„Carrying out design tasks related to the development of the Trans-European Transport Network – TEN-T inland waterway in the investment of NIF Zrt."
under a design contract
2014-HU-TMC-0606-S

THE DANUBE WATERWAY DEVELOPMENT PROGRAM

Section II. (Szob – southern national border)

Strategic Environmental Assessment

ENVIRONMENTAL REPORT – NON-TECHNICAL SUMMARY

Budapest, September 2020

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Strategic Environmental Assessment

ENVIRONMENTAL REPORT

Customer: National Infrastructure Development Corporation

Prime contractor: UTIBER Ltd. - VIZITERV-CONSULT Ltd. - BME consortium

Developer of Environmental Assessment:

VIKÖTI Engineering Office Ltd.
Phone: +36-1-206-6128
Address: 1519 Budapest, Pf.: 241.
E-mail: vikoti@vikoti.hu

ÖKO Ltd.
Phone: +36-1-212-6093
Address: 1253 Budapest. Pf.7.
E-mail: oko-rt@oko-rt.hu

It was prepared by:

– Istvan Bozso
– Julia Gaal
– Adam Heckenast
– Karolina Jurassza
– Julia Dr. Nagy
– Julianna Saling-Csordas
– Dora Veres
– Vilmos Vincze
– Emoke Magyar
– Szilvia Meszaros
– Gyöngyi Kovacsne Molnar
– Istvan Nagy
– Judit dr. Rakosi
– Marton Szappanos
– Endre dr. Tombacz
– Fanni Tombacz
– Bianka Videki
– Ferenc Zsemle

Subcontractors:
BioAqua Pro Ltd.
Hydrofon Bt.
Ágnes Zólyomi
Via Antica Bt.
Gabor Guti

Budapest, September 2020

CONTENCTS

1. JUSTIFICATION OF THE PROPOSED DEVELOPMENT

Sustainable mobility is a clear objective of the „Europe 2020, Strategy for Smart, Sustainable and Inclusive Growth", and the common European Transport Policy. Inland navigation has a relatively moderate environmental impact (emits 3.5 times less CO2 per tonne-kilometre than lorries) therefore it can be considered as an important mode of transport. The Rhine – Danube, connected by the Danube-Main-Rhine Canal, creates a direct connection between eleven countries, covering 3,500 km from the North Sea to the Black Sea. The Danube River is thus the backbone of the region. The development of waterways must go hand in hand with the creation of modern and efficient intermodal ports in order to integrate shipping with rail and road transport.

In the greater part of the Danube-Main-Rhine navigation channel, the conditions of the waterway class VI/B and VI/C are provided by river training and damming. Training and maintenance works have not been made on the Danube stretch between Bős and the southern border for decades, therefore the waterway does not meet the parameter requirements prescribed in the AGN Treaty[1] and in the new 2013 Danube Commission's Recommendation. Therefore, it is necessary to improve the parameters of the Danube to the core network level along the whole Hungarian Danube stretch of the water TEN-T network (in several other sections in parallel), thus increasing the number of navigable days, which can promote the growth of water freight transport. However, the **planned development** cannot be implemented in itself; **environmental, water reserve and nature conservation and other interests related to the river have to be served equally.**

This need is reinforced by the **EU's 2011 White Paper on Transport Policy**, which states: " *Optimising the performance of multimodal logistic chains, including by making greater use of more energy-efficient modes*." As a part of this:

- *„Thirty per cent of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed.*
- *A fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high-quality and capacity network by 2050 and a corresponding set of information services."*

This task is set not only by international but also by domestic strategies. According to the **National Transport Infrastructure Development Strategy** (NTS), „**an important task is to ensure the navigability of the Danube –** as a Helsinki corridor- **in accordance with the principles of sustainable development."**

In order to prepare the fairway development task, the European Commission submitted a project proposal entitled *"Extension of the preparation for the development of the Hungarian TENT inland waterway"* to the CEF 2014 call for proposals on the basis of Government Resolution 1102/2015 (III.5.), which is supported by the European Commission (CEF identification number: 2014-HU-TMC-0606-S). **The Danube waterway development program** (hereinafter referred to as the Program) and the present (strategic) environmental assessment (hereinafter SEA) are prepared within this framework.

[1] The AGN Treaty indirectly sets shipping parameters for European waterways.

2. OBJECTIVES AND FRAMEWORK CONDITIONS OF THE DANUBE WATERWAY DEVELOPMENT PROGRAM

2.1. THE OBJECTIVES OF THE PROGRAM

The Program aims to develop a multimodal corridor that integrates the environmental and ecological objectives in addition to inland navigation and takes into account other - socio-economic - functions of the waterway (primarily, the protection of water reserves, flood control and the interests of river basin management).

The lesson of the previous (2009-2010) planning process was that it is not justified for Hungary to implement technical parameters higher than **the minimum international requirements**. Therefore, in contrast to the previous design phase, the possibility of reducing the width of the navigation channel was examined in the present planning process in order to reduce the workload (mainly dredging), moreover, when the interests of nature and water reserve protection so require, the creation of a limited-width waterway, **providing one-way navigation** in certain narrow sections was also examined. The developments defined by the Program are therefore designed with the **least environmental and ecological impact**. The present environmental assessment demonstrates why the chosen variant is the most environmentally favourable (more precisely, why it is the least unfavourable).

In the current situation, several shipping problems (bottlenecks, shoals) make it more difficult for deep-sea cargo vessels to navigate along the whole Hungarian Danube stetch. In the extremely low water period of 2003, 13 shoals with critical depths were formed in the stetch above Szob and 12 were formed below it. The navigation depth of 27 dm is provided on average only in ~ 60% of the annual period. Mitigating these problems is the fundamental goal of the Program. The goals are described in more detail in the so-called **objective tree** (see ***Figure 1),*** the first column of which describes the problems to be addressed. Some of the problems should be managed by other projects (such as the issue of modernizing the fleet and making it more environmentally friendly). The second column indicates direct, typically technical objectives. The third column shows the expected results, and the last column shows the final objectives.

