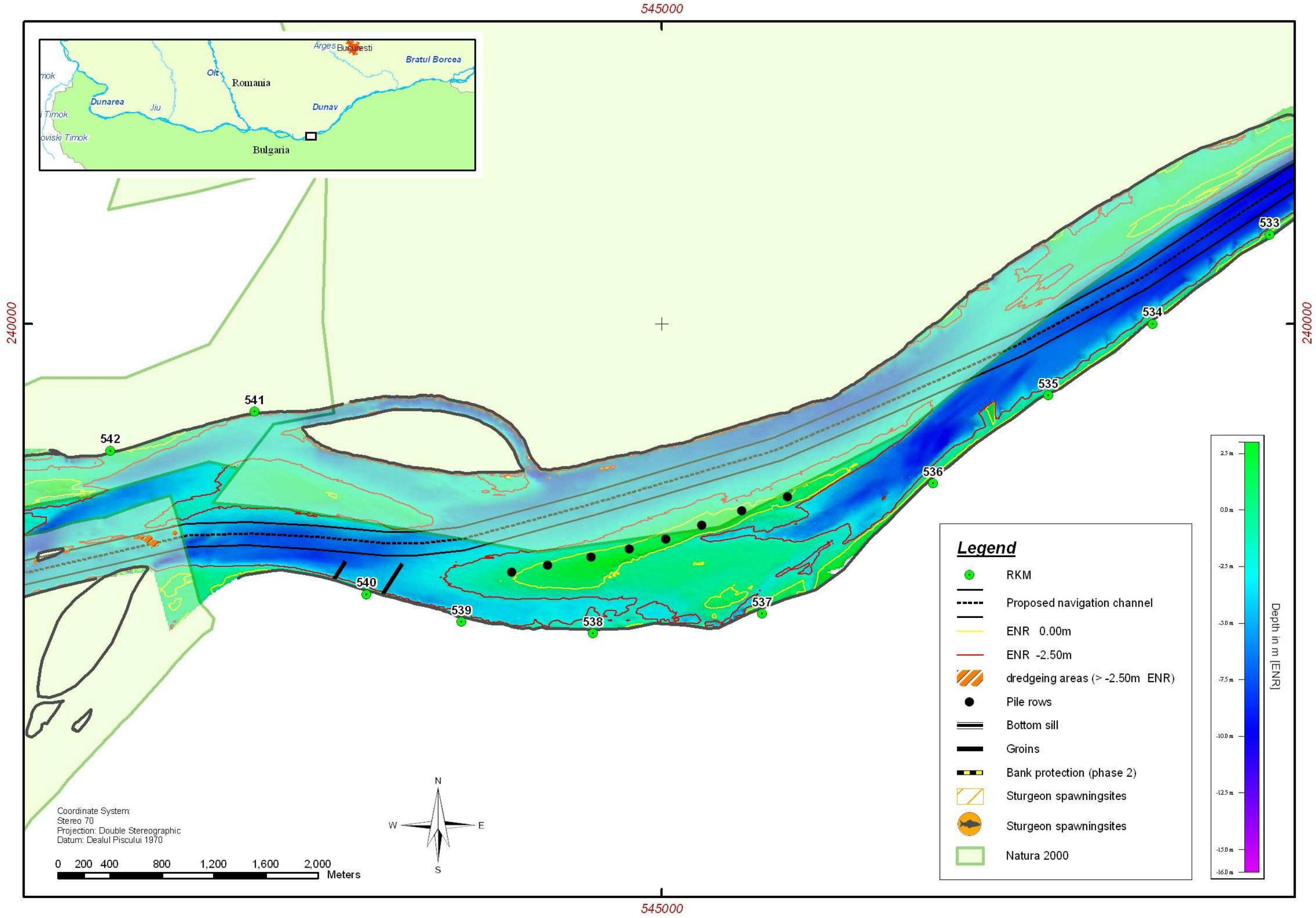

Figure 53: Gaska – Vardim Island Alternative Development Strategy

19. Batin – Stilpiste Island (km 530-515)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	19

Location:

Batin Island - Stilpiste

Position:	Danube sector:
rKm 530 - 515	Common Romanian – Bulgarian sector rKm 610 - 845.5

Sector for detail measurements:

Critical point reported by:

- Harris (1999)
- Navigation Directorate
- AFDJ Giurgiu

Description of the present situation:

The total cross-sectional flow area (channels on both sides of the island) is too large to naturally keep the required navigational depth and width during low flow periods. In the main channel, a number of shallow and narrow sections as well as some emerging sand bars may occur.
Navigation channel is near the Romanian bank at rkm 529, between a wreck and the bank.
Sedimentation is occurring on the north side of Batin Island and erosion occurs at the Romanian bank around rkm 526-525.
There is a pump station near rkm 524.
The new navigation channel has been moved towards Batin Island between rkm 525-522 due to the sand bar on the Romanian side.
Further in the river bend around Stilpiste, a small emerging bank occurs at rkm 519-518. The river width at this section is too large to provide sufficient water depth and width during low flow regimes.
The entrance to the south branch of Batin Island at rkm 531 has very shallow water having even less flow at this branch nowadays.

Proposed works:

Harris (1999):
It is proposed to construct a bottom sill at rkm 529. If this is not sufficient, construction of groins along the right bank of the main channel between rkm 528 and 523 may also be envisaged (constriction width to 800m). Another option is to construct only groins along the right bank of the main channel between rkm 528 and 521, constricting the river width to 600m).
For Stilpiste the possible option consists of construction of groins on the left bank, from rkm 521-518, in combination with the construction of groine/bottom sill on the left bank at rkm 519.
JV Technum, Tractebel, Trapec (2006):
Four scenarios were presented, basically a bottom sill in the secondary branch and different combination of groins and/or guiding wall.

Alternatives proposed by JV Technum, Trapec, Tractebel, CNR, Safege (2008):

A realignment of the navigation channel towards the left bank is proposed to improve the radius of curvature and dredging is needed. The area has a significant morphological activity for which a set of different training works is proposed along the critical sector to direct flow and reduce sedimentation in the fairway (TWS). The measures are accompanied with the protection of the left bank to assure the stability of the river cross section. The same measures are proposed in the MS. The measures proposed in the EES are basically the same than in the TWS, with alternative design of the training works allowing more space for flora and fauna. The width of the cross section of the river in this area gives valuable space for special development strategies in the GES. The selection of measures for the GES needs a more detailed study to cover the engineering and environmental aspects in an integral set of measures. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works; • Keep impact on deep areas as low as possible; • Useful application of dredged material; • Two open bottom sills instead of one; • Smaller number of groins with L-shape; • Reduce length of bank protection accompanied with a monitoring program in order to take actions if necessary.
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

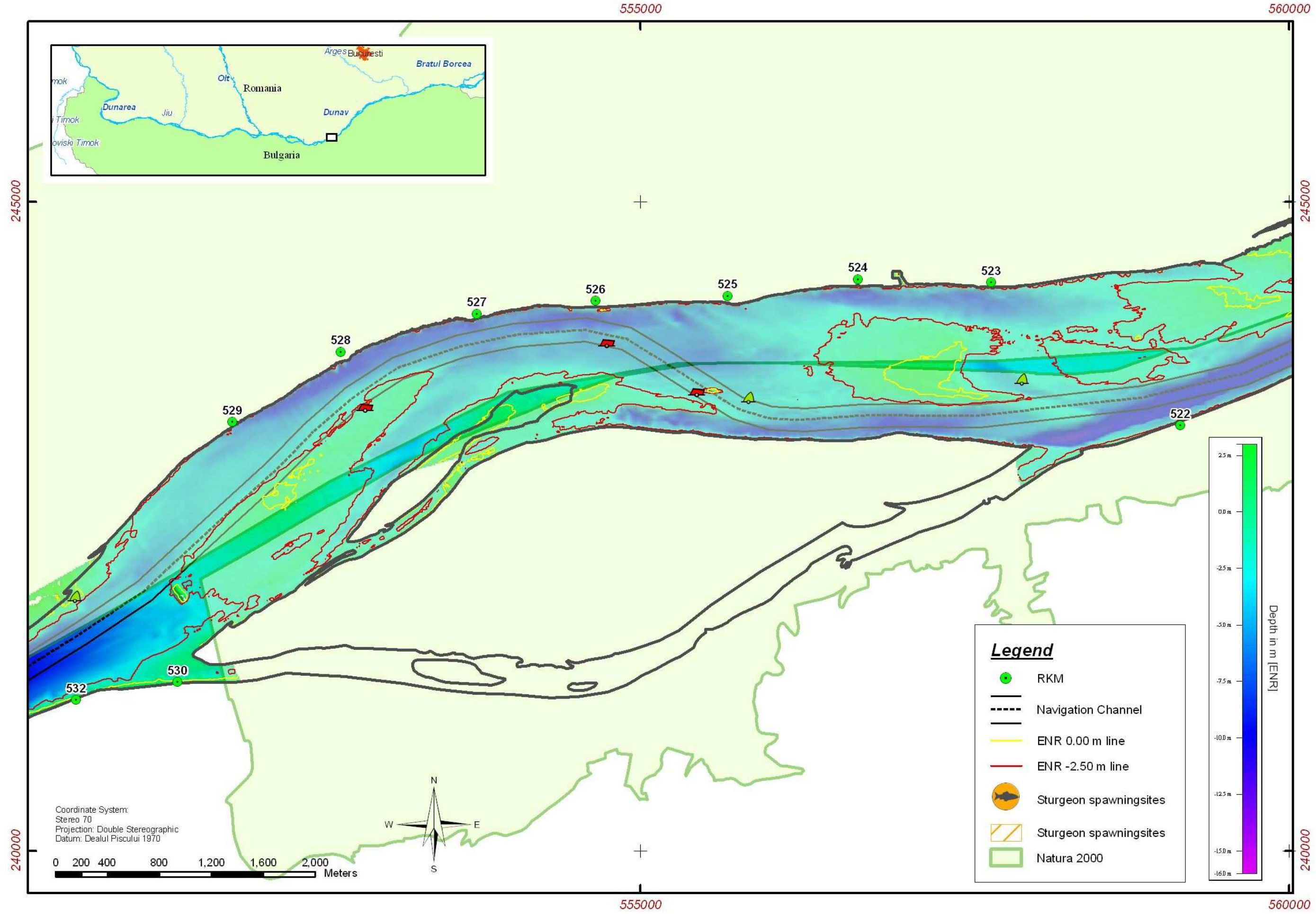

Figure 54: Batin Island - Stilpiste Present Conditions A

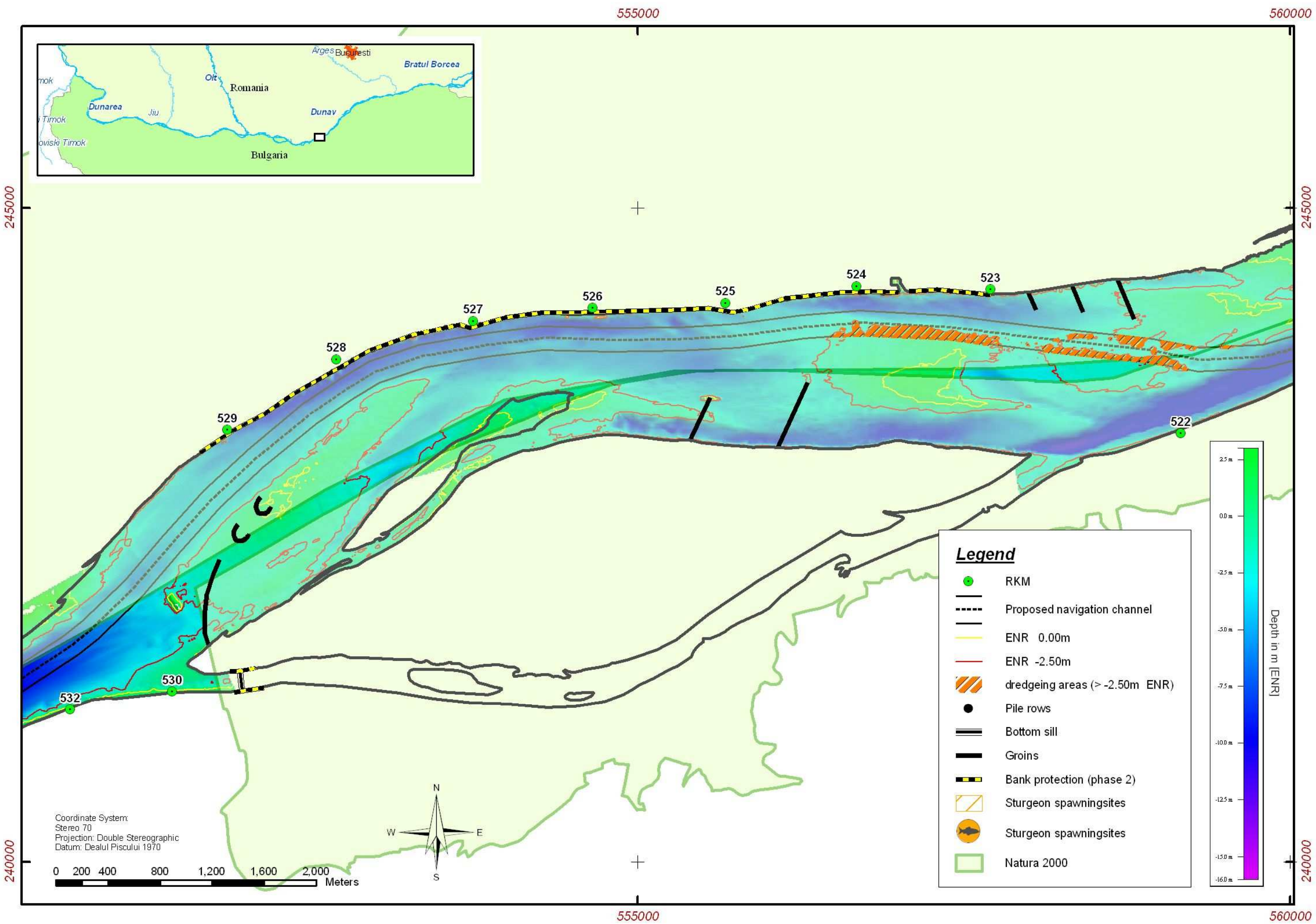

Figure 55: Batin Island - Stilpiste Alternative Development Strategy A

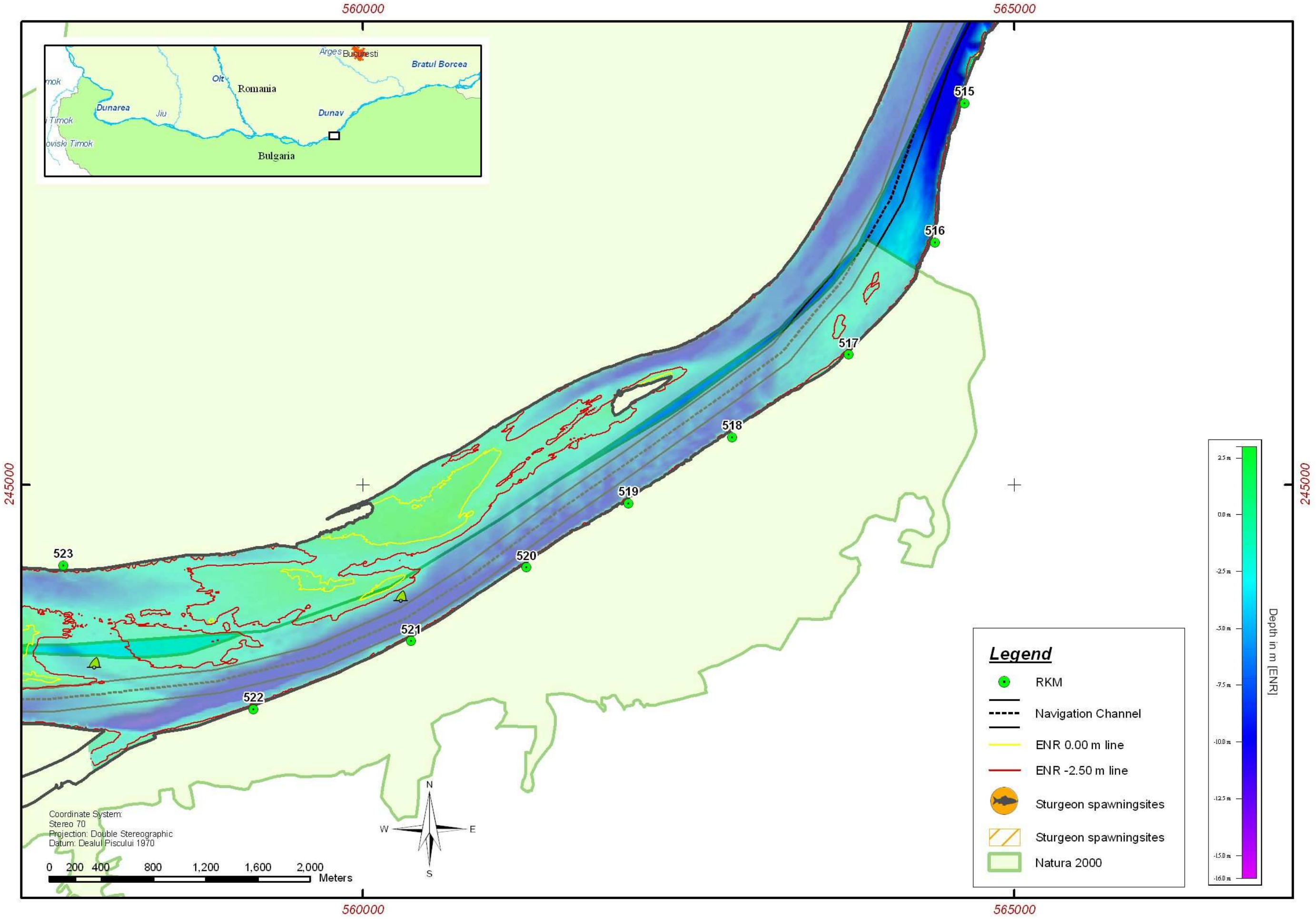

Figure 56: Batin Island - Stilpiste Present Conditions B

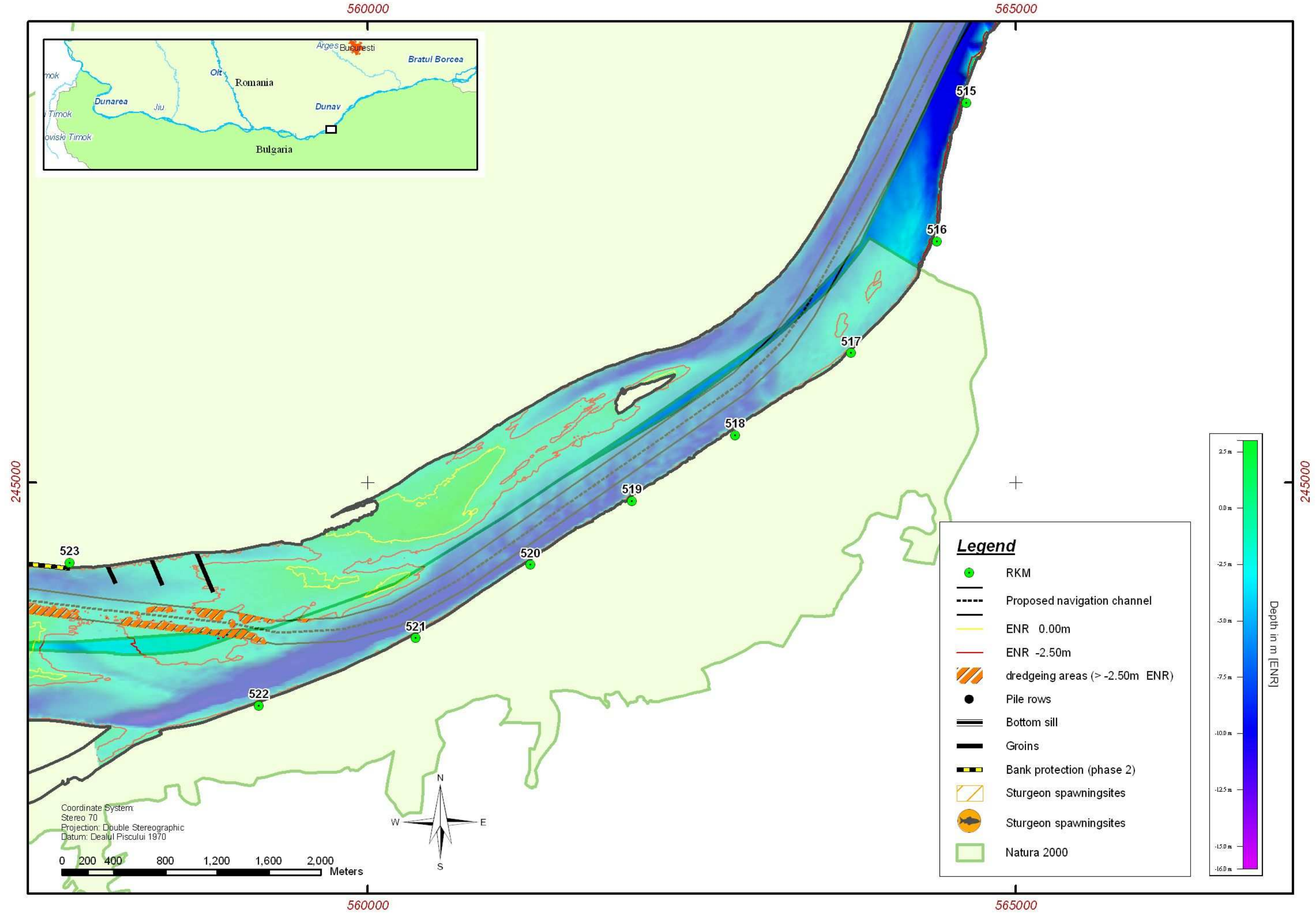

Figure 57: Batin Island - Stilpiste Alternative Development Strategy B

20. Kama and Dinu Islands (km 512-504)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	20
Location:		
Kama and Dinu Islands		
Position:	Danube sector:	
rKm 512 – 504	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Harris (1999) • Navigation Directorate • APPD Ruse		
Description of the present situation:		
A wide river and the presence of islands (Cama Island amongst others) is the cause of this bottleneck during low flow regimes. A small emerging sand bank occurs in this section of the river at rkm 512-511 where the widening of the river starts. The navigation channel has been relocated on the Bulgarian branch between rkm 507-505 since 1995. There is sand at the old navigation channel on the Romanian branch at rkm 507-506 and big erosion is happening at the peak of the downstream island at rkm 507.		
Proposed works:		
Harris (1999): The option is to construct a bottom sill/ groine/ parallel wall at the right bank of the main channel at rkm 512-511. Bank protection on the Romanian side will be required.		
Solutions proposed by JV Technum, Trapec, Tractebel, CNR, Safege (2008):		
Bottom sills at the secondary branches and groins at the wide areas are proposed in the TWS. These measures will concentrate the flow during low water periods in the main river branch where the navigation channel is located. The small bottom sill at rkm507 is not included in the MS and EES; the structure might be needed later if the secondary branch shows a significant increase in flow discharge. The bottom sill at rkm512 for the EES may have special design to allow fish migration along this branch (e.g. two partial bottom sills instead of one). Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works; • Keep impact on deep areas as low as possible; • Useful application of dredged material; • Open groins at the river bank; • Two open bottom sills instead of one;		