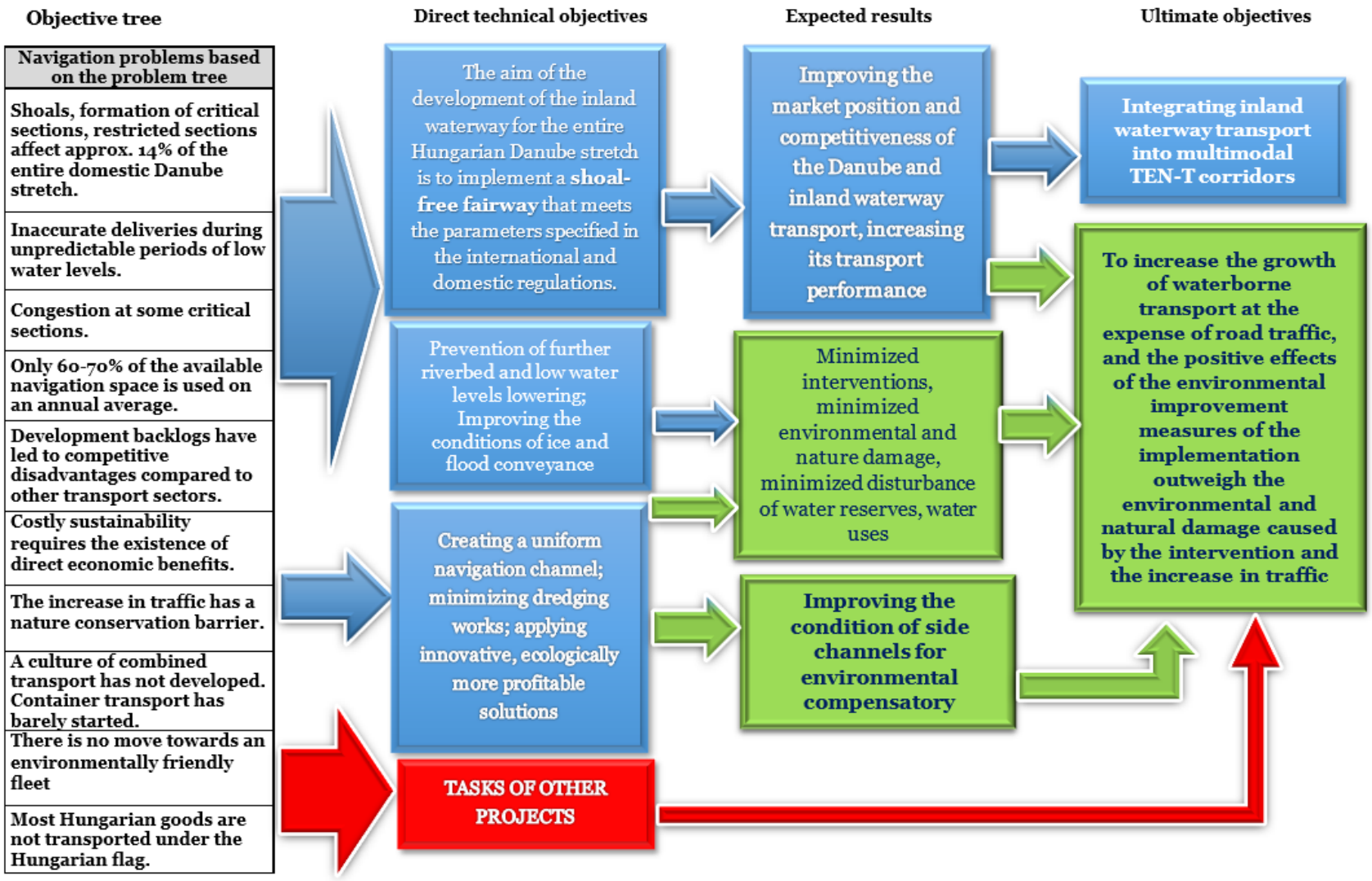
The overall goal of the Program is to provide the navigation parameters defined in the international and domestic regulations on the entire Hungarian stretch of the Danube in order to increase the depth and usability of the waterway over time. The required minimum width shall be provided where possible, if it is not possible due to some unavoidable obstacle (e.g. the impracticability of environmental, nature and water protection objectives) one-way sections need to be installed. **The technical interventions included in the Program are - still acceptable - at a minimum level, but an expected shoal-free navigation channel must be ensured.**

The Program aims to minimize the necessary dredging works and the construction of traditional technical facilities. At the same time, it intends to improve obsolete or deteriorated interventions in terms of uniform low water regulation both in terms of environmental and nature conservation considerations and savings in maintenance costs. To achieve the above-mentioned goals, **innovative solutions** were also applied. When looking for solutions to be developed, it is an advantage if the interventions can also bring ecological benefits. (Such **as notching a set of spurs close to shore,** creating a secondary channel this way, or the **chevron dike**, which functions as a valuable gravel bed in the mid-waterbed.)

The ongoing riverbed lowering together with the more intensive (longer and more frequent) low water periods, not only means losing the competitiveness of inland navigation, but it also has a negative impact on the Danube ecosystem. Thus, rising low water levels by gentle solutions has a positive effect from both aspects, and it follows the principles of river basin management. Therefore, **it is a fundamental planning aspect, that the planned interventions cannot cause further bed lowering and cannot decrease the present low water levels anywhere, even the goal is to raise them in some places.**

As a consequence of the fulfilment of the direct goals, **the primary expected result is the improvement of the market position and competitiveness of navigation on the Danube**, including domestic waterways. This should go hand in hand with an increase in waterborne transport performance. **The improvement of the navigation channel is necessary, but not a sufficient condition for the improvement of the market situation and the increase of the transport performance. Achieving this is only possible if favourable regulatory and support conditions are formed** for water transport. (So waterborne transport - especially in case of long-distance transport, heavy goods, and container transport - has an advantage over road transport). The implementation of economic regulation and incentives also arises at the level of the European Union, as only in this case can the targeted rail and water transport be prioritized over road transport.

The interventions must not worsen the condition of side channels, even their condition must be improved.



1. figure: Objective tree of the Program

The ultimate goal is better integration of inland waterway transport into the European Union's multimodal TEN-T corridor system. **Another fundamental national goal of the Program is to increase the growth of waterborne transport at the expense of road traffic, and the positive effects of the environmental improvement measures of the implementation outweigh the environmental and natural damage caused by the intervention and the increase in traffic.** With regard to traffic diversion, in particular transit and export-import traffic can have environmental benefits as a result of reduced space requirements and other reduced environmental damage resulting from the reduction of emissions, energy consumption and the constant development needs of motorways. (This benefit also exists when transport demand, increases with economic growth. This trend cannot be considered sustainable, but it should be the goal of another Program to stop it.)

The future inland waterway transport system is expected to bring economic and social benefits to the country, in addition to the above-mentioned environmental benefits.

2.2. FRAMEWORK CONDITIONS OF THE PLANNING

The most important environmental and water management conditions considered during the design were the following:

Generally

- It is not justified for Hungary to set a level higher than **the minimum international requirements**. (Therefore, during the design it was necessary to examine the reduction of the navigation channel width in order to determine compliance with the minimum requirement.) If the fulfilment of the nature and water reserves protection conditions so requires, the opportunity should be taken to maintain limited-width fairway, **providing one-way navigation**;
- **We need to be prepared for the climate change that are already being experienced in the present and can be estimated for the future**, also we need to deal with its effect on the result, functionality of the intervention to improve the adaptability;
- An analysis of the effects of expected changes in vessel traffic is also needed.

Water management aspects

- **The aim is to prevent further undesired lowering of the riverbed** and to stabilize it. The present low water levels and the riverbed cannot lower due to the planned interventions;
- Only those training structures can be applied that **do not have significant water level gradient increasing effect on the channel**, whose effect appears only in low discharge periods and that do not deteriorate flood and ice conveyance conditions;
- The planned training structures **must not worsen the movement of bedload,** must not cause velocity decrease in the navigation channel since it would generate suspended load deposition;
- The aim is to minimalize dredging works and apply innovative, ecologically more profitable interventions instead;
- The fairway can only be modified as a result of changes in the bed that had occurred in the meantime and only in well-founded cases. The allocation of planned river training interventions should be made aligned to this navigation channel;
- The width of navigation channel is 120-150m along the Wien – Belgrade stretch (1,921.05-1,170.00 rkm) according to the Danube Commission recommendation in force, which can be decreased in duly justified cases (geomorphological causes) if it does not risk navigation safety.

Environmental and nature conservation aspects

- **The lowest environmental and ecological load should be pursued;**
- The **aggregated, cumulative effects** of all planned technical interventions in the Danube riverbed should be examined, by presenting the results of related calculations and numerical model tests;
- Efforts should be made to minimize adverse effects on the affected Natura 2000 sites and species of

Community Interest;

- **The protection of existing and possible future water reserves** should be considered as a strict barrier during the planning;
- Solutions that would result in less favourable conditions for **side channels** than at present should be avoided, and even the **improvement of the water supply of side channels and side channel systems** is an important consideration;
- A deeper analysis of the impacts on water reserves, on the ecological status, and the impacts on wildlife is needed **in terms of acceptability**;
- The **active participation of society** must be provided from the very beginning of the planning.

2.3. EXPECTED RESULTS

The expected result of the planning is **to design a variant that provides sufficient navigation and involves lower costs and environmentally friendly solutions at the same time without compromising the RBMP classification of the affected water bodies and the status of water bodies and without disturbing existing water uses or helps to improve the ecological condition.**

The direct result of the development: **Establishment of a navigation channel with a temporary solution (for the next 20-30 years), that meets the international standards at a minimum level** according to the following parameters:

- **The fairway depth is 27 or 28 dm deep** at the lowest navigable water level (LNWL) depending on the quality of the riverbed, where LNWL is the water level corresponding to a water flow with a durability **of 94% (343 days)** calculated from the data of the ice-free period of the 30 years preceding the reference period.
- The **width of navigation channel** is 120 m along the Szap – Dunaföldvár Danube stretch, below it 150 meters.
- Where this cannot be solved because of nature and / or water reserve protection reasons, a 100 m - wide **navigation channel** is planned with **limited width**, with limited but two-way traffic.
- Where a width of 100 m is not possible for the above reasons:
  - a navigation channel with a minimum width of 60-80 m is designed for **actual one-way traffic**, depending on bending and other nautical conditions;
  - **a curve radius of 1000 meters**, which **may be reduced to 800 meters** in justified cases, while maintaining safety navigation

The established navigation channel could reduce the number of required ships therefore the traffic by 25-30% in addition to the current quantity of transported goods (as the dive of vessels, and thus their capacity utilization is increasing)

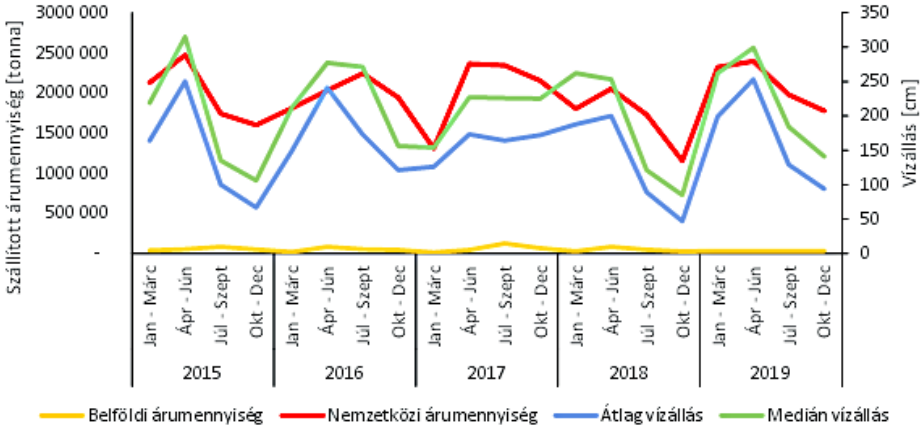
Further expected results:

- The share of inland freight transport in the total domestic freight transport volume should reach 10% by 2040;
- Traffic diversion should basically consist of a reduction in the road transport rate;
- Inland navigation should be better integrated into the long-distance transport system. In order to protect the environment, waterborne transport should be accompanied by rail transport as far as possible;
- Creating a more sustainable transport division of labor than at present, with less emissions, environmental damage and greater energy efficiency;
- The system should be synchronized with nature conservation needs and goals.

3. TRAFFIC PROGNOSIS

The following main statements can be made in relation to estimating the increase of shipping traffic:

1. **The main goal of the development is to increase the performance of freight transport, primarily to achieve favourable environmental impacts due to traffic load rearrange.** The rate of waterborne freight transport in domestic freight transport is currently small, but it varies from year to year. The reason for this is the weather-dependent nature of the navigation in addition to the market situation (water levels determine the number of navigable days, the rate of dive, the rate of cargo space utilization in a given year). The development goal may be realistic in the sense that there has been a clear correlation between the water level of the Danube and the amount of goods transported in the recent period. The performance of the sector was nearly 2.4 billion freight tonne-kilometres in the extra rainy year of 2010 and 1.6 billion freight tonne-kilometres in the extreme droughty year of 2018. This fluctuation is expected to be mitigated by the planned development; thus the water level dependence of freight transport is expected to be reduced and the reliability will be increased (see ***Figure 2***).



2. figure: Relationship between the weight of transported goods and the water level of the Danube

(between 2015-2019 in seasonal breakdown at 1646.5 rkm)

2. **The expected increase in traffic by 2040 is quite moderated in terms of water freight traffic, even in optimistic estimates.** Although transport capacity will increase by 80% in terms of freight tonne-kilometres, considering the higher capacity utilization possibilities for freight transport[2], the **number of vessels increases only by 34%.** (See the table below.) The shipping period also increases from 240 days to approx. 340 days, this increase is likely to largely disappear in the daily traffic as a result of the extra days. **So, overall, no more serious increase in daily traffic can be expected in terms of freight transport.**

[2] Compared to the current 60%, it is 80% in 2040, including empty runs.