• Smaller number of groins with L-shape; • Reduce length of bank protection accompanied with a monitoring program in order to take actions if necessary.
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):

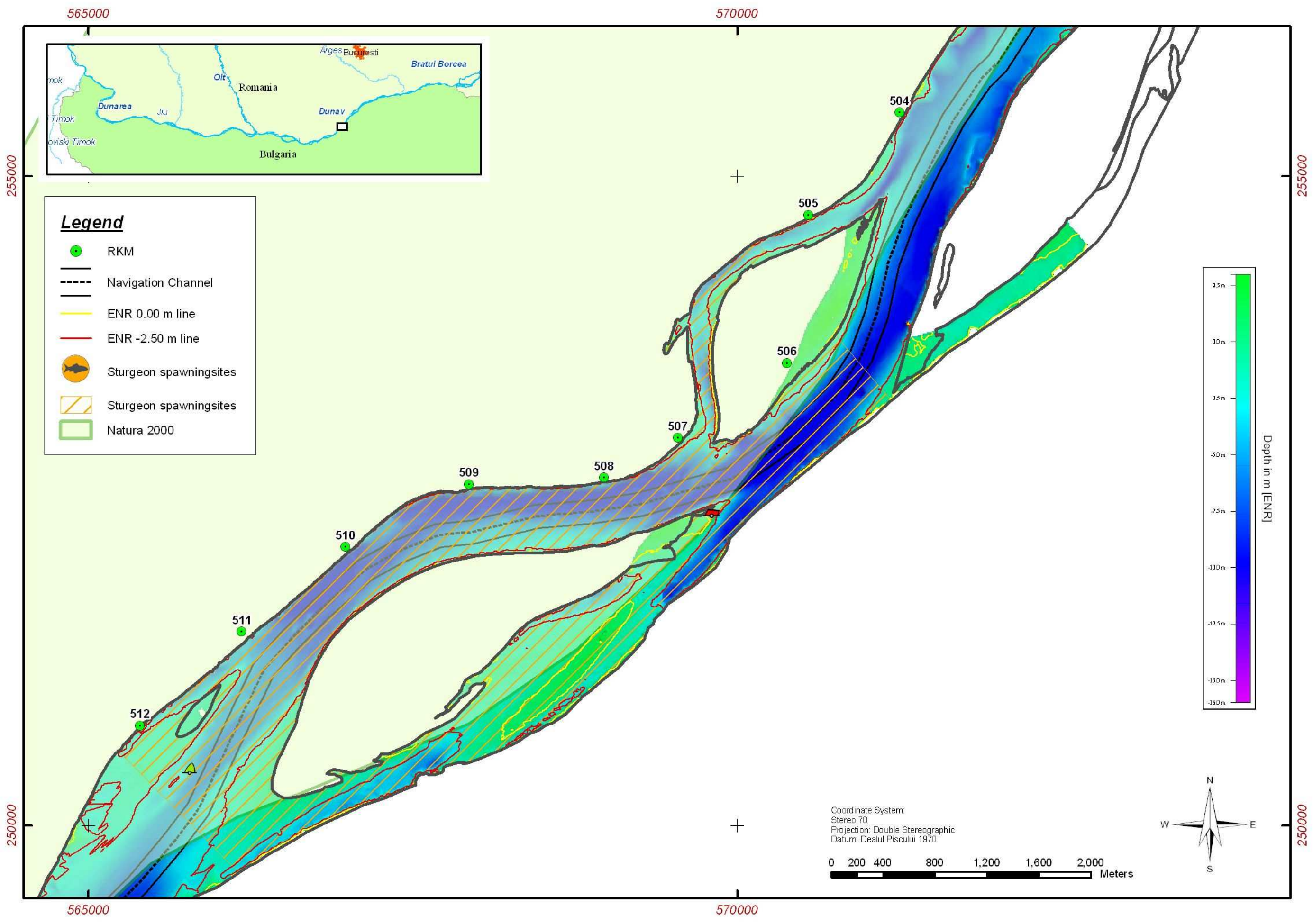

Figure 58: Kama and Dinu Islands Present Conditions

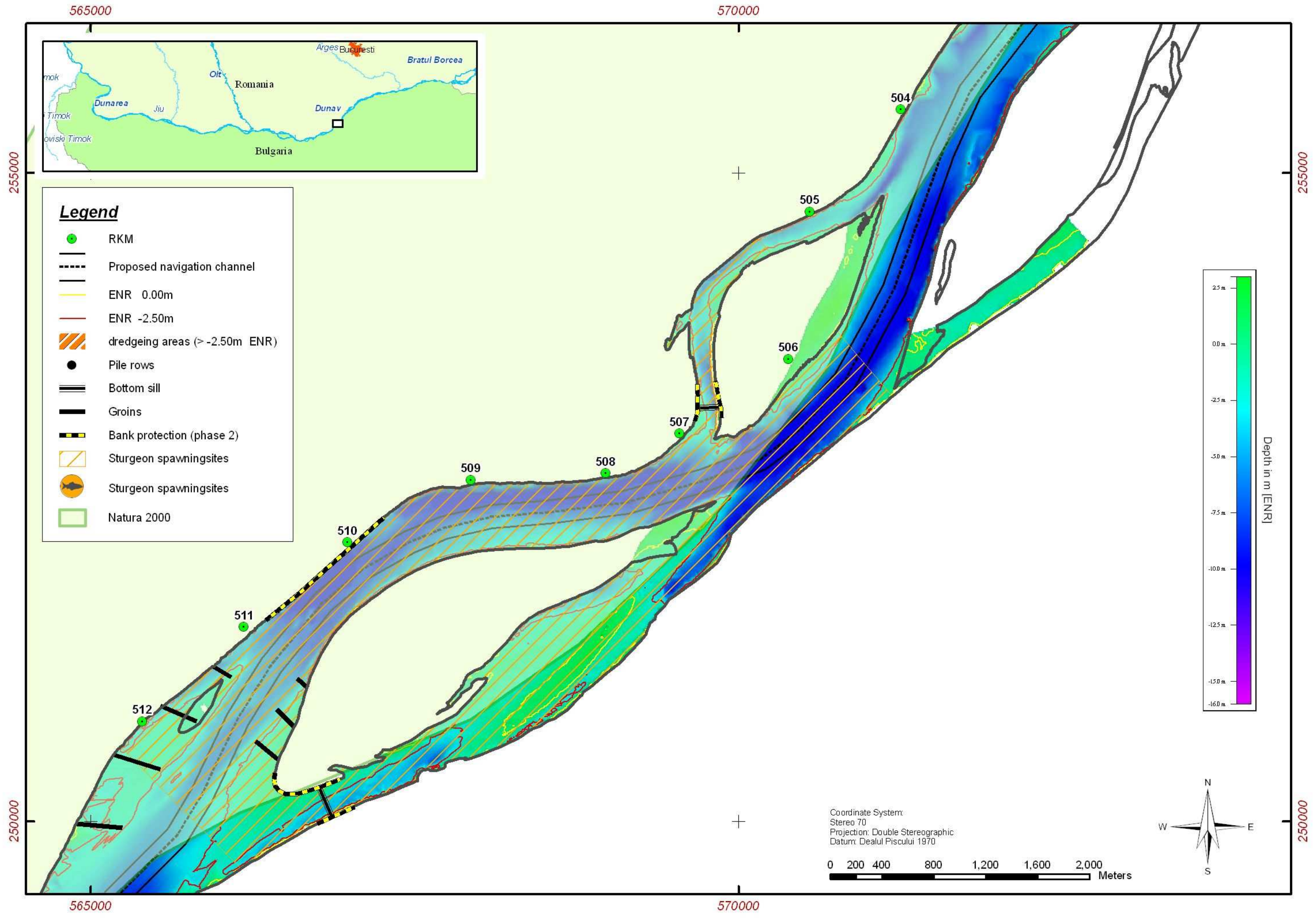

Figure 59: Kama and Dinu Islands Alternative Development Strategy

21. Slobozia (km 500-497)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	21
Location:		
Slobozia		
Position:	Danube sector:	
rKm 500 – 497	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• APPD Ruse		
Description of the present situation:		
No problems for navigation at present.		
Proposed works:		
Harris (1999): None		
Solutions proposed by JV Technum, Trapec, Tractebel, CNR, Safege:		
The last bathymetry of 2008 confirms no difficulties for navigation in the sector. No measures are proposed in this area.		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008):		

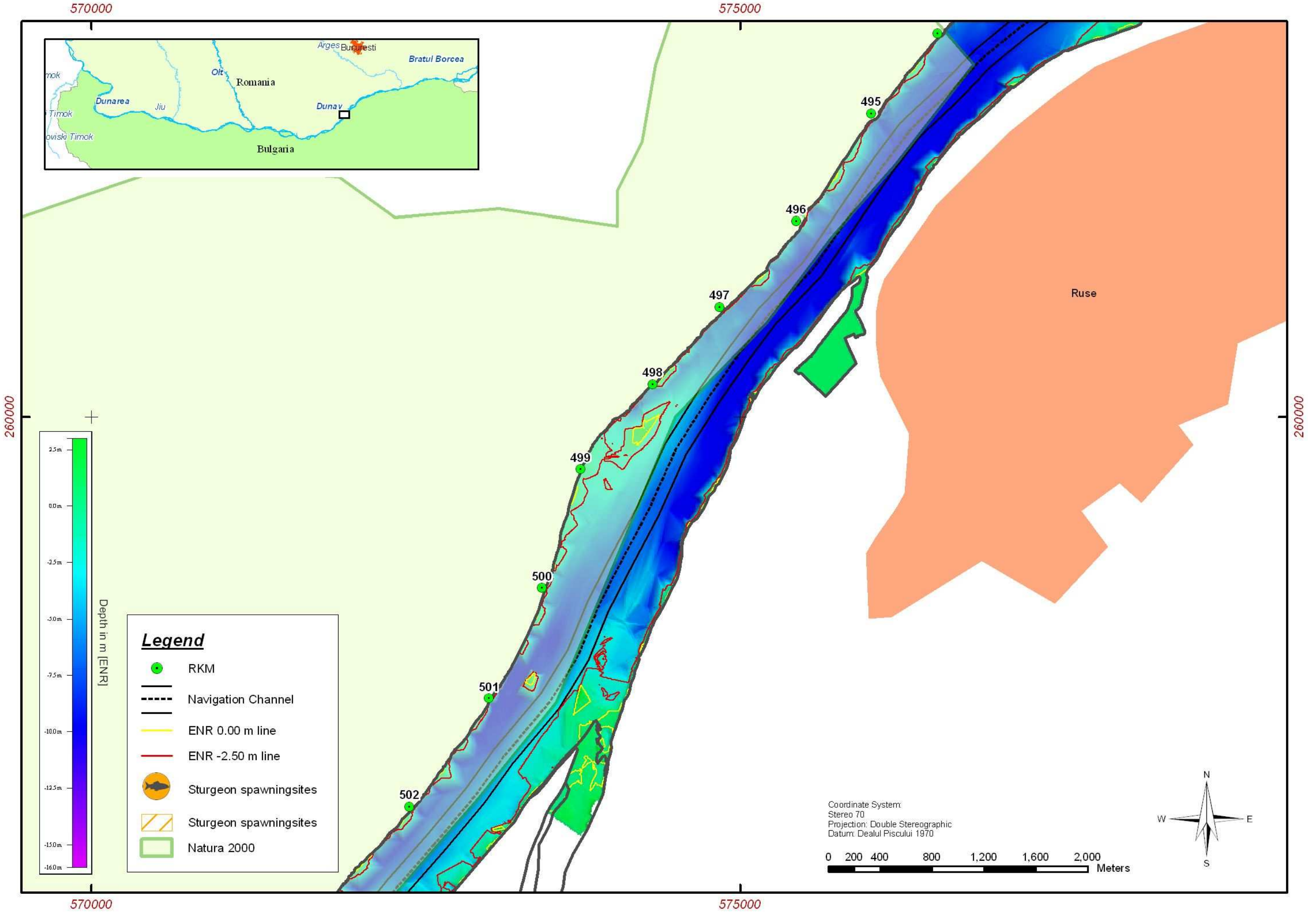

Figure 60: Slobozia Present Conditions

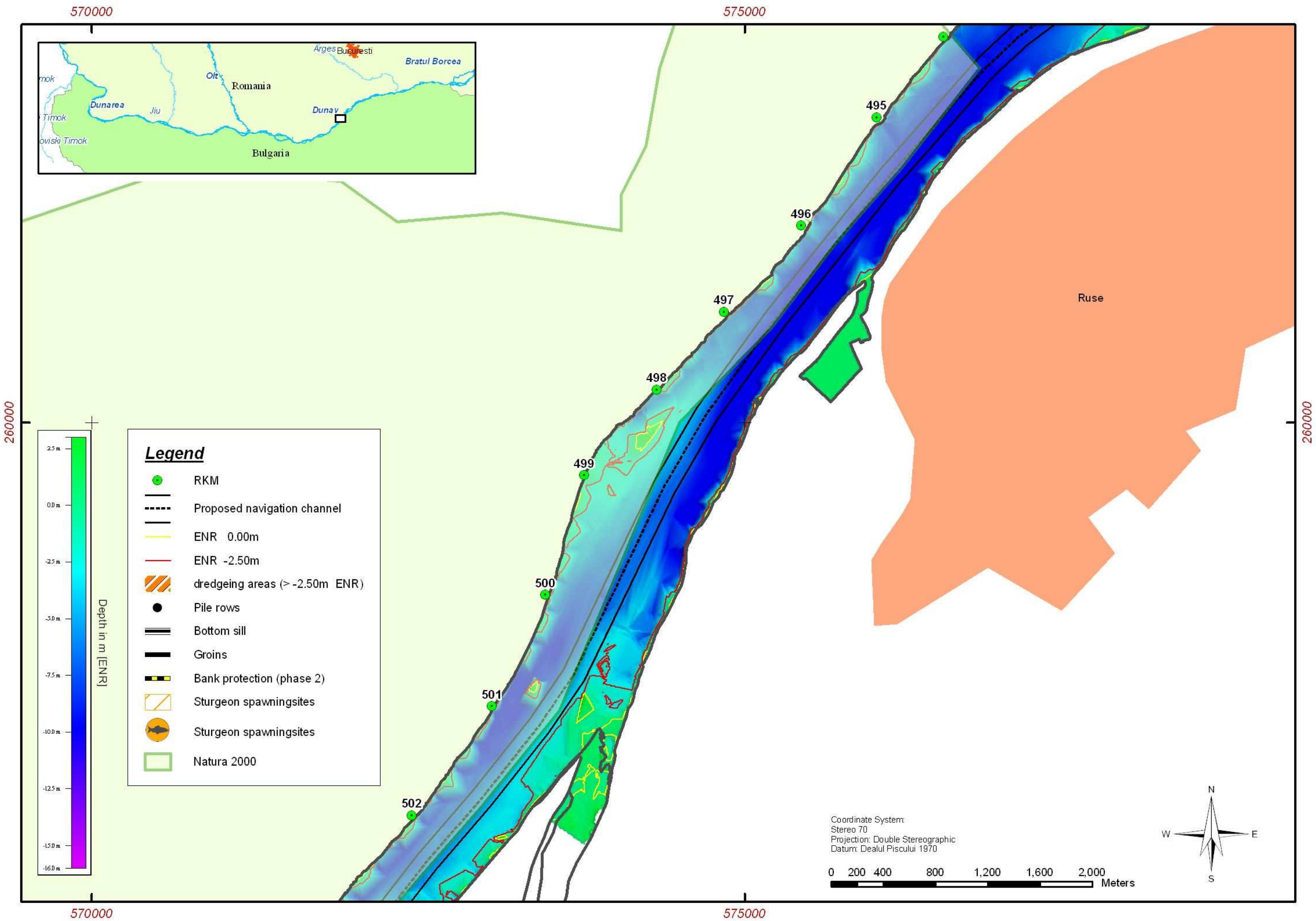

Figure 61: Slobozia Alternative Development Strategy

22. Giurgiu (km 490-486)

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<tr><td colspan="3">Location:</td></tr>
<tr><td colspan="3" align="center">Slobozia</td></tr>
<tr><td>Position:</td><td colspan="2">Danube sector:</td></tr>
<tr><td>rKm 500 – 497</td><td colspan="2">Common Romanian – Bulgarian sector
rKm 610 - 845.5</td></tr>
<tr><td colspan="3">Sector for detail measurements:</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Critical point reported by:</td></tr>
<tr><td colspan="3">• APPD Ruse</td></tr>
<tr><td colspan="3">Description of the present situation:</td></tr>
<tr><td colspan="3">No problems for navigation at present.</td></tr>
<tr><td colspan="3">Proposed works:</td></tr>
<tr><td colspan="3">Harris (1999):
None</td></tr>
<tr><td colspan="3">Solution proposed by JV Technum, Trapec, Tractebel, CNR, Safege:</td></tr>
<tr><td colspan="3">The last bathymetry of 2008 confirms no difficulties for navigation in the sector.
No measures are proposed in this area.</td></tr>
<tr><td colspan="3">Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)</td></tr>
</table>

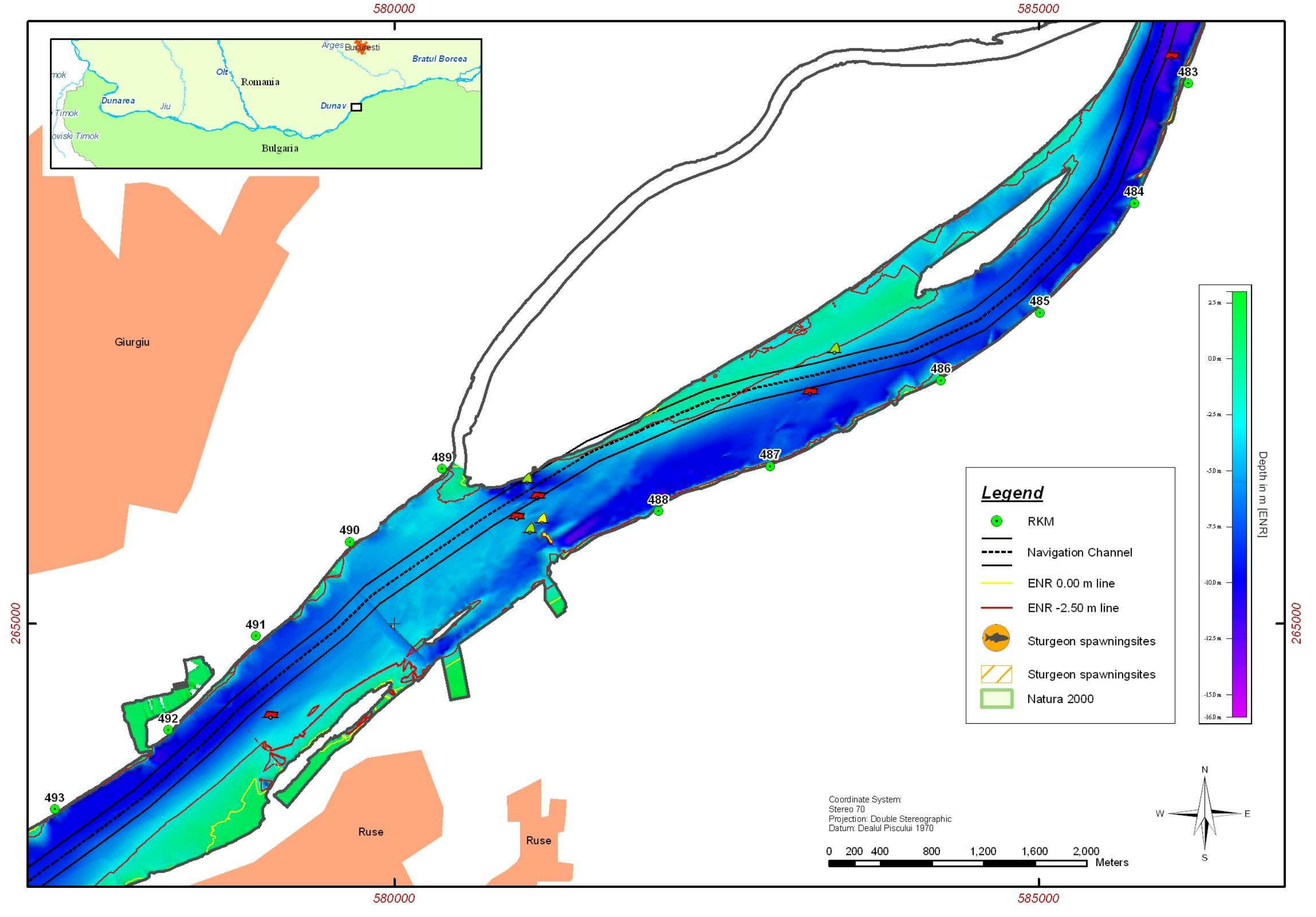

Figure 62: Giurgiu Present Conditions

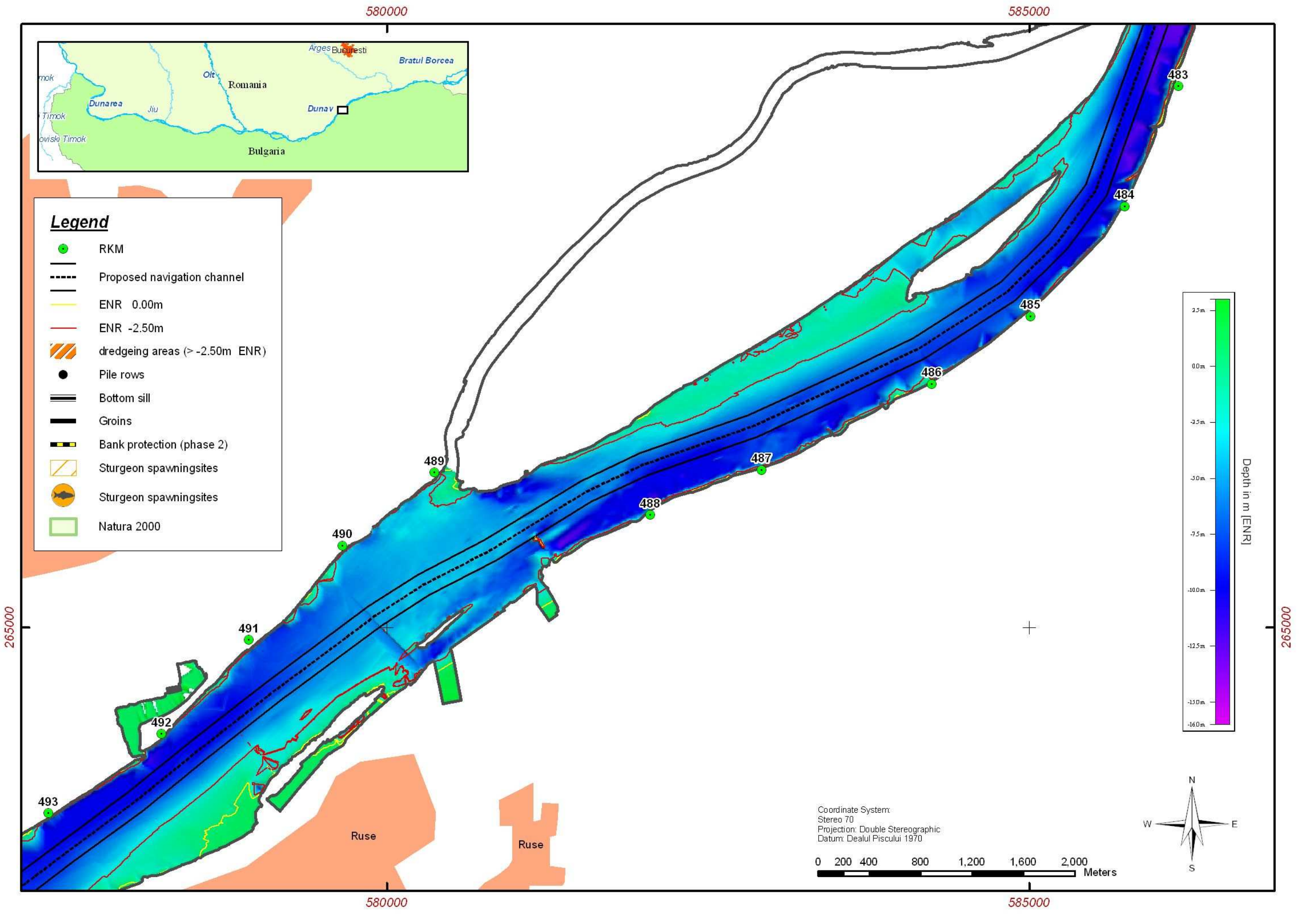

Figure 63: Giurgiu Alternative Development Strategy

23. Ostrovul Alek (km 481-478)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	21
Location:		
Slobozia		
Position:	Danube sector:	
rKm 500 – 497	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• APPD Ruse		
Description of the present situation:		
No problems for navigation at present.		
Proposed works:		
Harris (1999): None		
Solution proposed by JV Technum, Trapec, Tractebel, CNR, Safege:		
The last bathymetry of 2008 confirms no difficulties for navigation in the sector. No measures are proposed in this area.		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)		

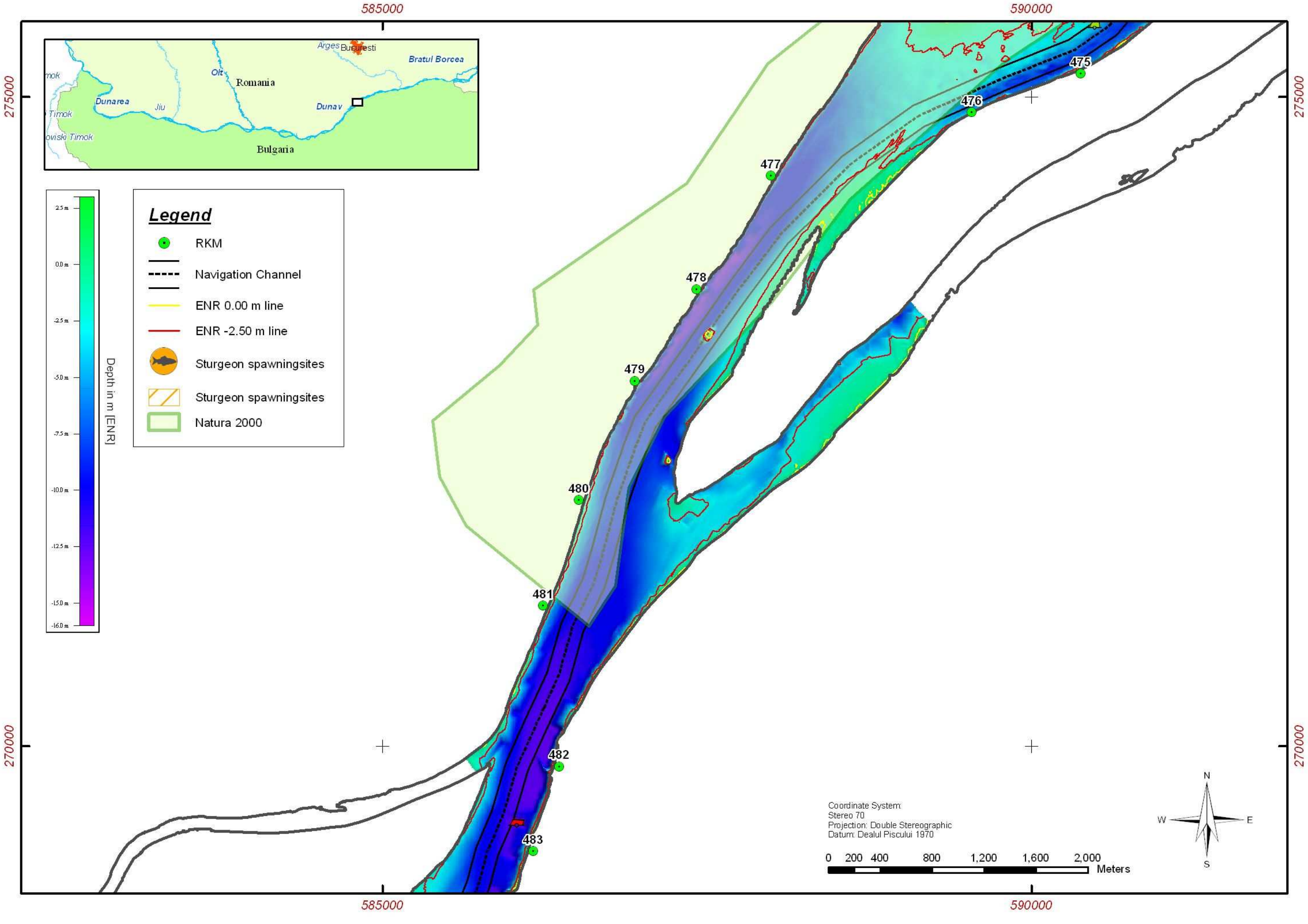

Figure 64: Ostrovul Alek Present Conditions

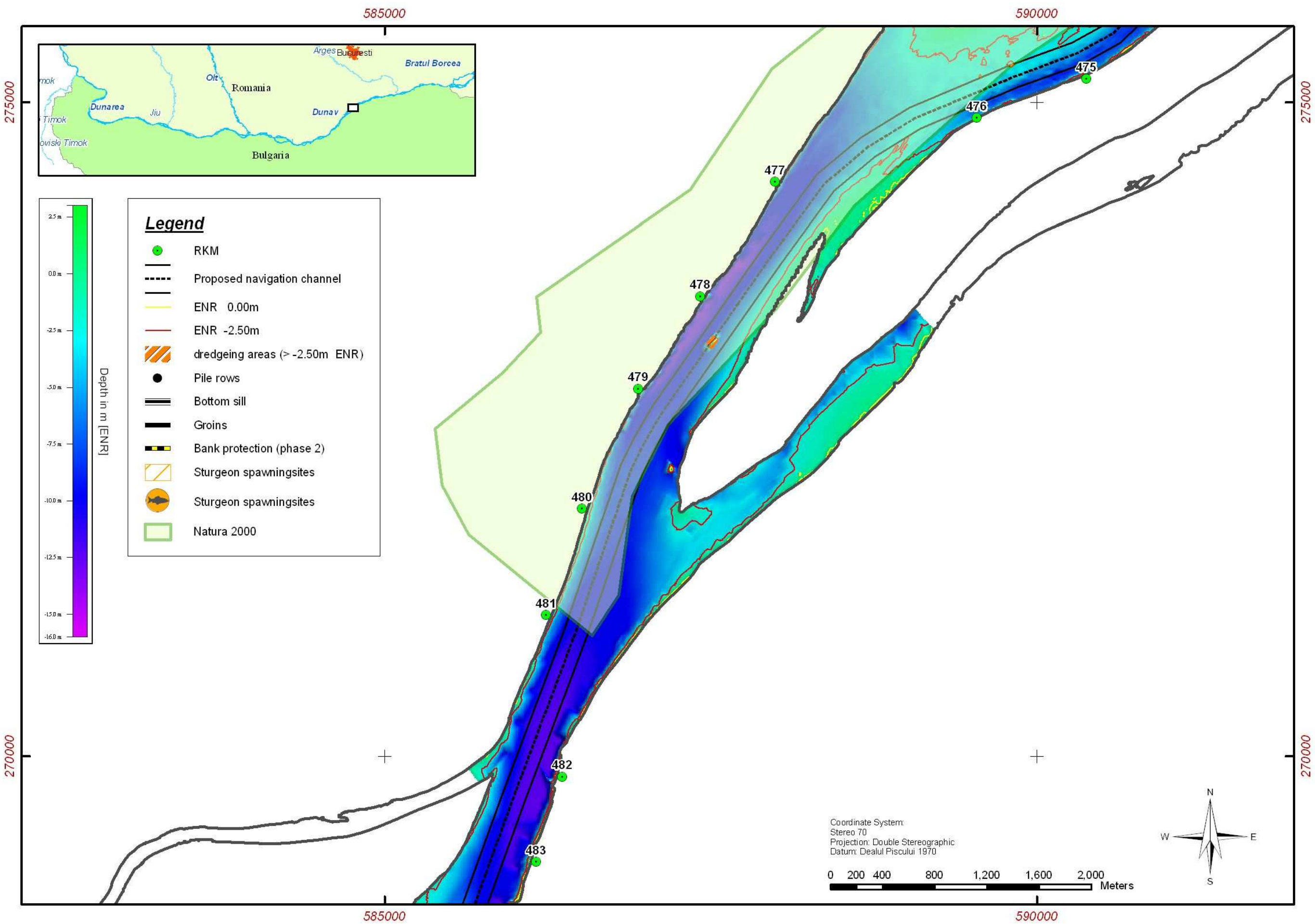

Figure 65: Ostrovul Alek Alternative Development Strategy

24. Gostinu Island (km 477-473)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	21
Location:		
Slobozia		
Position:	Danube sector:	
rKm 500 – 497	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• APPD Ruse		
Description of the present situation:		
No problems for navigation at present.		
Proposed works:		
Harris (1999): None		
Solution proposed by JV Technum, Trapec, Tractebel, CNR, Safege:		
The last bathymetry of 2008 confirms no difficulties for navigation in the sector. No measures are proposed in this area.		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)		

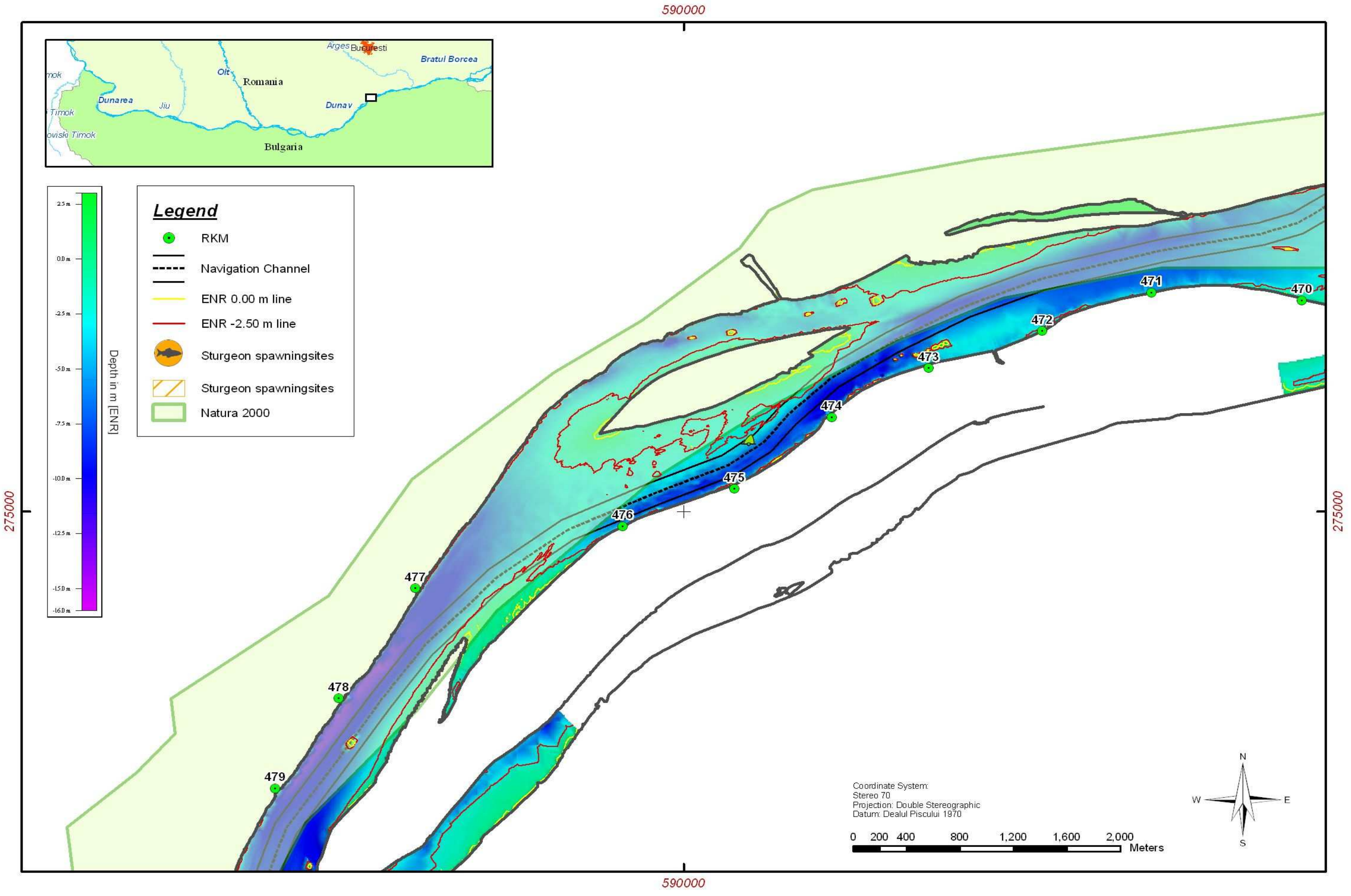

Figure 66: Gostinu Island Present Conditions

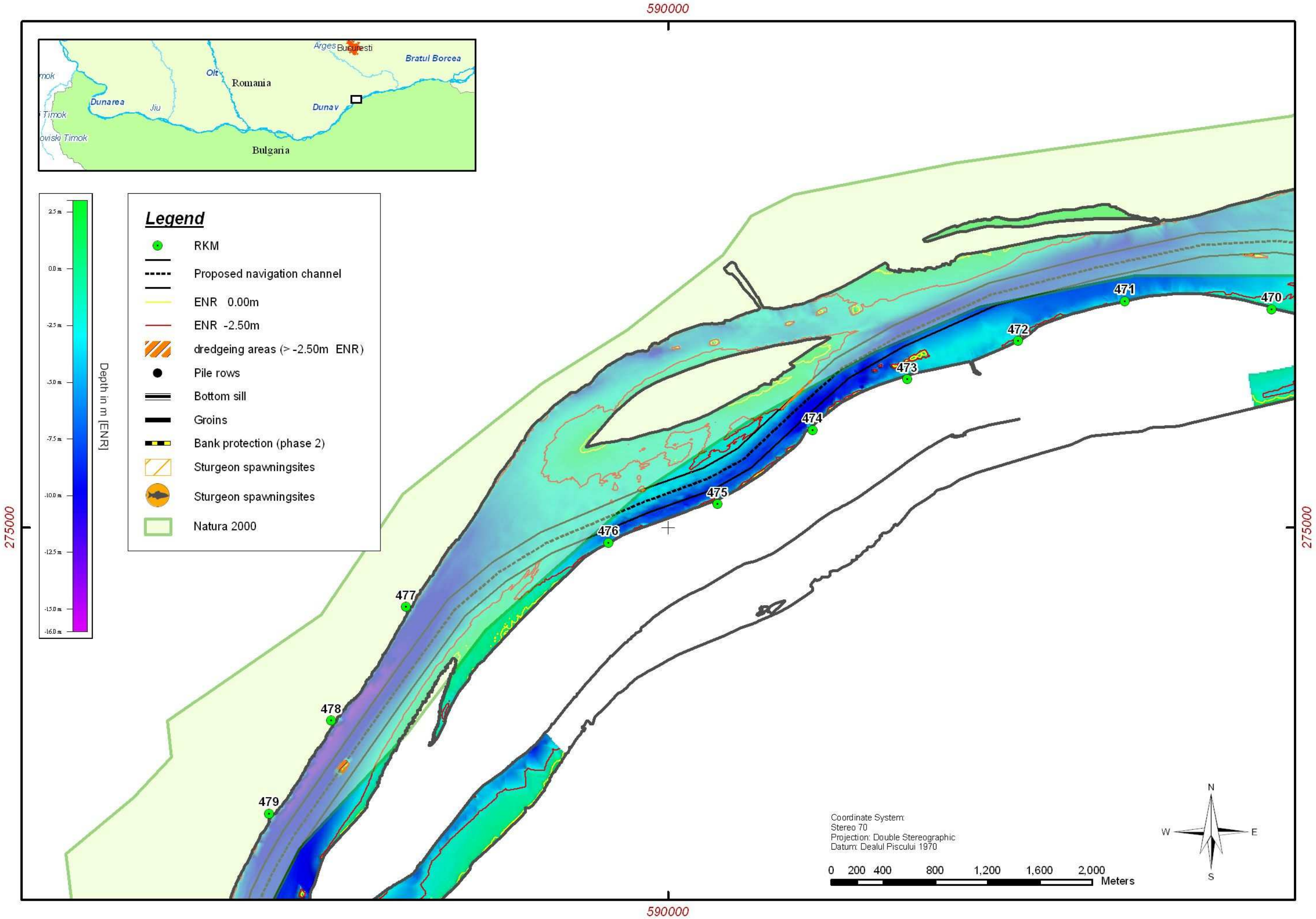

Figure 67: Gostinu Island Alternative Development Strategy

25. Lungu Island (km 470-467)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	25
Location:		
Lungu Island		
Position:	Danube sector:	
rKm 470-467	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Harris (1999)		
Description of the present situation:		
The width of the navigation channel does not comply the recommendations of the Danube Committee for the Danube maritime fairway at rkm 465. There is an industrial pump station at rkm 465+500.		
Proposed works:		
Harris (1999): The proposed structure is a bottom sill at Gostinul.		
Solution proposed by JV Technum, Trapec, Tractebel, CNR, Safege:		
The realignment of the navigation channel on the right bank is necessary to assure its minimum width, together with some dredging. Besides, a bottom sill on the secondary branch and a directional groin are proposed in the TWS. An alternative design of the bottom sill and the groin detached from the bank (e.g. wing dam notching) are suggested in the EES allowing flow between the structure and the banks. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works; • Keep impact on deep areas as low as possible (spawning sites); • Two open bottom sills instead of one; • Useful application of dredged material;		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)		