1. table: Expected traffic growth

Inland freight water transport	2008-2019 meridian	2030	2040	2050
Delivery performance (billion freight tonne-kilometres/ year)	**1,92**	**3,07**	**3,42**	**3,73**
of which transit	**1,07**	**1,72**	**1,92**	**2,09**
of which export-import	**0,84**	**1,35**	**1,50**	**1,64**
mode shifting traffic		**1,15**	**1,50**	**1,81**
Freight transport: number of vessels				
Total vessel (vessel pcs / year) transit and export-import with separate average distances	**7 857**	**10 059**	**10 505**	**10 783**
of which transit (calculated with 380 km)	**2 945**	**3 770**	**3 938**	**4 042**
of which export-import (avg 179 km)	**4 912**	**6 289**	**6 568**	**6 742**
cargo space utilization	***60%***	***75%***	***80%***	***85%***
Change in the number of cargo ships base year 2019				
Increase in total number of vessels		**28%**	**34%**	**37%**
of which transit		**28%**	**34%**	**37%**
Average load of vessels, tonnes / vessel	***960***	***1 200***	***1 280***	***1 360***

3. In the case of passenger transport, higher traffic growth has already been estimated, the number of vessels could increase by 75%. **Although this increase is not a consequence and the goal of the development under discussion, but it is largely related to tourism development goals and forecasts.** The lack of development is likely to have little effect on its development because tourist vessels are less sensitive to the depth of the fairway than cargo vessels.
4. **When describing environmental impacts, the increase in turnover in both transport sectors should be addressed**. For greater certainty in the prognosis, **an increase of 75% as an expected possible maximum and a worst-case scenario were considered during the estimation of the effects.**
5. It is likely that **the increase in total traffic will be somewhere between 35 and 50% by 2040, the increase in daily traffic – due to a 40% increase in the number of navigable days - will be probably much smaller.**
6. **The long-term goals of the Program** include- according to The National Port Development Masterplan Strategy and other background materials - **increasing the share of inland freight transport to 10% of the total domestic freight transport performance.** This is in line with domestic environmental and climate policy goals and EU's transport policy (White Paper). **This magnitude seems rather ambitious** based on estimates. In the calculations we must deal primarily with longer-distance partly transit and partly export-import traffic, as the share of water transport in domestic freight traffic is negligible. The table below summarizes the possible estimated results in this respect.

2. table: Development of freight transport performance excluding internal transport

Year	Freight performance total sector	Freight performance water subsector	Share of aquatic subsector	Status
	billion freight tonne-km			
median of the previous five years	**41,65**	**1,92**	**4,6%**	FACT
2040	**51,07**	**3,42**	**6,7%**	PROGNOSIS
2050	**55,97**	**3,73**	**6,7%**	PROGNOSIS

So, if we consider a realistic benchmark, the goal can be approximated.

7. From an environmental point of view, it would be the most desirable to replace road transport with waterborne transport as much as possible. **From this approach, freight transit** (where road transport can be fully replaced) **and export-import traffic can be beneficial if it involves road traffic diversion.**

We count on diversion on waterways in the case of long-term freight transport, we do not count on such benefits in the case of domestic traffic.

8. **In terms of rail and waterways, the two modes of transport are not intended to compete with each other**, in fact these developments should be synchronized. The EU's White Paper on Transport also prefers this direction. **Accordingly, we do not consider the benefits or harms of diversion for the two modes of transport**

According to the economic assessment based on the prognosis**, the development of navigability is economically favorable for both the EU and Hungary, mainly due to the shift from road freight transport. The balance of environmental benefits and harms is also expected to be positive.**

4. TECHNICAL POSSIBILITIES FOR INTERVENTION TO ACHIEVE THE OBJECTIVES

Possible technical interventions:

- **Shoal dredging in gravel or marl, sandstone, rock material by placement in the riverbed:** A limited-width navigation channel is planned on several sections, as this will reduce dredging volumes and thus meet environmental objectives while still meeting the required fairway parameters.
- **Construction and extension of spurs[3] from quarry stone**
- **Demolition of spurs, changing their height, reconstruction**: The crown level of the spurs has previously been scaled to the low water levels and as these water levels become lower and lower, reducing the height of the spurs will not be a problem for navigation, while it can provide positive results for the environment and flood protection.

- **Reconstructing spurs, notching spurs from the side of the bank:** By demolishing the near-shore end of the existing spurs, water movement can occur under the low navigation water level near the waterfront. In this way, a flow protected from secondary wave actions can be formed during low water period, which can serve as a drinking space or habitat. A secondary bed must also be formed by dredging in the spur fields.
- **Formation of a secondary bed in the cut-off spur fields, by placing the spilled material in shore protection water works, in the support body of dikes:** The aim is to reduce the effects on the areas between the guide banks, less sediment formation. The new spur designs improve hydromorphological dynamics on riverbanks, which slows down the filling process in the areas between guide banks. As the structural diversity of the areas between the guide banks improves, the existing conditions for aquatic life, especially juvenile fish, will also improve, while the intervention will not have negative navigational consequences.
- **Vegetation clearance of spur gaps, guide banks, shrub clearance and removal of woody vegetation**: Spur gaps must be cleared of vegetation in accordance with the "Water Management Plan" and must be demolished to such an extent that the vegetation cannot be re-established in these areas.
- **Breaking down of sediment deposited in spur gaps by placing it in bank protection structures, in the support body of flood protection dams**: In the areas between the guide banks, the removal of accumulated sediment is necessary to reduce further sedimentation and maintenance needs. The extracted gravel material can be placed in the water-side cassettes of the flood protection dams, while

[3] A stone structure built constructed transverse to the flow extending from one of the river banks into the river.

the humus top layer can be placed in the water-side maintenance band of the flood protection dams.

- **Construction, reconstruction, or extension of guide banks[4] from quarry stone or in work material handling**
- **Demolition, construction and extension of guide banks from quarry stone or material displacement within structure:** It may be necessary to dismantle the heights of the stone structure, to demolish the harmful guide banks, or to extend it as necessary.

- **Construction of bendway weirs:** In deepened sections, bed stabilization is possible

with gentle bent bendway weirs. These divert the flow towards the middle of the river, thereby assisting to navigation. The centred flow widens the riverbed by reef erosion. Sediment is deposited in front of and between the bendway weirs, preventing further deepening of the bed, thus preventing water level lowering.

- **Construction of Chevron dikes**: The innovative, "U" shaped stone structures are constructed parallel to the flow direction, separated from the shore, but usually close to it. They improve the navigability of the fairway and ensure coastal water flow by narrowing the riverbed. Inside the chevron dam, washing out develops where the water velocity is low, making it a good wintering place for fish, while behind it a dynamically changing bed surface is created.