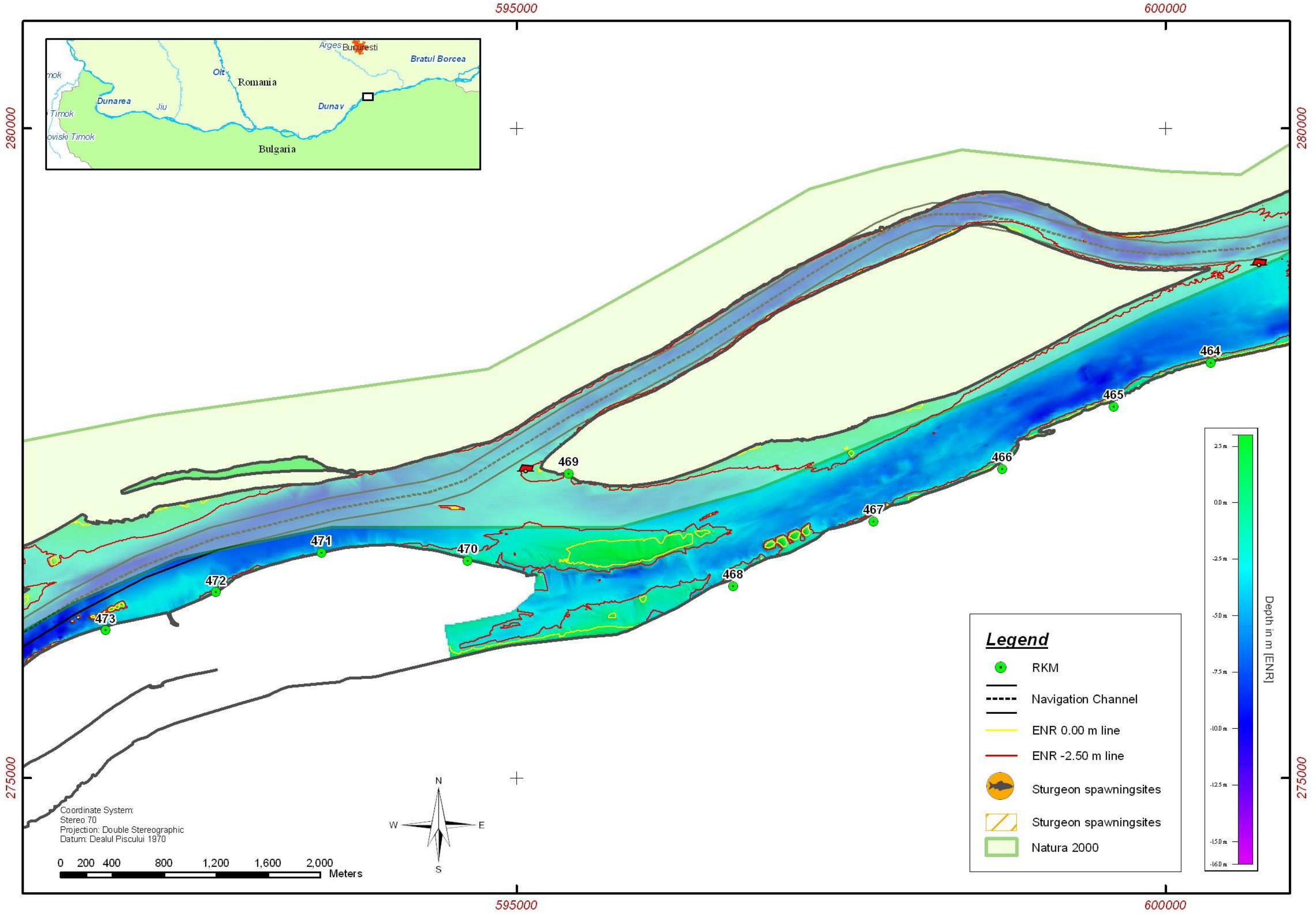

Figure 68: Lungu Island Present Conditions

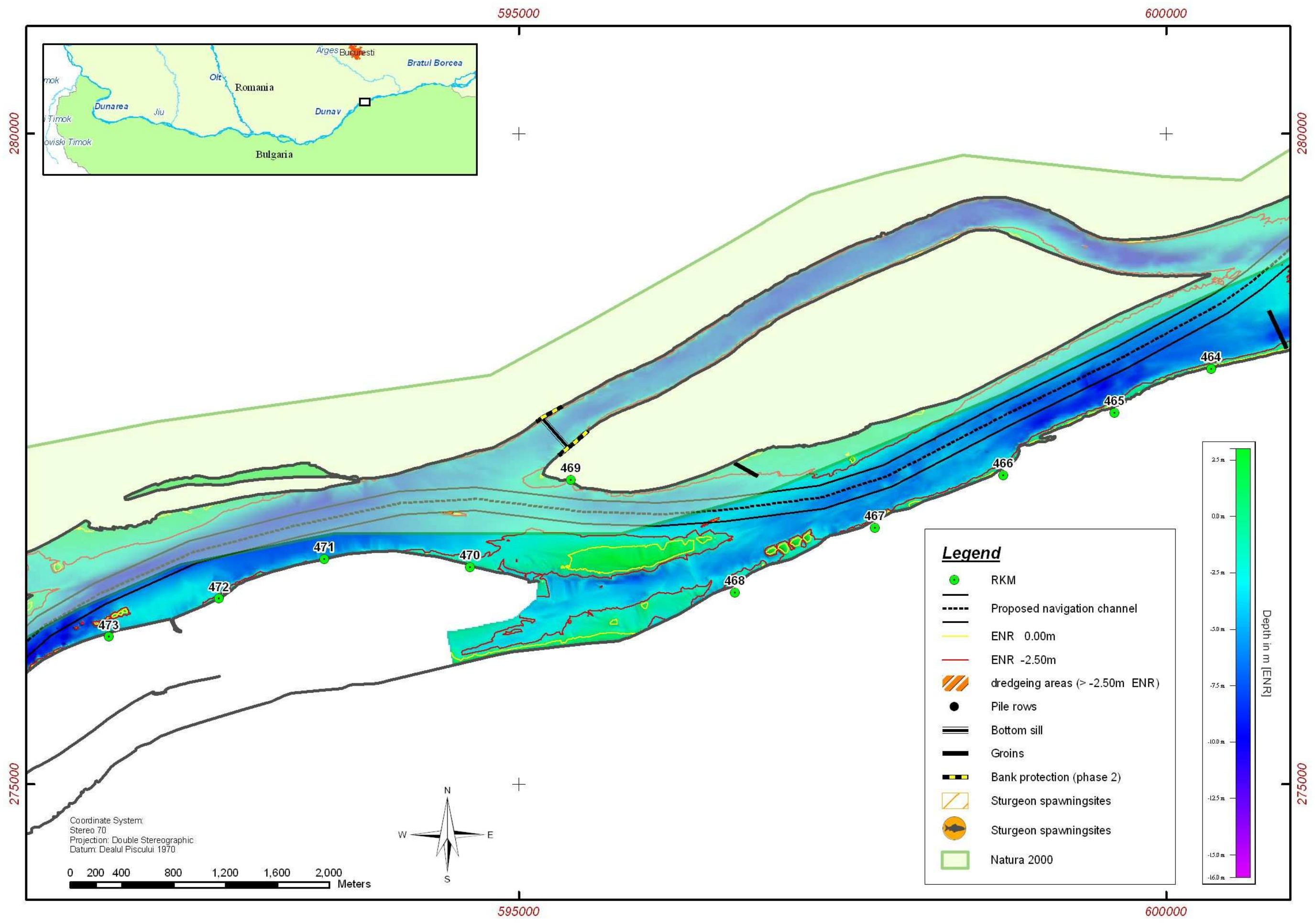

Figure 69: Lungu Island Alternative Development Strategy

26. Mishka Island (km 467-450)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	26
Location:		
Mishka Island		
Position:	Danube sector:	
rKm 467-450	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Harris (1999) • APPD Ruse		
Description of the present situation:		
The numerous branches of the river in this area make a wide river with shoals. Difficulties for navigation occur during low flow conditions when flow is distributed among the several branches. There are no problems for navigation at present.		
Proposed works:		
Harris (1999): The option is to construct series of groins that reduce the river cross-section and concentrates the flow in the branch of the navigation channel. Bank protection may be necessary.		
Alternative Development Strategies (Technum et al., 2008):		
The realignment of the navigation channel on the right branch is proposed (rkm468-464). This will allow a wider and straighter channel. The TWS also includes three groins between rkm464-461 on the right bank, and a set of structures (3 groins and 3 chevrons) between rkm458-456; these structures confine the river flow in the wide present cross sections. The MS (and EES) does not include the structures of the TWS. There are no problems for navigation at present and these structures can be implemented in a second phase of construction works. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of large training works; • Keep impact on deep areas as low as possible (spawning sites); • Useful application of dredged material; • Open groins at the river bank; • Smaller number of groins with L-shape;		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)		

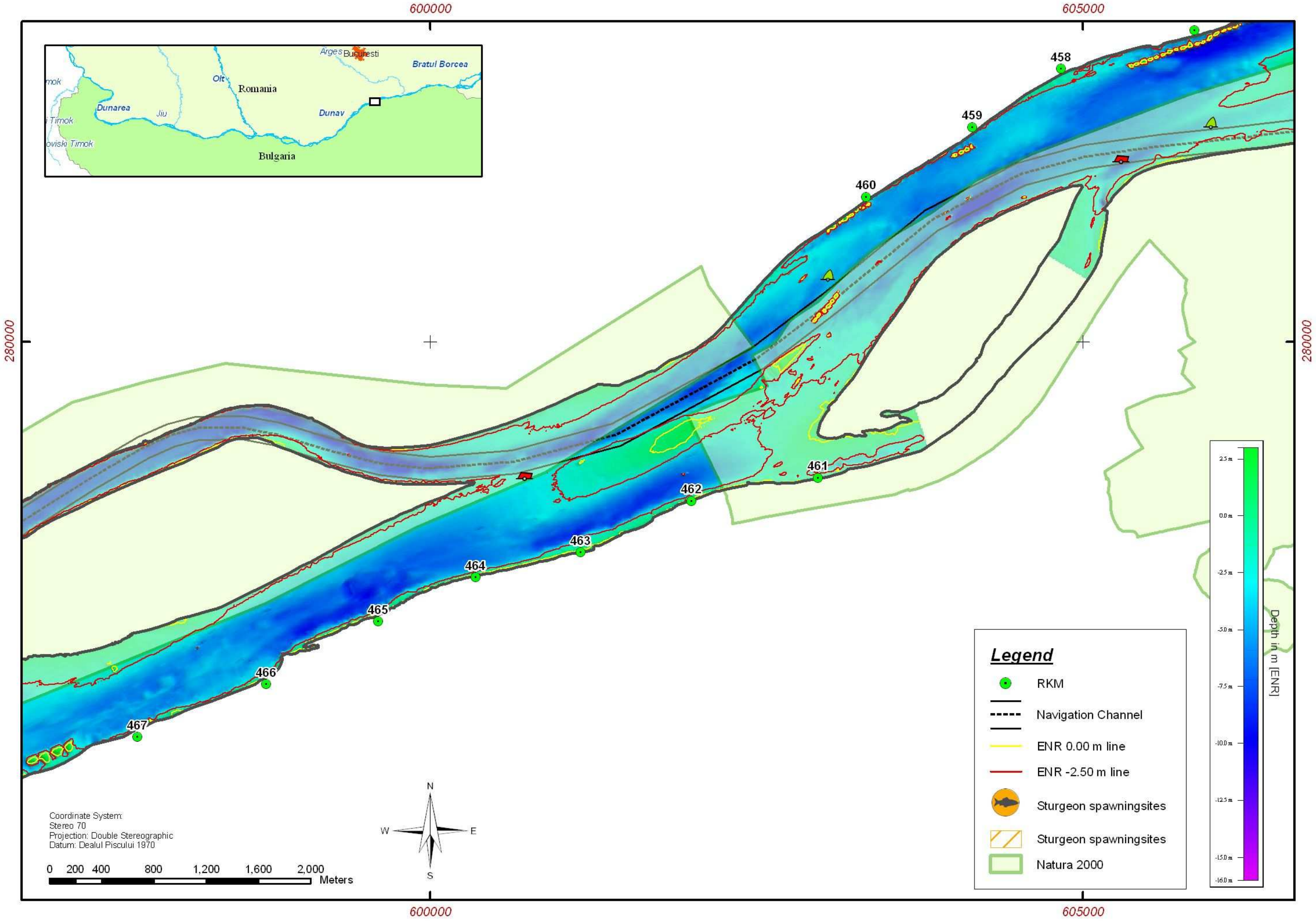

Figure 70: Mishka Island Present Conditions A

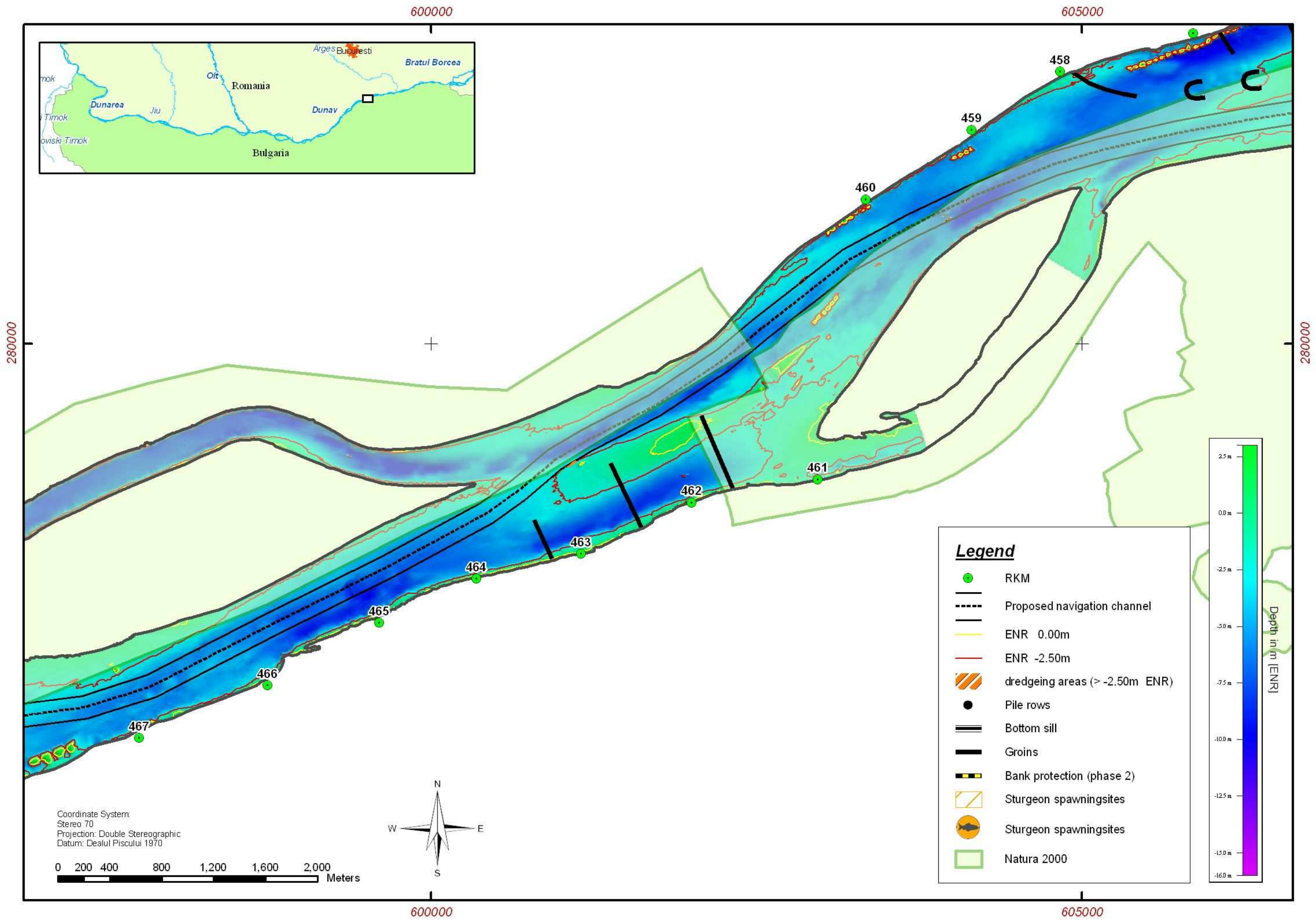

Figure 71: Mishka Island Alternative Development Strategy A

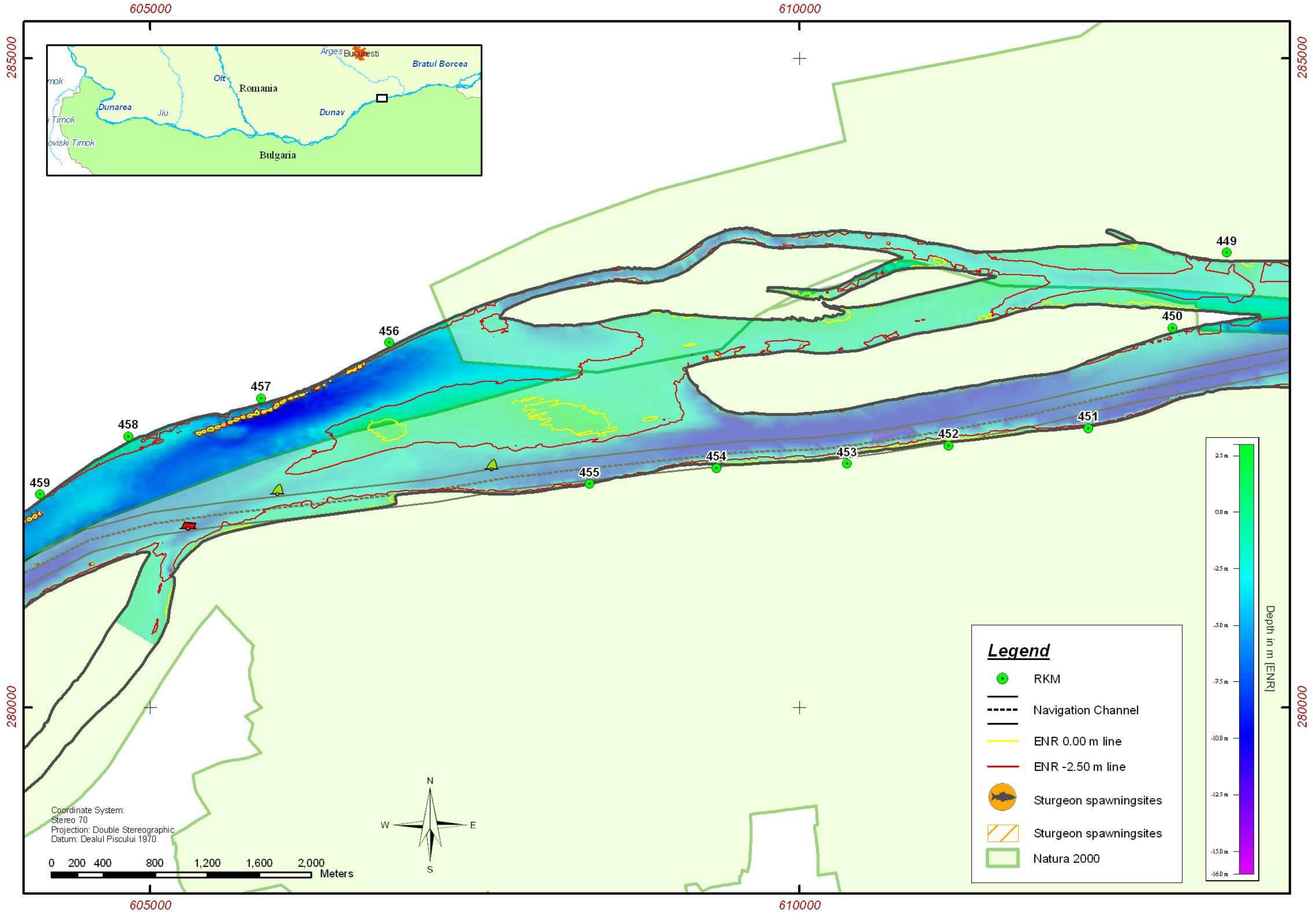

Figure 84: Mishka Island Present Conditions B

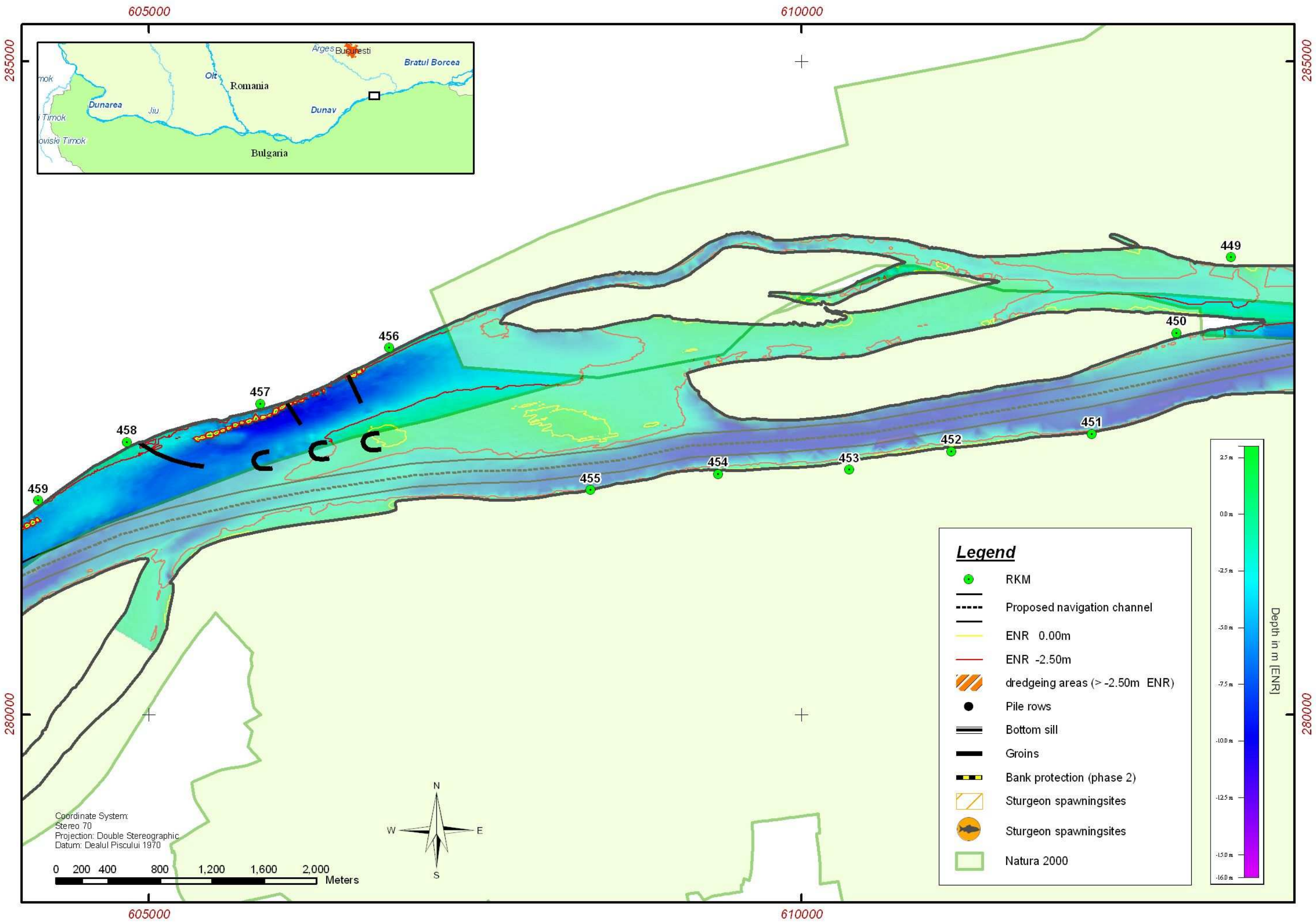

Figure 72: Mishka Island Alternative Development Strategy B

27. Radetzki Island (km 441-435)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	27
Location:		
Radetzki Island		
Position:	Danube sector:	
rKm 441-435	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• APPD Ruse		
Description of the present situation:		
There are no problems for navigation at present.		
Proposed works:		
Harris (1999):		
Alternative Development Strategies (Technum et al., 2008):		
A realignment of the navigation channel would be enough to improve this sector. No other measures are proposed in this area.		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)		

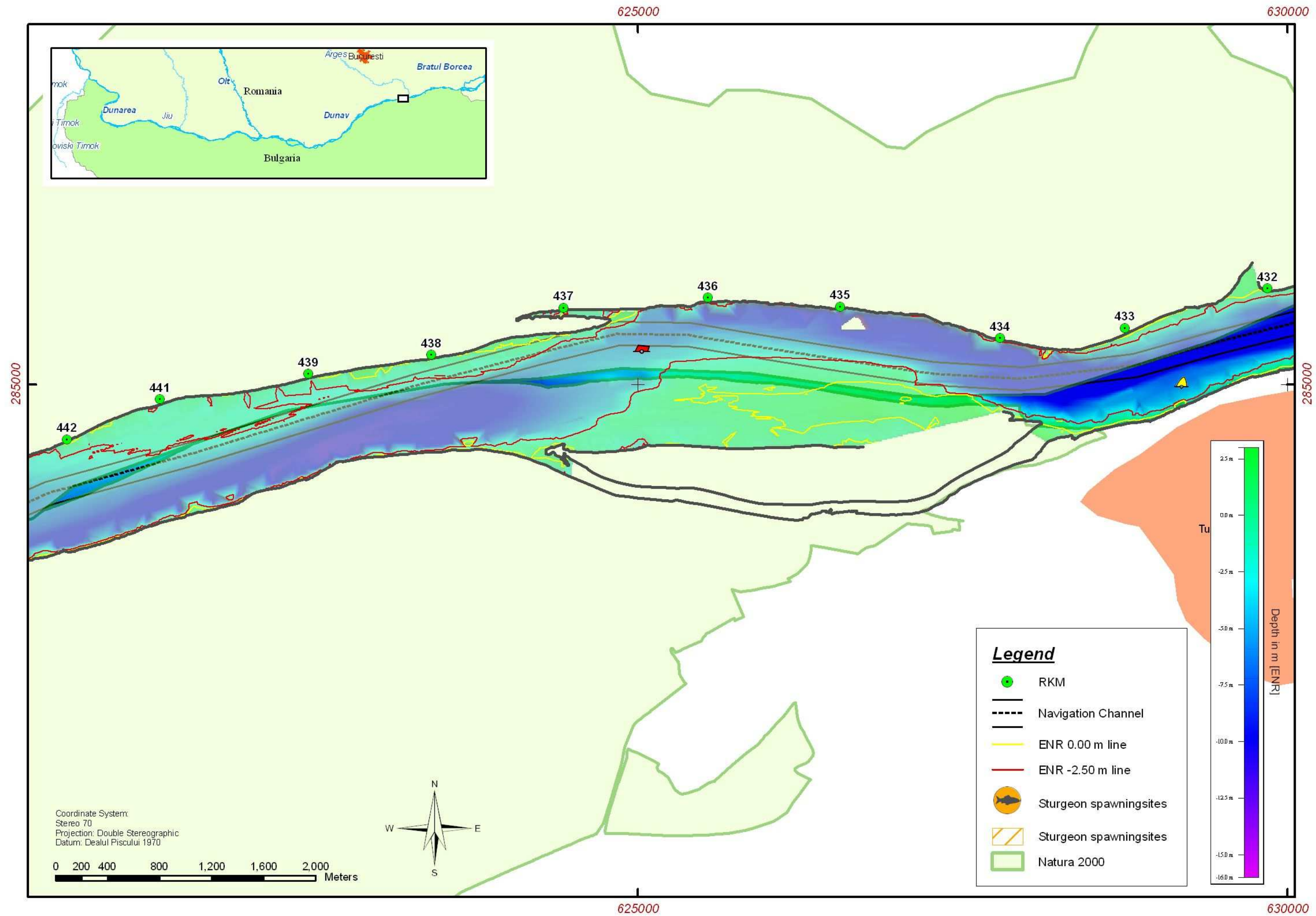

Figure 73: Radetzki Island Present Conditions

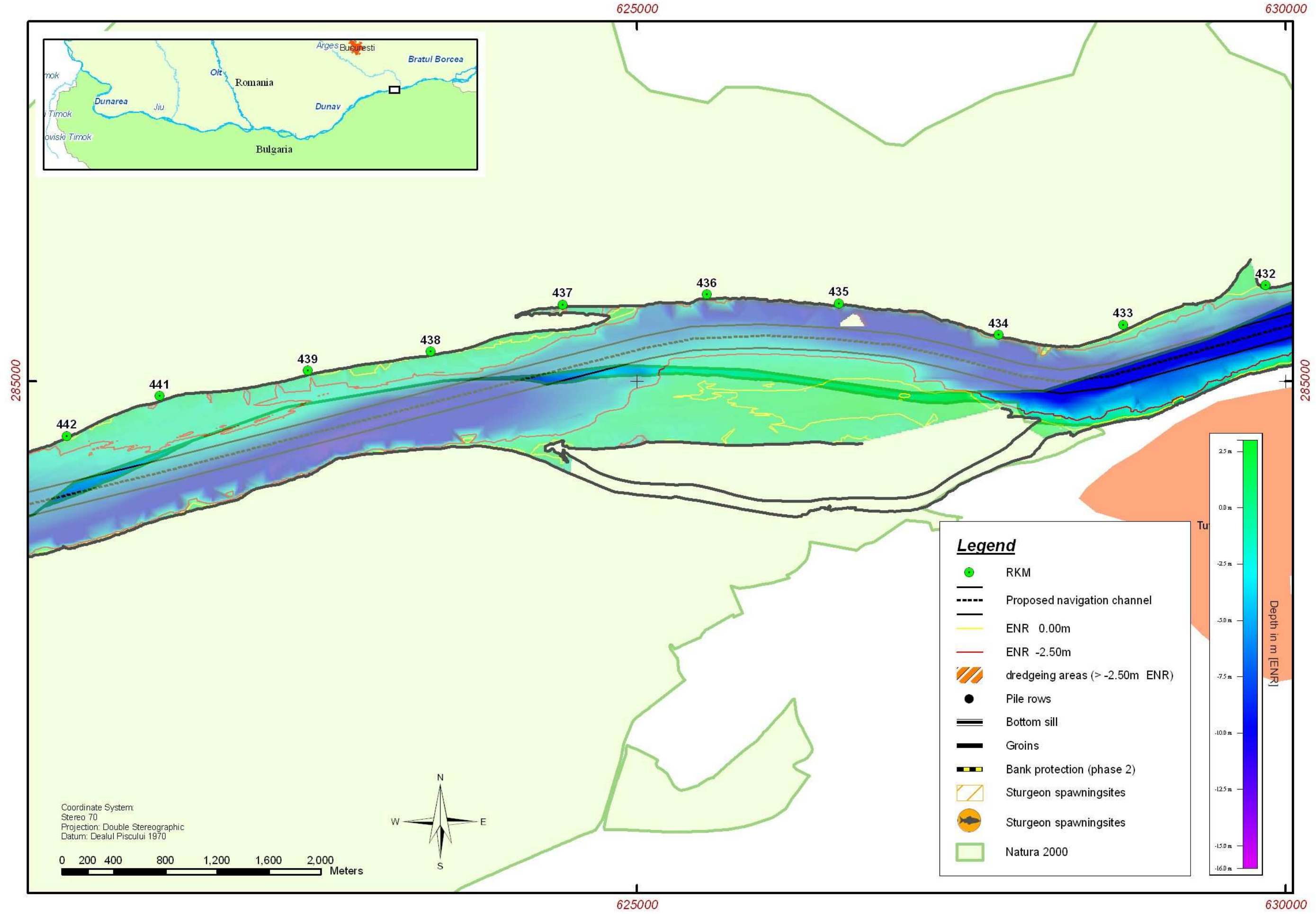

Figure 74: Radetzki Island Alternative Development Strategy

28. Kosui (km 426-420)

<table>
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<tr><td colspan="3" align="center">Kosui</td></tr>
<tr><td>Position:</td><td colspan="2">Danube sector:</td></tr>
<tr><td>rKm 426-420</td><td colspan="2">Common Romanian – Bulgarian sector
rKm 610 - 845.5</td></tr>
<tr><td colspan="3">Sector for detail measurements:</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Critical point reported by:</td></tr>
<tr><td colspan="3">• APPD Ruse</td></tr>
<tr><td colspan="3">Description of the present situation:</td></tr>
<tr><td colspan="3">At rkm 432 arrives the tributary Arges River from Romania. This is a source of sediment but it is not presenting difficulties for navigation.
Difficulties for navigation occur at rkm 427-426 during low flow regime. There were many difficulties at this location in summer 2007.
There are also difficulties due to the narrow width of the navigation channel, although the sand bar at the north of the Kosui Island is relatively stable.</td></tr>
<tr><td colspan="3">Proposed works:</td></tr>
<tr><td colspan="3">Harris (1999):
The option is to guide the Danube flows at low levels on the left branch by providing a sill for closing the right branch. Banks strengthening works may be required.</td></tr>
<tr><td colspan="3">Alternative Development Strategies (Technum et al., 2008):</td></tr>
<tr><td colspan="3">It is proposed dredging to comply the minimum depth, together with the realignment of the navigation channel to reduce the dredging volumes.
In addition, a bottom sill and 3 groins are proposed in the TWS to reduce the flow in the secondary branch during low flow periods and redirect the flow towards the left branch. The same measures are proposed in the MS.
In the EES is proposed to start with the groins of the TWS and the bottom sill only in a second phase after evaluation of the groins on the sedimentation of the fairway.
Other important aspects for the EES and GES, and in general for construction:
• Phasing of dredging to take into account fish spawning/migration;
• Phasing of large training works;
• Keep impact on deep areas as low as possible (spawning sites);
• Useful application of dredged material;
• Open groins at the river bank;
• Two open bottom sills instead of one;
• Smaller number of groins with L-shape.</td></tr>
</table>

Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)

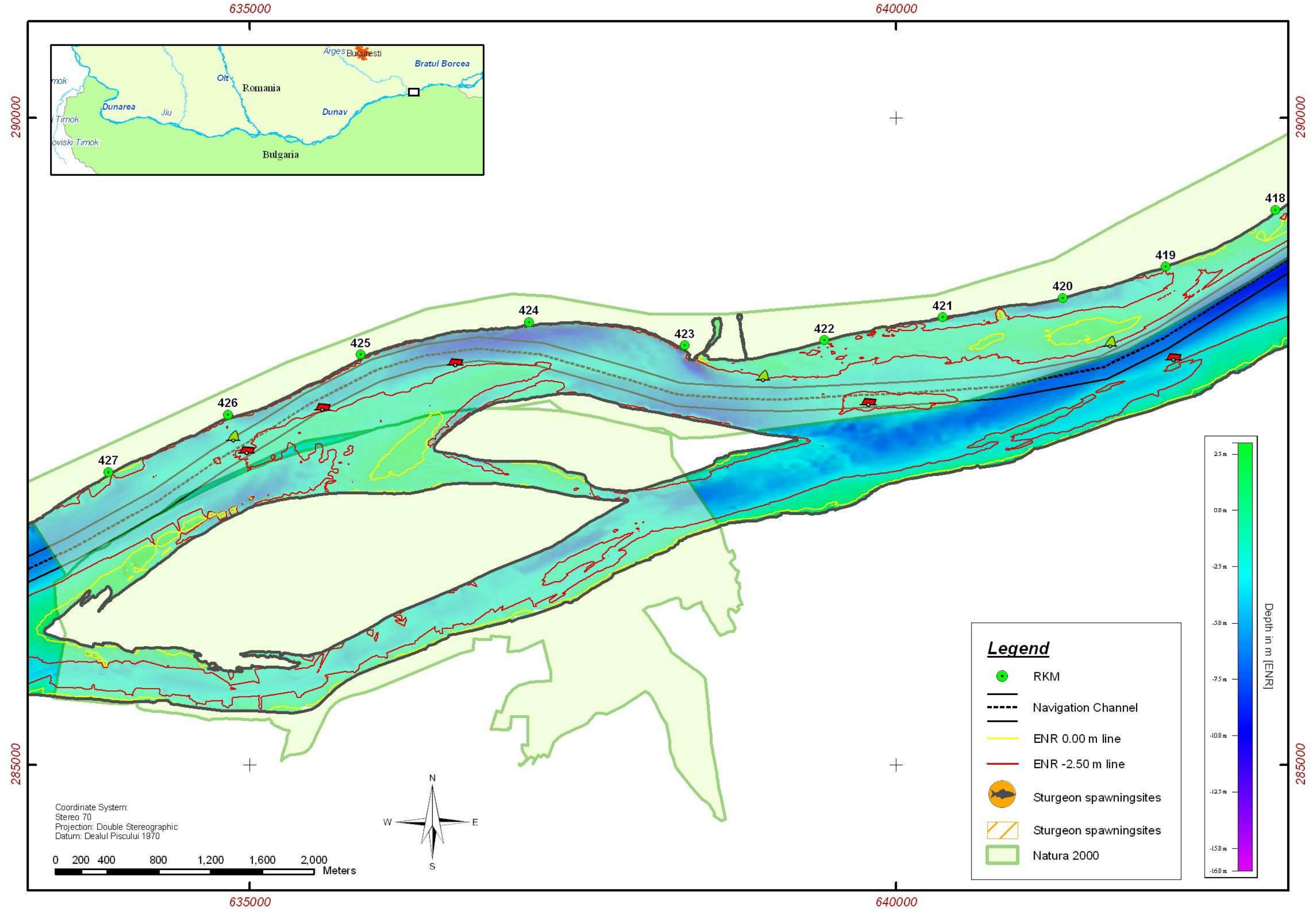

Figure 75: Kosui Present Conditions

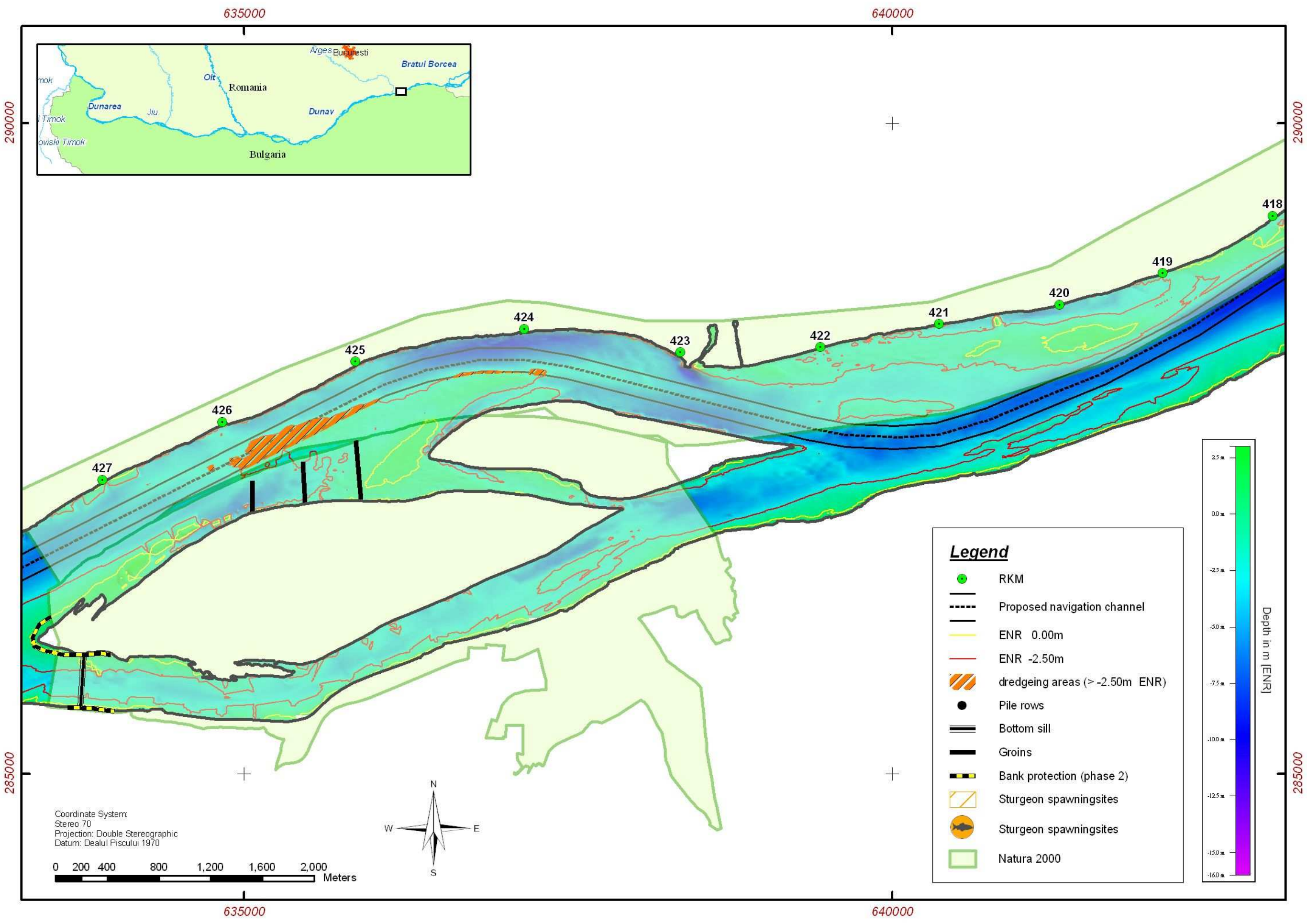

Figure 76: Kosui Alternative Development Strategy

29. Albina (km 415-410)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	29
Location:		
Albina		
Position:	Danube sector:	
rKm 415-410	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• APPD Ruse		
Description of the present situation:		
There are no problems for navigation at present.		
Proposed works:		
Alternative Development Strategies (Technum et al., 2008):		
A realignment of the navigation channel would be enough to improve this sector. However, because the river increases its cross section width at rkm414-413, the TWS includes three groins on the left bank. No training works are proposed in the MS and EES. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of training works; • Keep impact on deep areas as low as possible (spawning sites); • Useful application of dredged material; • Open groins at the river bank; • Smaller number of groins with L-shape.		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)		