The first chevron dike was built in 2019 in Novi Sad, Serbia

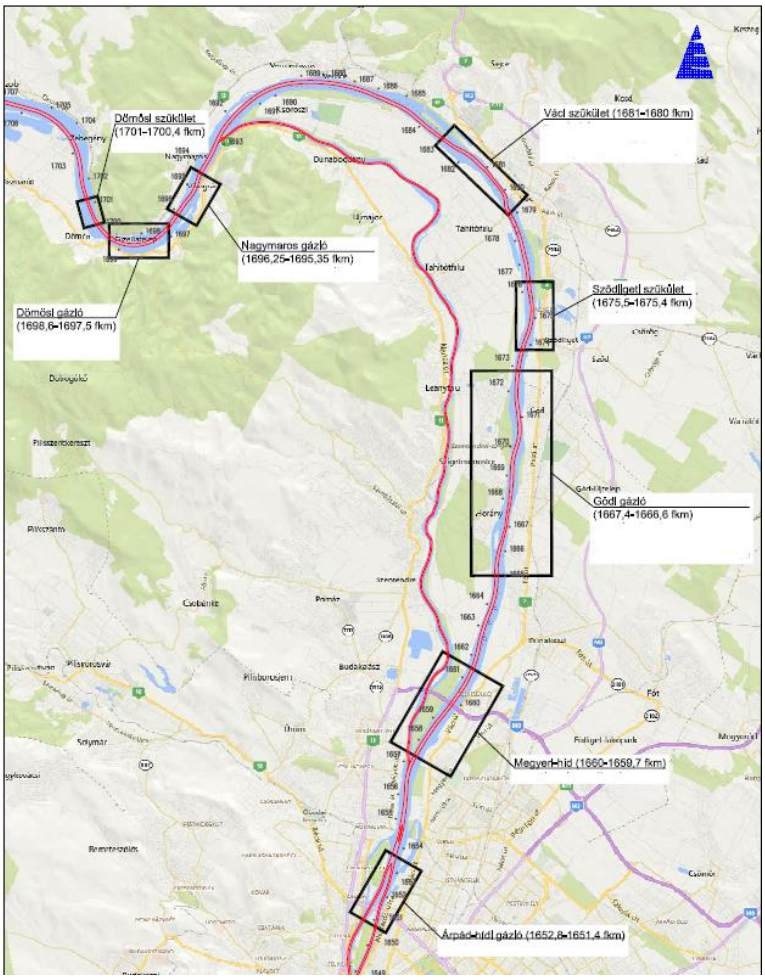
- **Demolishing of shoals and its vegetation clearance**: In the primary drainage zone, the forested in-shore shoals formed in the small and medium-water riverbeds must be partially demolished, the vegetation established on them must be reduced, and in some cases completely eliminated.
- **Waterway relocation:** The purpose of the relocation is to create more favourable flow conditions, navigation conditions and minimization of local dredging activity.
- **Establishment of a navigation channel with a limited width (60-100 m):** For reasons of nature and water reserve protection, it is sometimes necessary to provide one-way navigation with periodically limited-width (60 m, it is planned at Budafok shoal) or two-way traffic with limited width (80-100 m) in certain shoals and bottlenecks. The solution is to minimize the dredging works, which may be important for the protection of nature and water reserve at specific sites. The role of shoals is significant during low water periods, as a kind of natural dam, they raise the water levels towards the headwater, creating more favourable navigational conditions – thus a limited-width fairway can also be established due to riverbed morphological reasons.

5. POSSIBLE CONCEPTUAL TECHNICAL VARIANTS

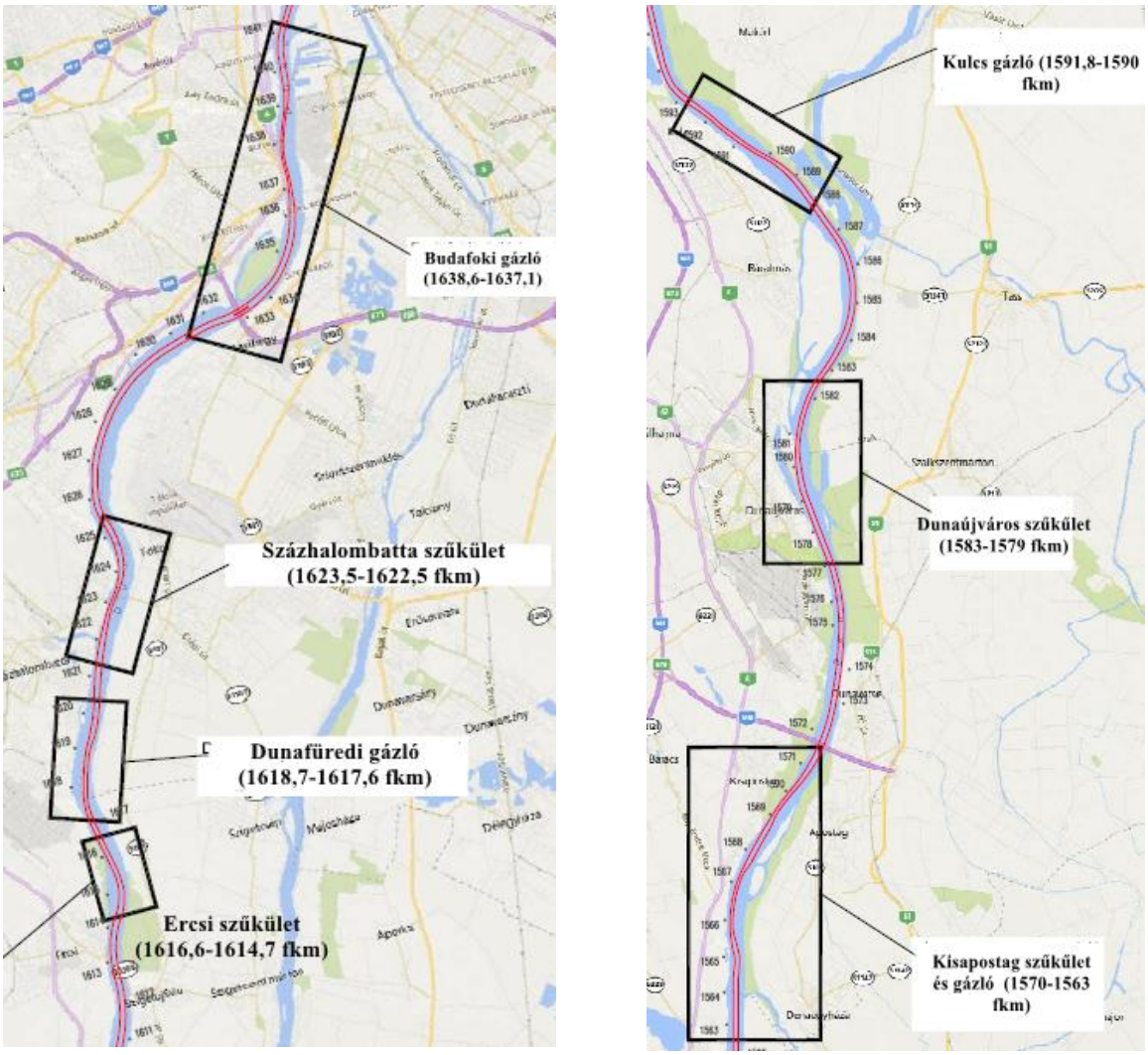
The number of intervention sites created during the planning along the reach between Szob and Dunaföldvár are 15, along the Dunaföldvár – southern national border reach is 6. The length of the affected river stretch: 23,5 km and 21,6 km. The waterway system cannot be used economically during a third of a year unless

[4] **Guide banks** are artificial embarkments constructed along the flow, which is built with a crest width of 2.0 m, and with a slope inclination of 1: 1.5 on the upstream side and 1: 3 on the downstream side.

obstructive sections are eliminated. The locations of the planned interventions are given in all variants (see *the figures below*).