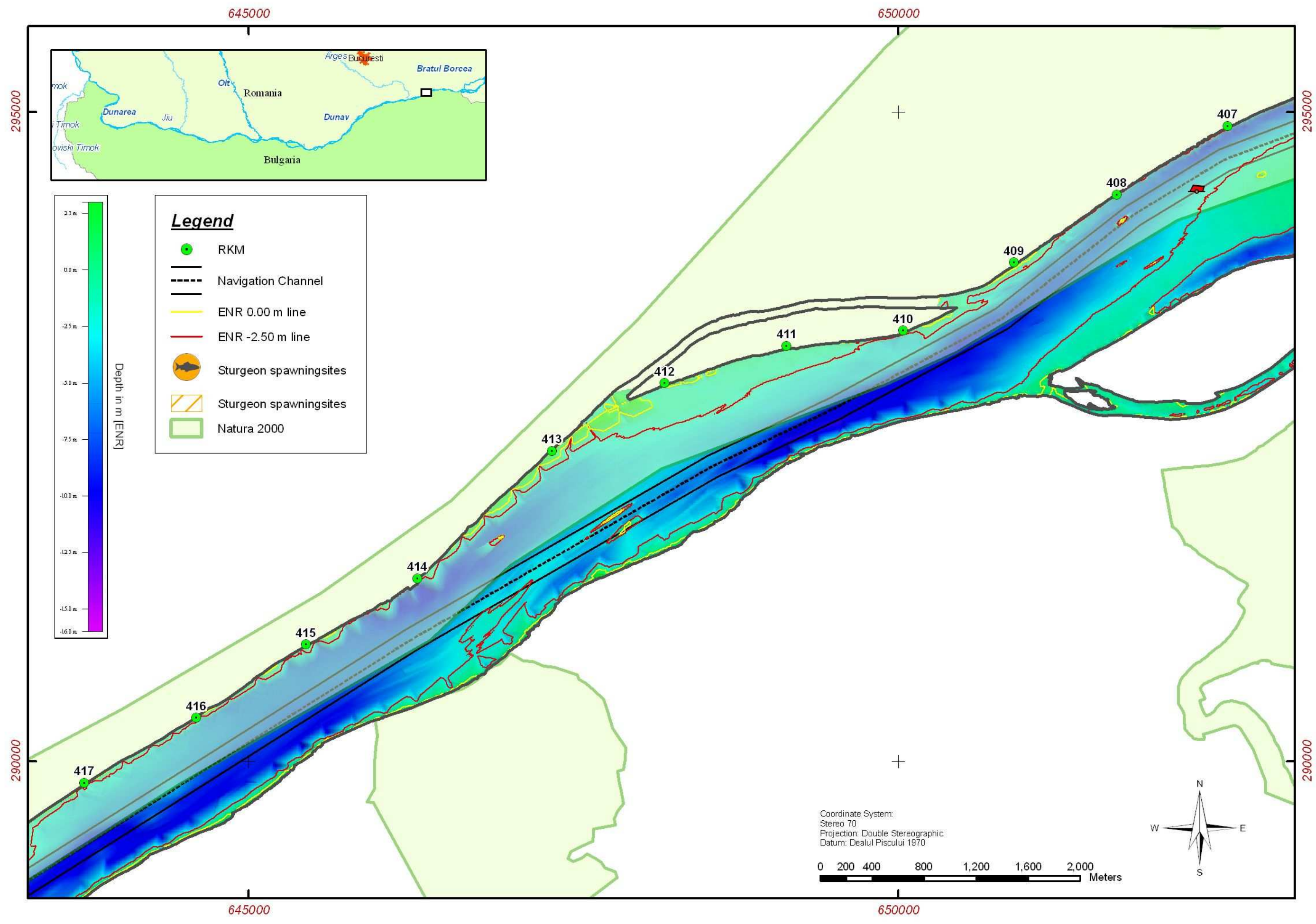

Figure 77: Albina Present Conditions

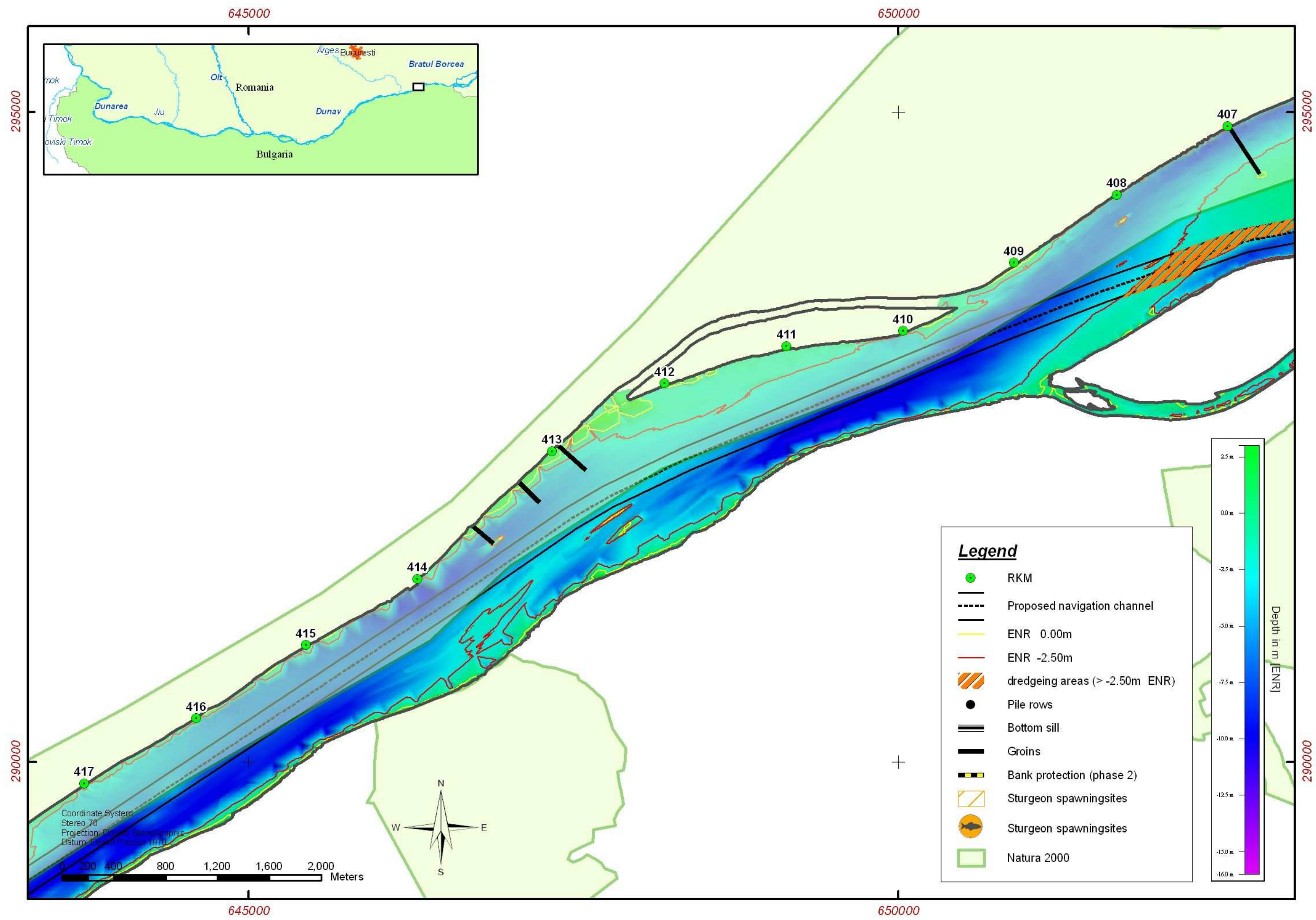

Figure 78: Albina Alternative Development Strategy

30. Popina (km 409-400)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	30
Location:		
Popina		
Position:	Danube sector:	
rKm 409-400	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Harris (1999) • Navigation Directorate • APPD Ruse		
Description of the present situation:		
Small islands and sand banks occur, distributing river flow among the several branches. This results in low flow velocities in the main channel during low flow conditions and the navigation channel depth and width cannot be kept naturally. There are no problems for navigation at present.		
Proposed works:		
Harris (1999): The proposed solution includes groins, bank protection and a bottom sill in Valasti (rkm 400).		
Alternative Development Strategies (Technum et al., 2008):		
The navigation channel is moved towards the right bank. Because the river increases its cross section width at rkm407-405, the TWS includes three groins on the left bank. No training works are proposed in the MS and EES. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of training works; • Keep impact on deep areas as low as possible (spawning sites); • Useful application of dredged material; • Open groins at the river bank; • Smaller number of groins with L-shape.		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)		

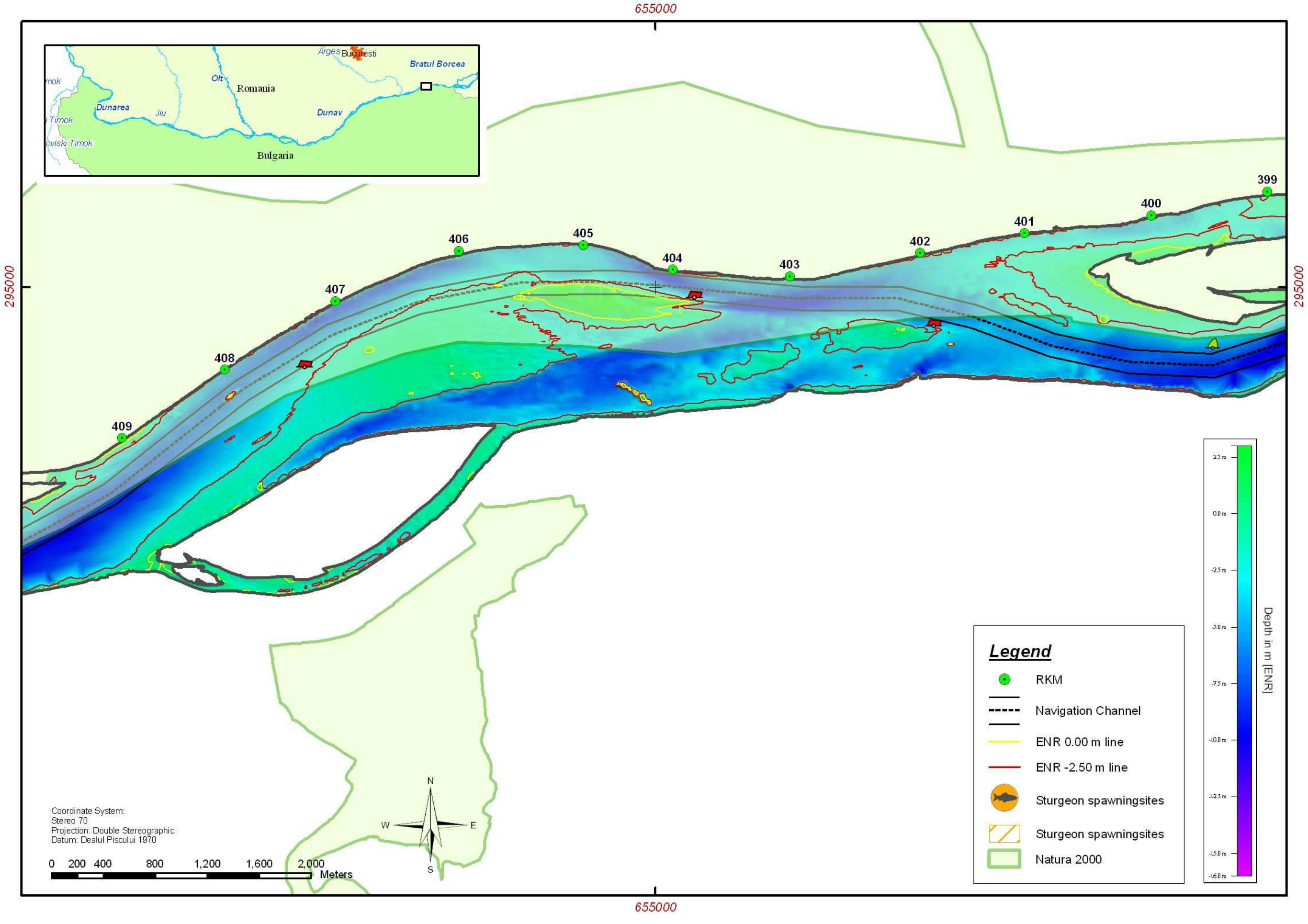

Figure 79: Popina Present conditions

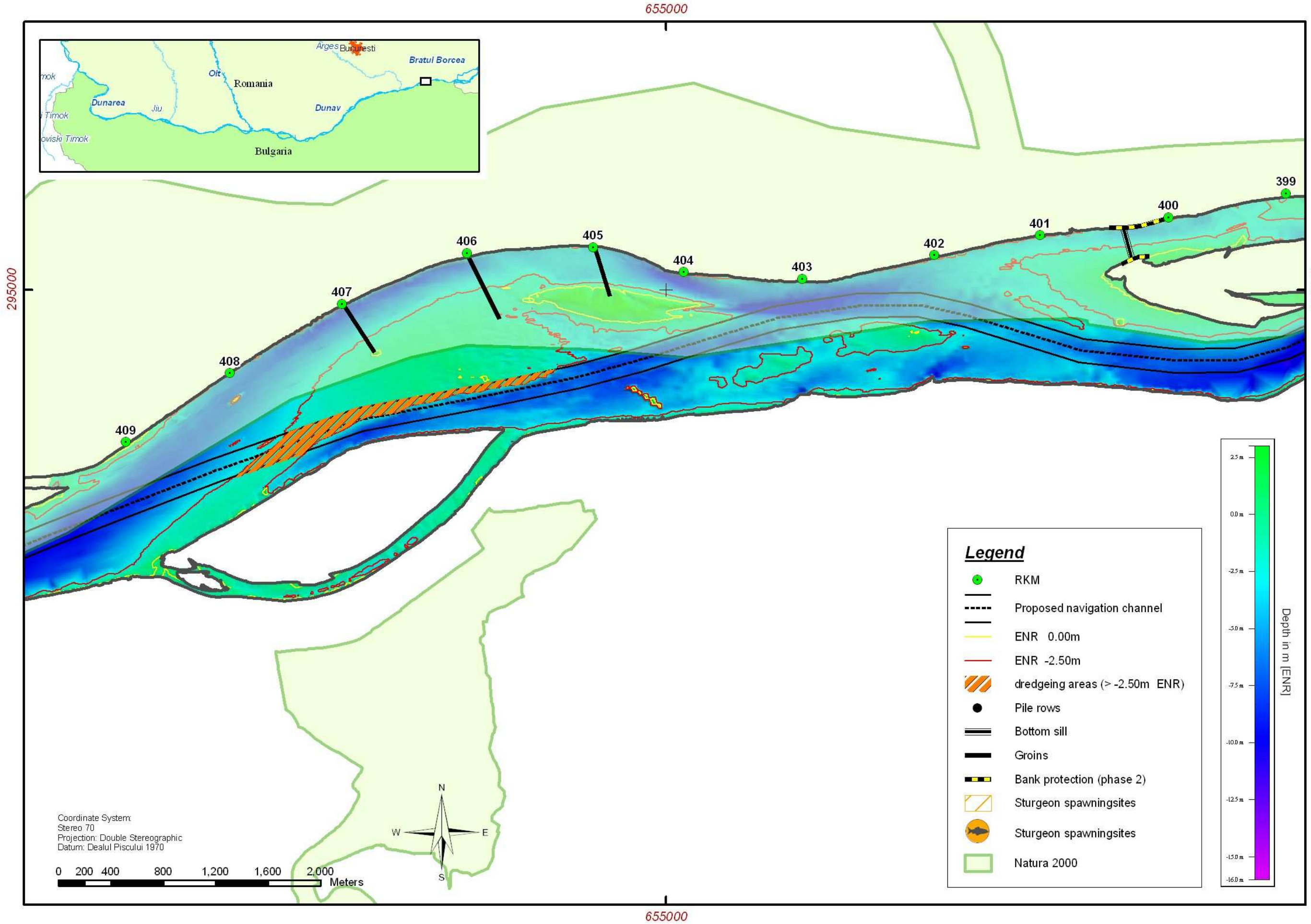

Figure 80: Popina Alternative Development Strategy

31. Varasti Island (km 400-399)

<table>
<tr><td></td><td>Last update of this sheet:</td><td>18/09/08</td></tr>
<tr><td></td><td>Critical Sector Number:</td><td>31</td></tr>
<tr><td colspan="3">Location:</td></tr>
<tr><td colspan="3" align="center">Varasti Island</td></tr>
<tr><td>Position:</td><td colspan="2">Danube sector:</td></tr>
<tr><td>rKm 400-399</td><td colspan="2">Common Romanian – Bulgarian sector
rKm 610 - 845.5</td></tr>
<tr><td colspan="3">Sector for detail measurements:</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Critical point reported by:</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Description of the present situation:</td></tr>
<tr><td colspan="3">The width of the navigation channel does not comply the recommendations of the Danube Committee for the Danube maritime fairway between rkm 400-399.</td></tr>
<tr><td colspan="3">Proposed works:</td></tr>
<tr><td colspan="3">Harris (1999):
The proposed structures are a bottom sill at Varasti and at Vetren.</td></tr>
<tr><td colspan="3">Alternative Development Strategies (Technum et al., 2008):</td></tr>
<tr><td colspan="3">The navigation channel is slightly modified on the right branch (rkm400) and a bottom sill in the secondary branch is proposed in the TWS. No training works are proposed in the MS and EES. Other important aspects for the EES and GES, and in general for construction:
• Phasing of dredging to take into account fish spawning/migration;
• Phasing of training works;
• Keep impact on deep areas as low as possible (spawning sites);
• Useful application of dredged material;
• Two open bottom sills instead of one.</td></tr>
<tr><td colspan="3">Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)</td></tr>
</table>

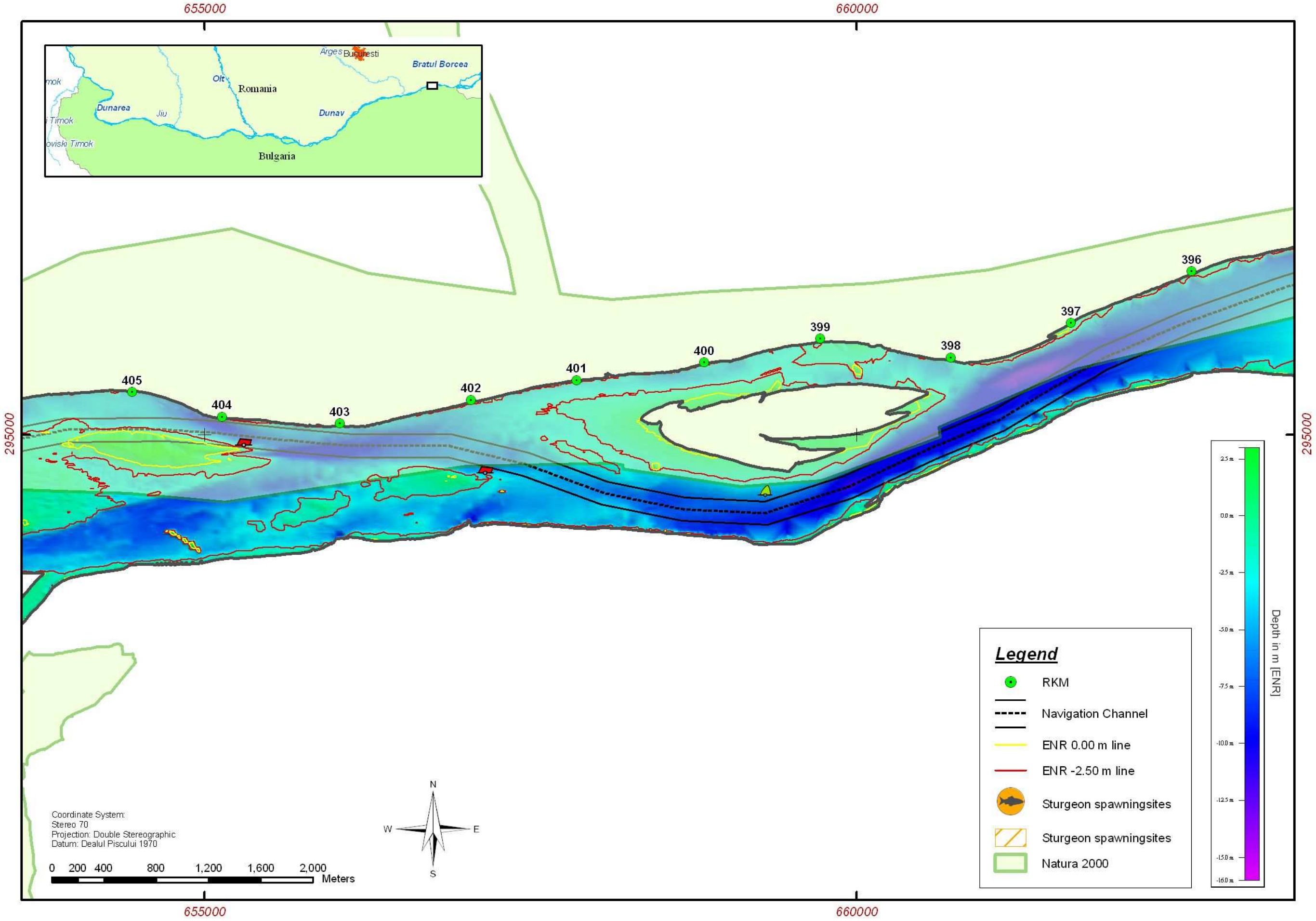

Figure 81: Varasti Island Present Conditions

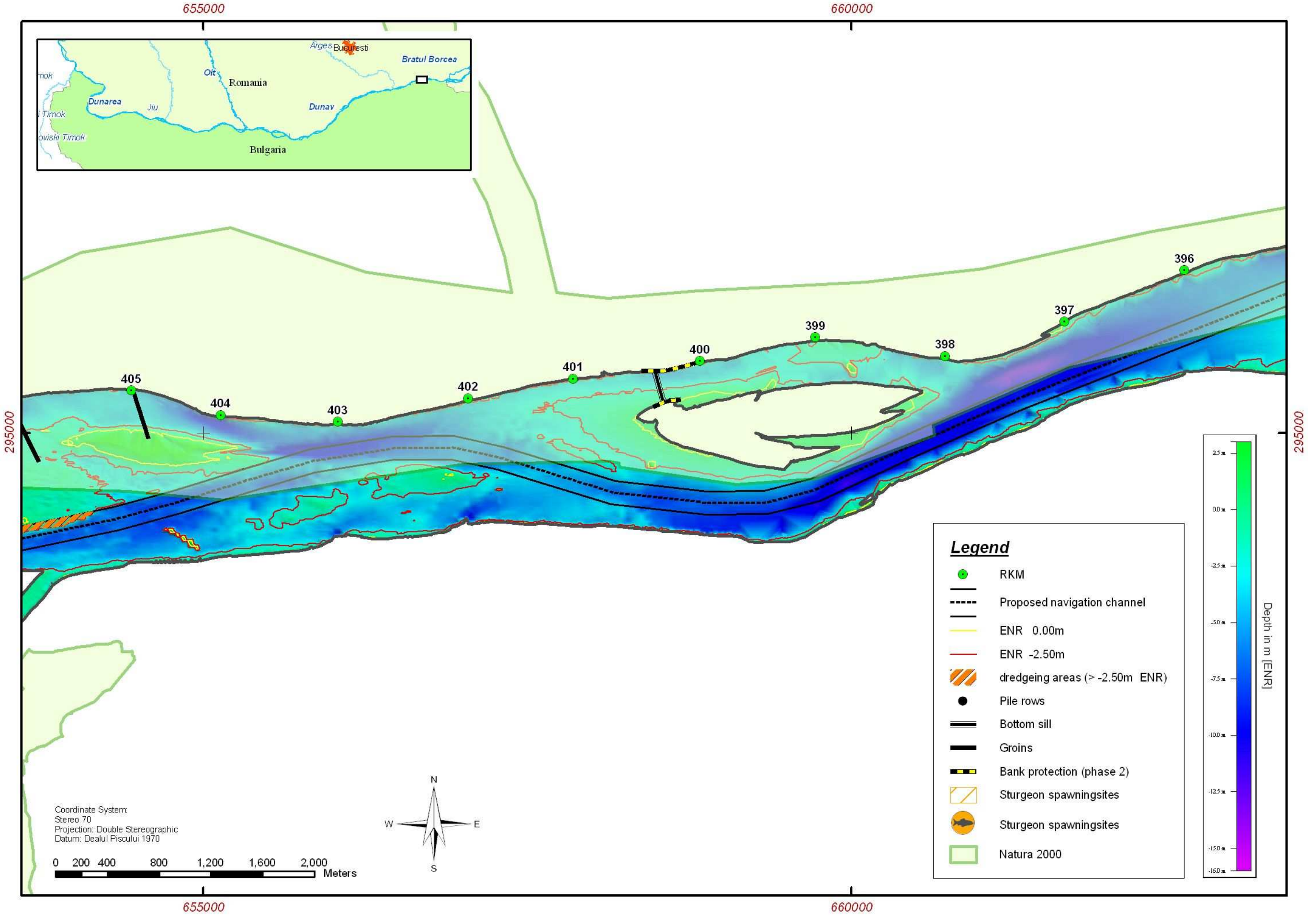

Figure 82: Varasti Island Alternative Development Strategy

32. Vetren (km 395-390)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	32
Location:		
Vetren		
Position:	Danube sector:	
rKm 395-390	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• Harris (1999) • Navigation Directorate • APPD Ruse		
Description of the present situation:		
There are no problems for navigation at present.		
Proposed works:		
Harris (1999): The proposed structures are a bottom sill at Varasti and at Vetren.		
Alternative Development Strategies (Technum et al., 2008):		
No measures are proposed in this area.		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)		

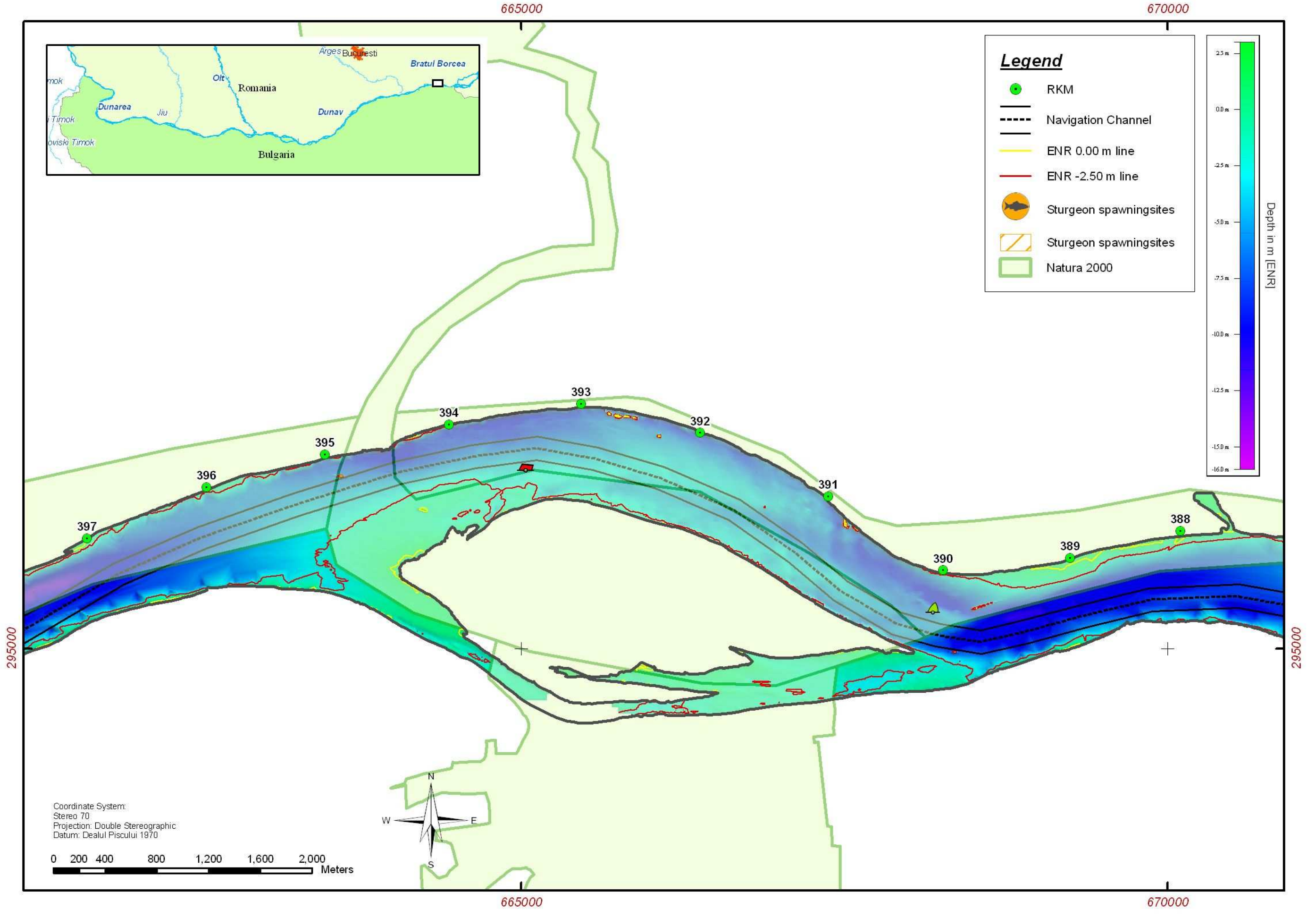

Figure 83: Vetren Present Conditions

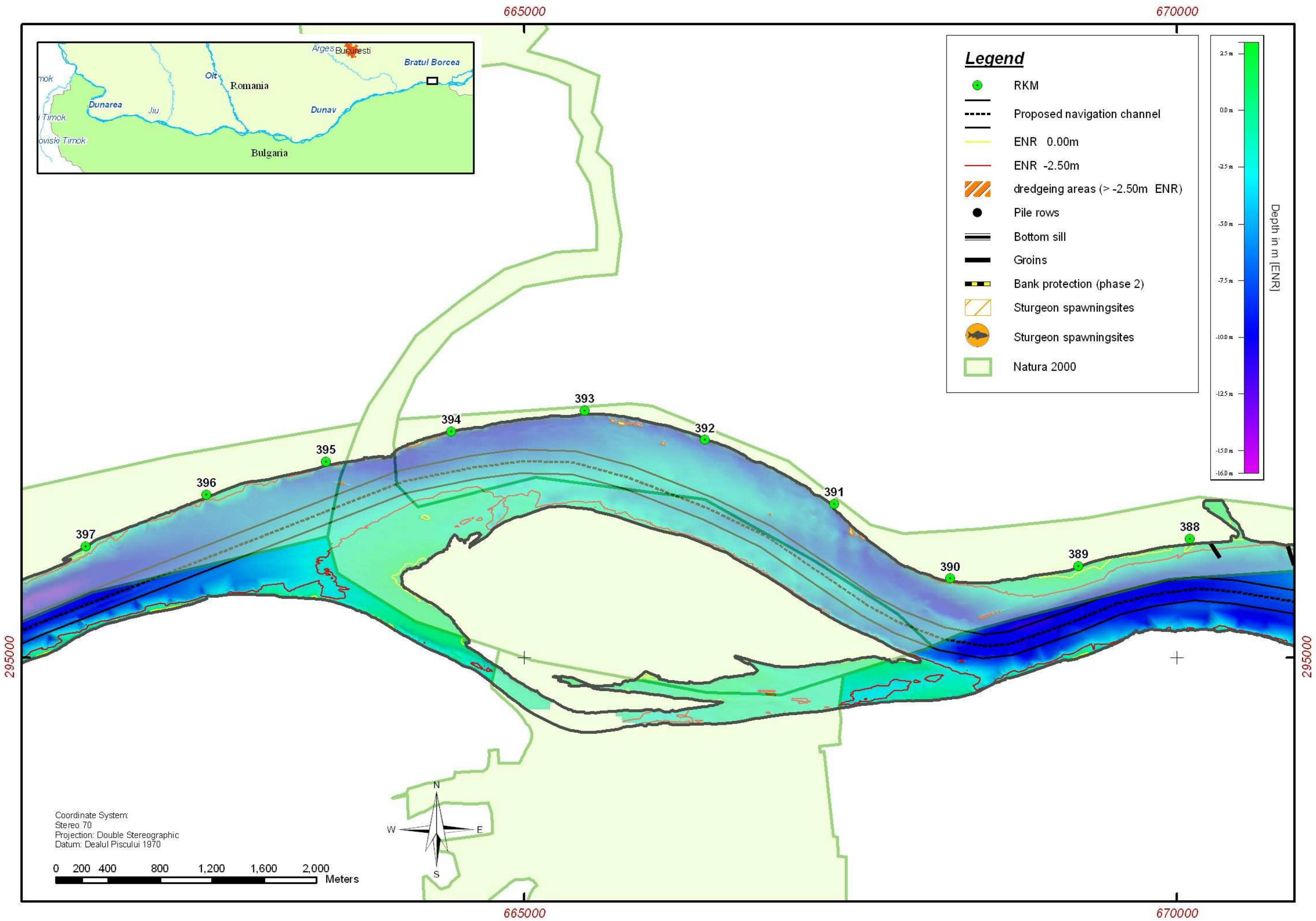

Figure 84: Vetren Alternative Development Strategy

33. Chayka Island (km 386-382)

	Last update of this sheet:	18/09/08
	Critical Sector Number:	33
Location:		
Chayka Island		
Position:	Danube sector:	
rKm 386-382	Common Romanian – Bulgarian sector rKm 610 - 845.5	
Sector for detail measurements:		
Critical point reported by:		
• APPD Ruse		
Description of the present situation:		
There are no problems for navigation at present.		
Proposed works:		
Harris (1999):		
Alternative Development Strategies (Technum et al., 2008):		
A realignment of the navigation channel and a small dredging volume would be enough to improve this sector. However, because the river increases its cross section width at rkm388-386, the TWS includes three groins on the left bank. No training works are proposed in the MS and EES. Other important aspects for the EES and GES, and in general for construction: • Phasing of dredging to take into account fish spawning/migration; • Phasing of training works; • Keep impact on deep areas as low as possible (spawning sites); • Useful application of dredged material; • Open groins at the river bank; • Smaller number of groins with L-shape.		
Selected solutions JV Technum, Trapec, Tractebel, CNR, Safege (2008)		

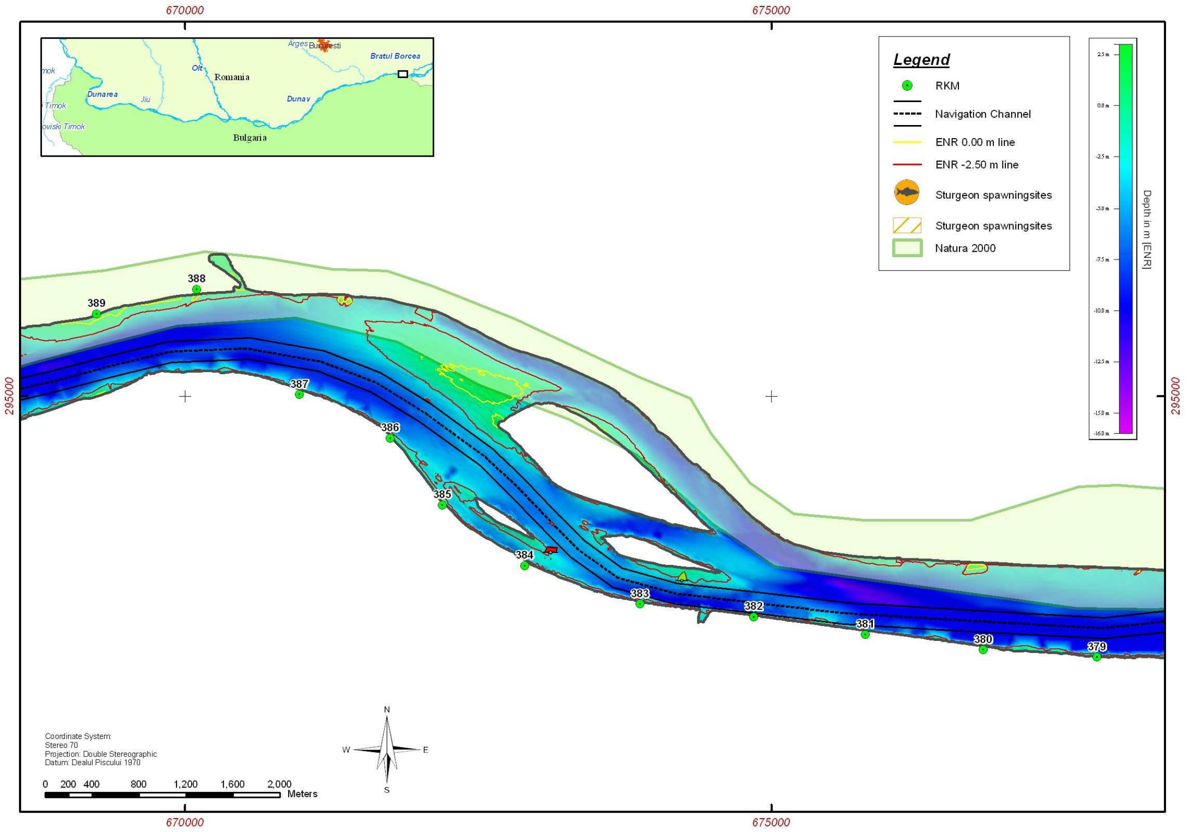

Figure 85: Chayka Island Present Conditions

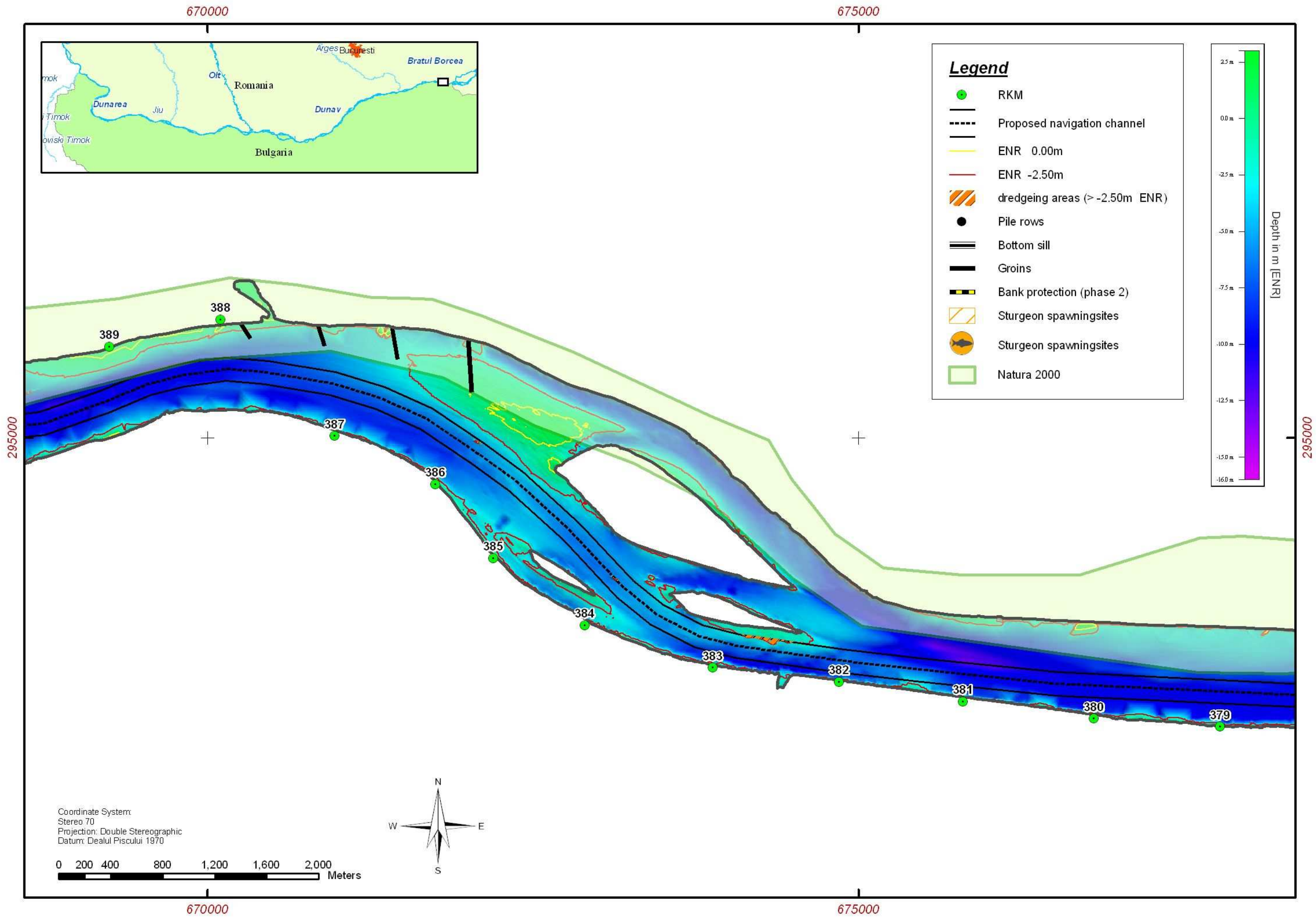

Figure 86: Chayka Island Alternative Development Strategy

IV. POLLUTION SOURCES AND ENVIRONMENTAL PROTECTION FACTORS

IV.1 Water Quality Protection

There are no sources of pollution directed to the waters for the proposed project. The main prospected issues are qualitative and refer to the re-picking-up of sediments during the works execution.

IV.1.1. Potential impacts during the works execution

The works volumes are relatively significant and their putting into operation will require the use of complex plant, which will include floating cranes, floating greifer, barges, terrace equipment (bulldozers, front loader) and road transport vehicles. The plant impact on water is reduced if the environmental protection norms are strictly followed. The materials used for the construction of breakwaters are inert materials (broken stone, fascine work, sand, ballast, dredging materials). These materials, during operation, do not affect the water quality.
The equipment's activity represents a potential water polluting factor. The pollution may be the result of the inadequate management of wastes with a high content of petrol products and other dangerous products resulted from the activity on ships. The discharge of this ship waste into the water should not be allowed. The waste should be collected in sacks or drums and discharged in a controlled manner onshore, where it is then sorted and sent to specialized centers for neutralizing, treatment and storage. The quantity of suspension sediments resulted depends on various factors, among which the construction technology, the sediments nature, the water depth and velocity.
The water silt charge may exceed some limits, but the induced silt charge is reduced, due to the negligible percentage of fine silty clayish particles in sediments. The sediments re-suspension, in terms of chemical pollution, is thought not to have notable effects.
Relatively reduced suspension alluvia quantities are resulted from the dredging operations. In case of using these dredgers, it is thought that a percentage of 0...4% of the dredged volume is represented by suspension alluvia. These alluvia re-settle farther or closer to the operation point, according to their granular composition, the current velocity and the water depth.

The re-settling distance may be assessed according to the relation:
D = 0,6 HTV
Where: D = distance until re-settlement
V = current velocity
H = water depth
T = time necessary for the particle to descend in the water by 1 m (descending time)
T respectively the descending time, function of the particle diameter.

For the particle diameter d = 0,1 mm, T = 2; for d = 0,05 mm (limit sand/silt) T = 7; for d = 0,005 mm (limit clay/silt), T = 700.
For dredging on the Danube, accepting the water depth H = 10 m, the current velocity V = 1,20 m/sec and the average sediment size d50 = 0,1 mm, the re-settling distance D results to be 1440 m (approx. 1,5 km).
For grosser sediments, with d50 = 0,2 mm, the re-settling distance results to be 350 m during high waters and less than 100 m during low waters.
On the studied sector, the average sediment diameter may be considered d50 = 0,2 mm.
It may be considered that usually the effects of the dredged sediments are located at approx. 150-200 m away from the working point.
The increase of the silt charge exceeds these limits, but the induced silt charge is reduced, due to the negligible percentage of fine silty and clayish particles in sediments.
In terms of chemical pollution, is thought not to have notable effects.
As shown above, the use of absorbing-cranking dredgers and the observance of the dredging technology represent recommended measures for reducing the effects of sediments re-suspension.

The Contractor will have the following duties:
- not to throw or store on the banks and in the riverbed of Danube waste of any kind;
- not to wash in the channel water vehicles, plant and packing with contents of oil, liquid fuel, lubricators, dangerous substances;
- to be equipped with waste storage and treatment installations, waste water treatment installations and discharge connections in onshore or floating installations for the ships and floating platforms that they own;
- not to discharge waste water from ships, floating platforms directly in the Danube, and not to throw any waste from the deck.
- during the works execution, the floating plant will be signaled according to the Danube Navigation Instructions;
- during the works execution period, the normal flow of the Danube and normal navigation conditions will be provided;
- the works execution should not affect the water quality and no material, of any nature, should be thrown in the riverbed;
- during the works execution, in case of necessity, the access and intervention of Waters Directorate should be allowed, for the execution of certain works and actions required in case of flooding, pollution or other situations specific to water flows.

IV.1.2. Potential impact during the operation/exploitation period

Due to the naval traffic increase predicted for this sector, some negative impact on water is possible during the following 10 years (reference year 2015) and further on.
As compared to the traffic values recorded in 1996, the percentage increases predicted for 2015 are of 62 – 65%.
For 2015, increased quantities of transported merchandises are provisioned. The traffic increase amplifies the accidents risk and also increases the quantities of waste specific to navigable transport. On the other side, ensuring the navigation channel and adequately signaling it reduces the accidents risk.