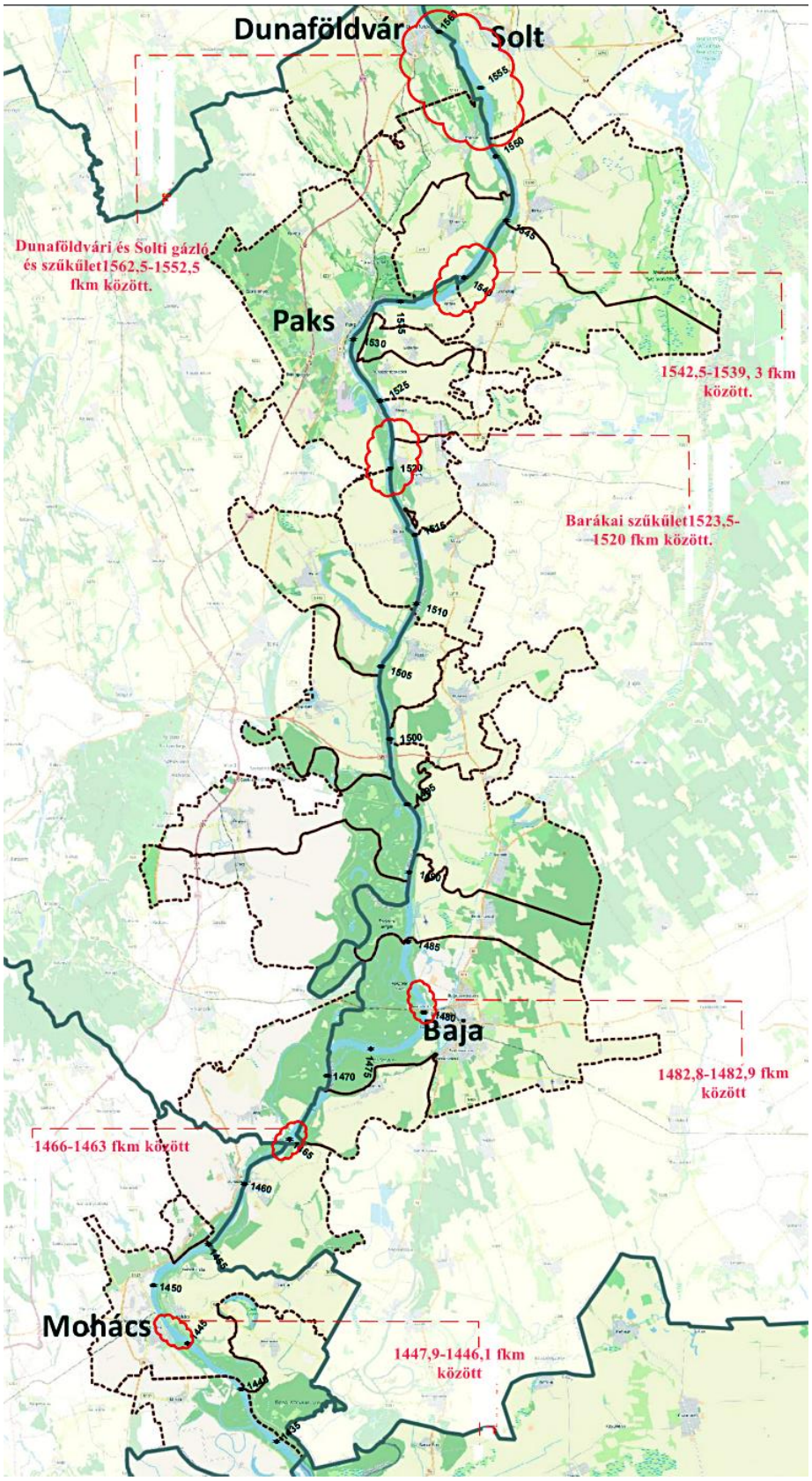


3. figure: Sites of interventions along the Szob- Dunaföldvár reach



4. figure: Sites of interventions along the Szob- Dunaföldvár reach

The concept of evaluating the variants of intervention was the following: the effects were investigated first applying traditional training structures, without limiting the fairway width (Variant no I). In Variant no. II, a wide range of innovative interventions was used besides the traditional interventions. The effects of these two variants were examined by hydrodynamic modelling, and after assessment was proposed for an optimal variant of river training, called Variant no. III. Finally, a navigation channel of limited width was created, called Version no. III/A (Recommended Version), in which dredging works and ecological damages are minimized. It can also be seen from this description, that **the variants developed during the design are not independent of each other, but they represent certain stages of the process of repair, rationalization and optimization and they are built on each other to a certain extent.**



5. figure: Sites of interventions along the Dunaföldvár – southern national border reach

Variant zero

The variant zero is the same as the current state, it expects the morphological changes to be maintained. (Another name: Deferred variant.) This basically means that interventions will not be fulfilled until they are forced to change by some changes in climate, in economy, or in regulation.

The Hungarian stretch of the Danube in its current state does not meet EU and domestic requirements, so this variant is not acceptable. The required safety navigation depth of 27 dm is insured for only 60% of the annual period. Experience also shows that "*during low water periods, the leaders of larger vessels and convoys count more than 50 places where they cannot meet each other, partly due to the geographical location of the fairway, partly due to abnormal flow difficulties, furthermore passing is not possible with an economic dive*"[5].

Variant I.

Variant no. I uses traditional technical solutions that aim full compliance with the regulations. (Short name: Rule-following variant.)

This variant involves the following interventions:

- shoal dredging,
- demolition of the heights of the stone structures, in case of spurs to WWL 2018 +0.5 m level or WWL 2018 + 1.0 m level. In case of guide banks to WWL 2018 + 1.0 m level,
- necessary extension of stone structures, construction of new spurs,
- bed stabilization by laying bendway weirs or refilling rolled sediment.

Variant II.

In Variant no. II, a wide range of innovative interventions was used besides the traditional interventions. Limited fairway width or fairway relocation was also used on certain sections. (Short name: Updated variant.) In full compliance with the prescribed requirements- In Variant no. II, some of the traditional training structures were substituted with innovative interventions for spurs, or construction of chevron dikes. In addition, relocation of the navigation channel is investigated at some sections by providing two-way navigation. At the Budafok shoal, it does not anticipate the elimination of the 60 m wide section of the riverbed, but it is planned to widen the current fairway in several places it.

Variant III.

Variant no. III. is a compliant version that optimizes the possibilities for intervention. (Short name: Impact Optimizer.) Variant III. was developed by eliminating the errors after evaluating Variant no. II. Basically, the width of the navigation channel is modified compared to the previous ones. In the lower section, the proposed narrowed section in variant III. - with the exception of the Solti bottom shoal- ensure unrestricted navigation

This version envisages the construction of a waterway narrowed in 4 places, 100 m wide, but providing two-way navigation.

Variant III/A

Variant III /A is a version that handles the regulations with more flexibility and minimizes interventions at the level of possibilities (Short name: Minimum variant). Variant III/A keeps interventions to a necessary and possible minimum, which deals more flexibly with the issue of narrower fairway, shorter one-way sections and fairway relocation. Thus, a narrowed fairway with a width of 60-100 m will be created in many places. The creation of a narrowed fairway means less intervention (less spur construction, bendway weirs, dredging) on sections that are sensitive to this.

5 Vituki Hungária Kft .: „Danube water transport development strategy" 2020.05.

Based on the multi-criteria comparative assessment (see next chapter**), the recommended variant (no. III/A) fulfils the requirements of river training principles in all respects:**

- In low water periods (WWL 2018) the minimum parameters of the navigation channel recommended by the Danube Committee are ensured:
  - depth: 2.7-2.8 m,
  - width of navigation channel: 100-120m (two-way navigation), 60- 80 m (one-way navigation),
  - curve radius: min. 1,000 m.
- By creating low water training lines, the plan is aligned to existing training structures and the channel form, and a uniform channel is established. This uniform channel helps ice- and flood conveyance.
- Bendway weirs play a role primarily in channel stabilization and water level raising, while chevron gates are important for preventing shoal creation and conducing ecological diversity.
- The applied interventions prevent any lowering of the bed and decrease of present low water levels, which is favourable from both ecological and water resource protection aspects.
- Interventions prevent shoal creating. Minimum water level rise is expected.
- Bendway weirs have been used to maintain or increase the water level in shoals. The interventions cause a water level increase of 0.5-1.5 dm along the Dunaföldvár and Harta reach.

The required workloads for each section and their variants are summarized in ***Table 3***.

3. table: Workloads associated with each alternative

	Szob - Dunaföldvár reach				**Dunaföldvár – southern national border reach**			
Planned works	**Variant I.**	**Variant II.**	**Variant III.**	**Variant III/A**	**Variant I.**	**Variant II.**	**Variant III.**	**Variant III/A.**
Total shoal dredging with placement in the riverbed m³	354 000	350 000	286 000	286 000	47 000	23 000	15 000	13 000
Construction, extension of spurs from quarry stone m³	248 000	74 000	57 000	55 000	83 000	57 000	68 000	62 000
Construction, extension of spurs from crushed stone m³	23 000	15 000	19 000	15 000	21 000	13 000	13 000	13 000
Reconstructing spurs with in-work material handling m³	0	0	0	0	3 000	2 000	2 000	2 000
Construction, extension of guide banks from quarry stone m³	0	0	0	0	61 000	39 000	39 000	39 000
Construction, extension of guide banks from crushed stone m³	0	0	0	0	0	0	0	0
Construction, extension of guide banks with in-work material handling m³	0	0	0	0	0	0	0	0
Construction of bendway weirs m³	0	99 000	91 000	80 000	0	0	0	3 000
Construction of Chevron dikes m³	0	45 000	27 000	27000	0	25 000	25 000	18 000
Vegetation clearance of spur gaps and guide banks, woody vegetation m²	0	0	0	0	2 000	1 000	1 000	1 000
Dismantling of sediment deposited in spurs gaps by placing them in shore protection structures, or in the support body of flood protection dams m³	0	0	0	0	0	0	0	0

Creation of a secondary river bed in the notched spur field by placing the extracted material in shore protection structures, or in the support body of dams m³	0	10 000	10 000	10 000	0	0	0	0
Total work*	**625 000**	**593 000**	**490 000**	**472 000**	**217 000**	**160 000**	**163 000**	**151 000**
Vegetation clearance of spur gaps and guide banks m²	0	0	0	0	14 000	7 500	7 500	7 500

Equal workloads marked with a yellow background *The summary covers very different types of work, so the number only refers to the different magnitude of the total activity.

The interventions performed well during the modelling. The stone structures aligned to the low water training lines had a beneficial effect on flow conditions at all locations; in addition, they ensured the navigation channel according to the requirements by minimizing maintenance costs.

Velocity figures of the model results show that by using bendway weirs, velocity values decrease, and flow conditions are improved even at average discharge periods. At the locations where the aim is to prevent recreation of shoals, chevron dikes are effective tools to increase velocities. The conditions of ice conveyance are also improved by the river training interventions and the regulation of the channel gradient, bends, low water levels, shoals, and floodplains.

6. MULTILATERAL COMPARATIVE EVALUATION OF THE VARIANTS

The aim of the variant analysis is to select a proposed variant that provides sufficient navigation and involves lower costs and environmentally friendly solutions at the same time, without compromising the WFD classification of the affected water bodies and the status of water bodies and without disturbing existing water uses and helps to improve the ecological condition and also reduces maintenance work during operation (less dredging). This summary contains only a brief description of the evaluation criteria and the results of the evaluation.

6.1. METHOD OF VARIANT ANALYSIS

The variants were compared by multi-criteria evaluation. We prepared the evaluation according to the following four groups of criteria:

A) Technical and navigation criteria group
B) Economic and efficiency Criteria Group
C) Economic and efficiency Criteria Group
D) Social and acceptability Criteria group

The above approach is justified by the fact that the European Commission strongly recommends an integrated approach to the planning of inland waterway projects. An integrated approach is considered particularly important when the development affects one or more Natura 2000 sites, as it allows designers to consider the ecological requirements of the site at an early stage in the planning process and to take into account the site's conservation objectives. According to our expectations above, only that variant can remain as an alternative, that meets all the evaluated criteria. **Accordingly, exclusion criteria were also used.**

The evaluation system makes a general comparison of the individual variants, without considering the specific sites, where the main question is not only which variant has the most favourable characteristics, but also which variants are acceptable at all.

Within each criterion system, a different scoring scale was assigned to each criterion according to their cumulative. In order to determine favourable and unfavourable trends, the scale may extend in both negative and positive directions, if justified.

An acceptable variant may be that one, where there is no exclusion criterion, and the total score determined for the groups of technical, economic and social criteria is positive in all three cases, it does not fall below -10 from the point of environmental and nature protection view. And the total score is greater than +10, which means the mean of the scoring in our case.

4. table: Cumulation of evaluation criteria

Criteria Group	Cumulative	Scoring scale	Scale design considerations	Number of evaluated criteria
A) Technical and navigation aspects; manageability of extreme situations in water resources	35%	From-5- to +30	Technical solutions must meet the set goals as much as possible, at the same time serious constraints must be reckoned with.	19
B) Economic and efficiency considerations	15%	From-5- to +10	We expect positive results, but we can also expect economic negatives.	17
C) Protection of environment, nature and landscape; flexible conformity to natural environment	40%	From-25- to +15	The expected direct environmental effects (mainly implementation and traffic growth) are typically negative, but positive direct and indirect effects can also be expected. A positive amount is not expected here, but -10 it is.	51
D) Social and acceptability issues	10%	From-5- to +5	Judgment can be expected in both directions. Current direct water uses are more likely to be adversely affected, while benefits can be expected at the level of society.	7
Total	**100%**	**From -40-to +60**	**A positive result is the minimum expectation. Its magnitude can be defined as the minimum criterion, which was recorded in 50% of the scoring range, i.e. +10 points**	**94**

6.2. RESULT OF VARIANT ANALYSIS

The scoring is quite strict, and it was prepared with a more pessimistic attitude. We considered the harms to be real, more realistic rather than the benefits. We also took into account the worst-case scenario in terms of the shipping traffic increase. So, this assessment in contrast to sustainability investigation, takes into account the presumed problems of concrete implementation and operation. Some of these problems can be improved and avoided during further planning and implementation. In terms of traffic effects, it does matter what growth and engine modernization will take place over the next 20 years. According to the division of the design work, the variant evaluation was performed separately for the stretch between Szob - Dunaföldvár and Dunaföldvár - southern national border. The tables below show the overall score.