The collection of bilge waste and their controlled discharge deters the risk of polluting the water with these products.
The increase of the traffic values will also have unavoidable negative effects. These refer to the morphological effects of waves produced by ship traffic.
The waves produced by the convoy movement will increase the bank erosion. It is difficult to establish the quantity of the effect of the naval transport waves out of the total bank erosion.
Qualitatively, it may be estimated that the erosion effects of the naval transport waves are more reduced as compared to the wind and current waves. It is estimated that the waves produced by the ship traffic will be compensated by the bank protection works effect.
In terms of assuring the navigation requirements, the proposed works will have positive effects. It will be necessary to punctually treat the critical points, to adopt the indicated solutions and to monitor their effects. The works for the protection and direction of currents are justified in the critical points identified within the project.
Finally, all the measures proposed for sills must be taken in accordance with the EU-WDF provisions. This directive requires immediate measures so as not to affect the physical and biological quality of the water, as well as for a “good/potential ecological status” (GES or GEP) until 2015.

IV.2. Air Protection

IV.2.1. Impact during the works execution

During the works execution, the activity of cranes, greifer, motorboats and tugboats, terrace equipment etc. represents an air polluting factor, due to the fumes resulted from burning the fuel in engines. It is considered that this pollution generated by the use of plant will be substantially lower than the one specific to onshore construction sites. The concentrations of polluting substances in the air in the working points will be lower than the allowed maximum concentrations.

The Contractor will have the following duties:
- to observe the regulations regarding the atmosphere protection, adopting adequate technological measures for retaining and neutralizing the air pollutants;
- to equip the technological installations, which represent pollution sources, with measurement systems, to provide their proper operation and qualified personnel and to provide the necessary data to the environmental protection authorities, at request or according to the conformity program.;
- to improve the technological performances in order to reduce the emissions and not to put into functions installations which exceed the maximum allowed limits.

IV.2.2. Impact during the operation/exploitation period

Knowing that the naval transport is a less polluting transport mean, the increase of the naval merchandise transport will have as a global effect the reduction of the

emissions resulted from the total transport activity, because otherwise the transport would have been carried out on roads or railways.
The emissions regime related to the ratio quantity of naval transport merchandise / quantity of road transport merchandise is clearly inferior for the naval transport.
Overall, it is considered that the future increase of exhaust fumes due to the potential intensification of the naval transport will have insignificant effects locally.
Globally, the increase of the transport necessity and implicitly of the transport activity at regional-international scale, will obviously lead also to the increase of the air pollutants emissions, but this increase is given by the potential regional economic and commercial development, being less dependent on the current project. However, the project will represent a viable transport alternative; therefore choosing the naval transport will have positive effects as compared to other transport means, less environmentally “friendly”.

IV.3. Protection against noise and vibrations

The project is not characterized by producing high intensity noise and vibrations.
During construction, the noise produced will be the one specific to construction works, especially due to the operation of specific plant. It is estimated that the noise level will be below the standard one.
During operation, the noise produced by the naval transport does not usually reach a level where the effects could be significant.

IV.4. Protection against radiations

The project implementation will not generate radiations and no radiation sources are used during execution.

IV.5. Protection of soil and sub-soil

The production of pollutants affecting the soil or the subsoil is not prospected. The dredged material will be stored in special places, according to the current procedures for annual maintenance dredgers; moreover, from the preliminary analyses it resulted that this material can be classified as inert and does not require special measures for discharge or storage.
The total volume to be dredged on this navigable channel and for the minimum navigation depth of ENR -2.5 m is of 5.1 million m^3.
A correct realignment of the navigable channel based on the latest bathymetry and following the deepest areas reduces the dredged volume by more than a half.
The designed works have a direct and considered reduced impact on the soil and the underground components.

It is estimated that these hydro-morphological changes of the riverbed have an insignificant geologic impact.

Apart from the works for correction of the navigable channel and flow regulation, the project also includes bank protection immediately downstream of the main proposed works, as well as in the areas where the bank degradation endangers important lands or structures.
The riverbed erosion potential is dictated by the riverbed stability and by the erosion capacity of water. The banks may be protected or re-built for increasing the erosion resistance.
The bank protection works may be seen as works for diminishing the negative effects, regardless that these effects refer directly to the project or to the natural development of the river, where this led to the degradation of the lands nearby the river.
The solutions for the problems specific to the riverbed erosion considered the characteristics of the river flow system as well as the availability of the construction materials and the construction costs.
The project complies with the protection requirements corresponding to the erosion potential of the river area.
The impact of the works on the soil and sub-soil environmental components will be detailed within EIA.

IV.6. Protection of land and water ecosystems

On the anayzed sector, between km 875 - Portile de Fier and km 375 - Calarasi/Silistra, the Danube crosses a series of protected areas (poultry-fauna protected areas – SPA community interest protected areas SCI) within Natura 2000 network, both on the Romanian and Bulgarian territory. It must be mentioned that the impact on the protected areas within Bulgaria will be treated according to the documentation corresponding to Bulgarian legislation.
On this sector, the following areas protected on the Romanian territory are found:

1. Blahnita [SPA]
2. Gruia – Garla Mare [SPA]
3. Maglavit [SPA]
4. Ciuperceni – Desa [SPA]
5. Calafat – Ciuperceni – Dunare [SCI]
6. Jiului Corridor[SCI]
7. Jiu – Dunare Confluence [SPA]
8. Olt – Dunare Confluence [SPA]
9. Olt – Dunare Confluence [SCI]
10. Suhaia [SPA]
11. Gura Vedei – Saica – Slobozia [SPA]
12. Gura Vedei – Saica – Slobozia [SCI]
13. Ostrovul Lung – Gostinu [SPA]
14. Danube – Oltenita [SPA]
15. Ciocanesti – Danube [SPA]
16. Ciocanesti – Danube [SCI]
17. Oltenita – Mostistea – Chiciu Ciocanesti – Danube [SCI]

These areas have been declared as belonging to Natura 2000 due to the presence of certain types of habitats mentioned in Directive 92/43/EEC (regarding the conservation of natural habitats and wild flora and fauna).
Moreover, in these areas may be found species of mammals, amphibians, reptiles, fishes, non-vertebrates, plants which are mentioned in annex II of Habitat Directive.
Many of the protected species are mentioned in international conventions and in the red list IUCN.
OUG 57/2007 mentions some of the species in the Danube Delta in its annexes.
Objectives referring to the areas of integral protection, such as water quality improvement, research and monitoring of bio-diversity for its protection and conservation
The general objectives with permanent character to be followed are the following:

- modeling and improvement of hydrological conditions;
- knowledge of ecosystems functioning;
- knowledge of biodiversity;
- monitoring of morphological processes;
- sustainable exploitation of reviving natural resources and regulation of economic activities, especially of the traditional ones;
- reconstruction of damaged ecosystems;
- assessment and limitation of pollution phenomena and natural and artificial hazards;
- development of informational system and integrated monitoring;
- ecological information and education of the public and local community;

These areas are important for an extended number of species of birds, which build their nests in different periods of the year. Many of these species are mentioned in international conventions and in the IUCN red list.

- nest building period
- migration period
- winter period

There are some human activities carried out, which may affect the bird species:

- Industry
- Professional fishing (industrial)
- Sports activities and outdoors leisure activities
- Waste storage.

The following activities around the protected areas must also be taken into consideration:

- grazing
- sports activities and outdoors leisure activities
- Professional fishing (industrial).

It is considered that various zones in the protected areas may be vulnerable to factors such as: agricultural development, drainage of wet areas through sewerage along the rivers, mowing in the nest building period, uncontrolled reproduction of invasive species, trees cutting and forestry works, tress planting in natural and semi-natural areas, navigation.
Regarding the land ecosystems, as a general feature, Danube meadow stands out in the analyzed area, with insertions of isolated forests

The species of land fauna existing in the area do not always have well established areas.
A great diversity is seen, just as in the case of birds and mammals.

The impact of the works on biodiversity must be analyzed within the assessment.
The changes of the hydro-morphological elements which support the biological elements must be considered. The points which must be taken into consideration are the following:

Impact on physical system:

- Water quality;
- Hydro-dynamics;
- Ground water;
- River morphology (river continuity);
- Great waters hydrology;
- Impact on primary resources

Impact on the biological system:

- Aquatic Ecology;
- Terrestrial Ecology;
- Impact on protected habitats and species;

Impact on humans:

- Damage and pollution;
- social-economic impacts;
- Landscaping and patrimony;
- Legal aspects and regulations.

<u>Measures for diminishing the impact</u>

The following minimal recommendations are given to the Contractor:

- To follow the execution technology and the design, especially observing the locations for storing the dredged material and the gauges.
- to use performing plant which do not lose pollutants during operation and do not generate noise beyond the allowed limits.
- In exploitation, to follow the navigation corridors and restrictions imposed for the transported materials.

Adjusting the construction for environmental protection

- The dredging phasing considers berry lay-out and fish migration, as the dredging may cause significant increase in silt charge, affecting the fish life;
- Phasing certain important hydro-technical works for reducing the environmental impact: the big structures are built, if possible, considering the effects on the habitats and species;
- Keeping the impact in deep areas as low as possible (areas of berry lay-out): dredging upstream and downstream of berry lay-out areas may cause damage and influence fish behavior.

From the data available it may be considered that this chapter of biodiversity has a significant importance within the project and the EIA. In terms of biodiversity, the sector included in this project is very sensitive and the works execution on this sector is sensitive, this facts being justified by the numerous protected areas (community interest sites SIC and poultry-fauna protection areas SPA). The promotion of construction works on this sector must be detailed in terms of the impact on the biodiversity.
The works to be executed nearby SPA and SCI may affect the birds species due to the noise produced during execution. Moreover, a negative impact, with serious consequences, may be produced if the works are executed during the birds' reproduction cycle.
In terms of protected fish species, we believe that these will not be significantly affected, due to the proposed punctual changes of completion of works, knowing that native species find good living conditions at medium water levels, even close to the areas where changes occur. However, a potential impact may be generated by the noise during the works execution.
The protected species of amphibians and reptiles, within the SCI in the execution area may be affected both by noise and by the local damaging of the works area.
The terrestrial flora protected species, within the SCI in the execution area, will be punctually affected by the clearing necessary for ensuring the sites installation.

IMPACT REDUCTION AND CONSERVATION MEASURES

In order to diminish the impact produced by the working devices on the biodiversity components, we recommend the use of phonic insulation for the plant with a high level of noise.
Moreover, we considered it is necessary to maintain all plant and installations in normal operation conditions and quip them with efficient noise suppressors. In addition to reducing the general noise level, this measure will also lead to removing the impulsive or intermittent tonality noises. These tonality components are usually generated by the faulty operation of plant and installations and may be removed by adequate maintenance measures.
For removing the possible negative impact of the works execution during the reproduction cycle of the species whose habitat is close to the working areas, we recommend that the works are carried out outside the reproduction periods, as follows:

- The birds reproduction cycle, according to the specie, may begin at the end f March, beginning of April and ends at the end of June, first decade of July.
- The fish reproduction takes places, according to the specie, in the interval March – first decade of July.
- The amphibians and reptiles reproduction takes place in the period April – middle of July.

In conclusion, we believe it is necessary to avoid the interval 15 March – 15 July for the works execution.

METHODS OF BIODIVERSITY CONSERVATION

After the completion of works, we believe the beneficiary has the duty to demolish all constructions for site organization, to level the land and cover it with vegetal soil, to re-plant the damaged areas.
Simultaneously with the works progress, a monitoring program will be carried out, for monitoring the behavior of the biodiversity components. Knowing this behavior will contribute to maintaining the specific diversity of ecosystems at a satisfactory level.
Therefore, the monitoring results, will serve to prepare the recommendations regarding the status of the plants species, necessary for re-doing the local flora and also for increasing the ecological capacity for attracting a higher number of species in the area where the works are carried out, therefore contributing to maintaining the ecological balance.

III.7. Protection of human settlements and other public interest objectives

The improvement of the Danube navigable conditions will have a positive impact on the social and economic environment, by facilitating the naval transport, which is cheaper and less pollutant than the road transport.
On the demographic characteristics of the local population, the impact will be positive, leading to the occurrence of new jobs, due to the economic development of the area and the predicted increase (not to such a big extent) of the established and transit population.
The improvement of the Danube navigable conditions has a potentially positive impact on the local economic conditions, contributing as well to the decrease of unemployment.
The purpose of an environmental protection strategy is completed, on the one hand by the improvement of navigation and by the European legislation regarding nature combined with WDF objectives on the other hand. The measures for each critical sector must be designed as complex set of measures, increasing the local natural values and improving the local navigation.
The designed works have a positive impact, represented by the improvement of the merchandise and passengers transport, with beneficial effects on tourism and leisure activities. It is assessed that there will be no population segments unhappy with the existence of this project.
The noise in the area of the studied navigable route mostly comes from the activities carried out the on port platforms, as well as from the nearby transport ways, and less from the activity of naval transport.
During the execution of the designed works, a negative impact on the objects of the cultural patrimony on the Danube may be generated by non-observing the execution technology, especially the inadequate waste storage or storage of dredged materials outside the parameters recommended by the authorities responsible with the environmental protection.
The designed works have a beneficial trans-frontier impact, by improving the navigation conditions on the studied sector, thus creating conditions for increasing the merchandise and passengers naval traffic.

IV.8. Waste Management

During the works execution, the main waste volumes are represented by quantities of construction materials (broken stone, ballast, sand, land, concrete, fascine etc.), representing loss or surplus. These waste volumes, if they do not contain dangerous substances, are included in the category of inert waste, according to Order 867/2002 of MAPM. Reduced quantities of waste specific to construction activities will also result, which cannot be considered inert. These waste materials are represented by worn-out batteries and tyres, worn-out engine oils, fluorescent tubes, paints etc. For these waste materials, the Contractor will follow the specific regulations for collection, storage and discharge.
According to the European Waste Catalogue, the waste from constructions and demolitions (code 17.00.00) is considered to be the excavated or dredged land and materials (code 17.05.00), this category including land and stone (code 17.05.01) and excavated or dredged materials (code 17.05.02).
According to Order 863/2002 of MAPM regarding the criteria to be met by waste materials to be included on the list specific to a storage place and on the national list of waste materials accepted in each class of storage places, in the storage places for INERT waste materials may be accepted the waste materials from constructions and demolitions belonging to the following categories:

- land and stone (code 17.05.04)
- dredging materials (code 17.05.06)
- ballast rests (code 17.05.08)

except for the cases when they contain dangerous materials. Not applicable to the current project.

The Contractor will have the following duties:
- to store garbage or other waste only in places authorized in this sense;
- to use, in case of burning the garbage, only facilities homologated by the environmental protection and health authorities;
- to follow the requirements for restoring the natural ground in the storage areas provided in the environmental authorization and to be financially for this;
- to recover the re-usable waste and to value it by the means of specialized units.

Currently there are no community regulations for assessing the degree of polluting the riverbeds sediments. In the specialized literature is highlighted the risk of contaminating the aquatic and terrestrial ecosystems which contact the dredged materials, in the storage places. The problem of storing the dredged materials is important, given the risk of polluting the storage locations and the big amount of operated materials.
The increase of the volume of maintenance dredging did not led to a significant improvement of the navigation conditions, the year 2003, a relatively drier year, being characterized by completely inadequate navigation conditions, in the warm season.

IV.9. Management of toxic and dangerous substances

The project does not provide the use of dangerous or toxic substances, and will not lead to the production of such substances.

Regarding the fuels and lubricators to be used by the contractor, his activity will be carried out according to the regulations in force, the potential risks and effects being the ones specific to construction works.

V. WORKS FOR RESTORING THE LOCATION

V.1 <u>Possibility of occurrence of accidents with significant environmental impact</u>

The potential industrial accidents may occur differently during the execution and exploitation periods.

<u>Potential accidents during execution</u>

These accidents are the kind which occur on construction sites, being generated by the indiscipline of the personnel and by them non-observing the health and safety rules and norms, as well as by the lack of use of protection equipment.
These accidents may occur during the following activities:

- working with plant and transport means;
- internal and access roads traffic;
- fire generated by various causes;
- electric shocks, burning, blinding due to welding devices;
- dust or gas inhalation;
- explosions of oxygen cylinders or other recipients due to storage of flammable substances;
- bank falls;
- falls from height or in the water;
- crushing by falling elements;
- drowning during execution of consolidations and work in the water;
- accidents caused by the presence of “curious” or tourists which sneak on work sites;

These types of accidents don not have any effects on the environment, having a limited time and space character, but may cause invalidity and even life loss.
Moreover, they can also have negative economic effects, namely loss of materials and delay of works.
Another category of accidents which may occur during this period is due to the local population which is not used to traffic concentrations induced on the access or local roads.
Moreover, the population may be affected by incomplete works of works in progress, not signalized or without warning elements – excavations, scaffolds fallen electric wires etc.
The victims are usually the more curious and unaware children attracted by the novelty of the site, worst period being in the non-working days and when the control of access to the working points is more reduced.

Potential accidents during exploitation

These accidents are mostly due to the inadequate operation of ships in the channel, but may also occur due to the irresponsible behavior of the tourists.
Here a brief of these potential accidents:

- accidents due to the unfavorable weather conditions: fog, ice, storms with strong winds.
- accidents due to failures of the navigation supervision system;
- severe accidents due to technical failures of the naval transport means: impermeability breakage, breakage of various mechanic components.
- accidents with explosions or fire caused by vehicles transporting flammable products.
- accidents strictly due to the crew: alcohol consumption, weariness, quarrels with the passengers, or even health, by losing the capacity of taking decisions (heart attack, stroke etc).

V.2 Accident prevention measures

Prevention measures during the execution period

These measures must be taken by the general contractor and by the subcontractors, following the Romanian law regarding Health and Safety, Fire Protection, Civil Protection, Waste Management and others. Moreover, the provisions of the Terms of Reference, of the constructions quality Laws and Norm will be followed.
The measures will refer to:

- the strict control of workers regarding the site discipline: periodic training, wearing the protection equipment, alcohol or even drugs consumption controls, presence only in the distributed location.
- visible signaling of the working points and of the navigable channel.
- signaling the navigation restriction points and times.
- checking, prior to being put into operation, the plant, transport means, cranes, equipment, mechanisms and devices, for assessing their integrity and operability.
- checking, at standard intervals, the electric installations, compressed air installations, oxygen cylinders, or other containers with explosive, toxic, flammable or dangerous materials.
- checking, when being put into operation, especially at the beginning of the week, the excavations supports and splicing, scaffolds or other supports for bank protections.
- checking the indicators for restricting the access to certain areas, the plates signaling danger.
- fencing, signaling and other warnings for delimitating the work areas.
- controlling the access of persons on site.

Accidents prevention measures during the exploitation period

- execution of works in strict accordance with the provisions of the documentations and terms of reference, assuring the technical and geometrical elements of the construction.

- visible signaling of the navigable channel and of the navigation restriction points.

All the works and actions above are necessary and useful if they are continuously supervised and properly maintained.

These prevention measures help avoiding or substantially diminishing the risk of accidents which, even if they do not usually affect the environment, cause significant damage and even life loss, these consequences belonging to the human life and activities protection domain.

The specific measures to be taken were previously presented as a consequence of assessing the risks of accidents and damages occurrence.

Apart from these, a series of general measures are also necessary, such as:

● The general concept and design of the works must be awarded to companies which can provide documentations, detailed designs and terms of reference which include the most efficient and modern solutions.

The compiling should be clear and concise, and the drawings and graphs should be explicit and suggestive.

● The terms of reference must include provisions for the measures to be taken for the environmental protection during the execution period.

During the analysis of the tenders for the works contract, a major element for the awarding decision will be represented by the preoccupation and the actual results obtained by the respective companies in the environmental protection field.

● In the contracts to be signed, there will be special clauses of liability and responsibility between the parties regarding the environmental protection.

● The construction unit(s) will prepare accidents and damages prevention programs, including adequate measures for Environmental Protection, Health and Safety and Fire. These must clearly state the decision schemes and decision makers for prevention.

● The beneficiary, designer, the representatives of the Constructions State Inspection and of the environmental authorities will permanently act according to their legal competences regarding controlling the observance of the designs, documentations, issued permits and authorizations.

In general the project does not create significant negative effects on the environment, and apart from improving the navigation conditions, its role is to remediate the problems caused by the unfavorable development of river.

The proposed hydro-technical works lead will lead to the local increase of the water velocity. In view of reducing the risk of bank erosion, which also affects the nearby lands, bank protection works were provided next to all proposed works, in order to compensate this phenomenon.

VI. ENVIRONMENTAL MONITORING PROVISIONS

<u>Monitoring plan for the execution period</u>

Bathymetry measurements for monitoring the changes of the minor riverbed morphology due to the maintenance dredging works. The bathymetry measurements will be carried out on Danube cross sections at distances between 50 - 250 m.
Noise produced by the works. The measurements will be carried out with sonometers between 30 – 140 Hz. In the execution period, the noise measurements will be carried out monthly on each site.
Sampling and laboratory tests for the dredge material, discharged in the storage location. The heavy metals and the petrol products will be analyzed and the results will be compared with the allowed values (CMA according to Order 758/1997 – Order for approving the Regulations regarding the environmental pollution assessment). The laboratory tests of the dredged material deposited on the soil are carried out monthly on each site.

Monitoring the environmental factors of site organizations

During the construction period, the environmental factors for soil, water, noise and air on site organizations are monitored.
There will be periodic sampling of the soil and water on site organizations.
There will be periodic sampling of the air at the enclosure limit and the chemical pollutants and the suspension and settling powders will be determined.
Noise monitoring will include the areas where overruns of the allowed limits are expected or notified by the local inhabitants. The sampling will be carried out on a monthly basis.
The monitoring activity is monthly synthesized by submitting reports to the environmental authorities, the beneficiary and the contractor, in view of establishing the possible measures for protecting the environmental factors.
The monitoring plan is periodically updated in agreement with the local environmental protection authorities.

Monitoring plan for the operation period

In the operation period, the environmental factors monitoring is organized by the beneficiary, which must allocate the necessary funds for this activity.
The annual bathymetry measurements in the critical areas give the opportunity to monitor the riverbed morphology development on the sectors where the navigation improvement works included in the current project were carried out.
Moreover, it is considered necessary to monitor the biodiversity, especially within the protected areas of Natura 2000 network.
Both the monitoring plan for the execution period and for the operation period will be detailed in the documentation for the environmental impact assessment.