5. table: Aggregate scoring results of the Szob- Dunaföldvár Danube stretch (1708,0- 1561.0 rkm)

Criteria Group	Scoring Scale	Variants				
		0	I.	II.	III.	III/A
A) Technical and navigation aspects; manageability of extreme situations in water resources	From-5-to + 30	**8**	**18**	**20,1**	**24,1**	**25,4**
B) Economic and efficiency considerations	From -5-to + 15	**0,8**	**0**	**0,5**	**2,2**	**3,1**
C) Protection of environment, nature and landscape; flexible conformity to natural environment	From-30-to + 10	**-1,1**	**-11**	**-9,6**	**-7**	**-5,5**
D) Social and acceptability issues	From-5-to + 5	**-0,6**	**0,3**	**0,7**	**1,1**	**1,6**
Total	**From-40-to + 60**	**7,1**	**7,1**	**11,7**	**20,4**	**24,6**
Exclusion		**Excluded**	**Excluded**	**Excluded**	**Excluded**	**Optimum**

The variant zero received a total of 7.1 points, but eventually it was excluded due to non-compliance with the Danube Commission's recommendation on permanence. According to the present assessment, if all three had not been excluded, two of the three variants would have been acceptable according to the scores (overall score above +10, environmental score above -10, and positive technical, economic and social opinion). Of this approach, only Variant no. I was placed in the non-proposed category, but Variant II. is only at the limit of acceptability too.

Regardless of the scores obtained, all three development variants were excluded due to the involvement of water reserves, except Variant III./A. Accordingly, only **Variant III./A can be proposed**, which already received the highest overall score.

6. table: Aggregate scoring results of the Dunaföldvár – southern national border Danube stretch (1708,0- 1561.0 rkm)

7.

Criteria Group	Scoring Scale	Variants				
		0	I.	II.	III.	III/A
A) Technical and navigation aspects; manageability of extreme situations in water resources	From-5-to +30	**10**	**22,2**	**25,3**	**26,2**	**26,5**
B) Economic and efficiency considerations	From-5-to +10	**0,6**	**0,7**	**3**	**3,5**	**4,7**
C) Protection of environment, nature and landscape; flexible conformity to natural environment	From-25-to +15	**-0,9**	**-10,4**	**-6,8**	**-4,7**	**-2,9**
D) Social and acceptability issues	From-5-to +5	**-0,6**	**0,7**	**0,9**	**0,9**	**1,2**
Total	**From-40-to +60**	**9,1**	**13,3**	**22,4**	**25,9**	**29,5**
Exclusion		**Excluded**	**Excluded**	**Excluded**		**Optimum**

The variant zero received a total of 9.1 points, but eventually it was excluded due to non-compliance with the Danube Commission's recommendation on permanence. According to the present assessment, two of the

four options are acceptable; there is no exclusion and a total score above +10, environmental score above -10, and positive technical, economic, and social opinion. So **only Variant no III. and III/A may be proposed**. Varioant no. II. would have been acceptable according to its scoring, but it was excluded due to the planned dredging on the outer protective zone of the Foktő-Barákai water reserve. **Variant no. III./A received the highest score, and it has lowest need for intervention.**

7. EVAULATION OF ENVIRONMENTAL IMPACTS

The environmental evaluation of the Program has been carried out according to three approaches:

- **First**, we examined how the objectives of the Program fit into the relevant national and EU environmental policy goals and expectations. Achieving the environmental policy objectives of Hungary and EU is a main condition (through legislation and regulations) and it is necessary to implement development efforts within its framework.
- **Second**, we performed a traditional environmental assessment, where we examined the impact of the planned interventions on the affected. (In the present phase, only the direction and tendencies of the effects can be predicted, a detailed impact assessment can be made during the environmental impact assessments.) Therefore, in this phase, the expected environmental problems, their causes, and consequences have been identified.
- **Third**, we defined sustainability criteria for the Program. This can be applied as a design requirement during the planning. Sustainability criteria define the aspects that form the basis of environmentally and naturally sustainable socio-economic processes and behaviour.

The following is a brief presentation of the results of the studies performed from the three approaches.

7.1. ADAPTATION OF THE PROGRAM'S TARGET SYSTEM TO EU AND DOMESTIC ENVIRONMENTAL OBJECTIVES

In the course of the study, we examined the aims and expectations of 18 EU and 22 Hungarian environmental and transport policy documents. The examined documents included the EU Strategy for the Danube Region - Action Plan, Living well, within the limits of our planet, National Biodiversity Strategy, Water Framework Directive and River Basin Management Plan, The European Landscape Convention and National Landscape Strategy, National Energy and Climate Plan of Hungary, The Second Climate Change Strategy of Hungary, EU White Paper on Transport, National Transport Infrastructure Development Strategy, Environmental Basics of the Sustainable Use of the Danube as a Waterway, National Water Strategy, IV. National Environmental Protection Program, National Forest Strategy, National Framework Strategy on Sustainable Development of Hungary, National Development 2030 - National Development and Territorial Development Concept. The detailed assessment is briefly summarized in ***Table 7.*** In the first column of the table, the objectives in the examined documents are presented in a consolidated form, the second column shows the evaluation, whether the Program helps or hinders the achievement of the given objective.

Sign	Description	Occurrence
☺	In terms of the criteria, a clearly favourable displacement can be expected based on the Program.	**10 pcs**
😐	In terms of the criteria, there may be favourable and unfavourable processes, but either their extent is likely to be small or we must reckon with adverse effects that may neutralize the result. / The Program has only a small impact on the objective under review.	**5 pcs**
☹	In terms of the criteria, a clearly unfavourable displacement can be expected.	**1 pc**
☺/☹	Typically, favourable effect, but there are adverse effects too.	**11 pcs**
☹/☺	Typically, an adverse effect, which can be made favourable with appropriate treatment, there may be also beneficial effects in addition to the typically adverse effects.	**6 pcs**
NM	Only indirect effects that cannot be classified at this stage	**2 pcs**

8. table Relationship between the Program and general environmental objectives

Merged environmental objectives	The connection of the Program to the goal
I/a PRESERVATION OF VALUE: general objectives	
Preservation, sustainable use and development of our natural resources and values	The Program can contribute to the promotion of a resource-efficient economy by shifting freight transport from road to water. The Program takes into account natural values whenever possible (e.g. the aim is to minimize interventions), but conflicts are also expected ☺/☹
Integrating landscape protection into all policies that may have a direct or indirect impact on it: **protection of landscape structure, landscape character and landscape potential**	Some of the objectives of the Program are in line with the principles of landscape protection (e.g. protection of natural and cultural historical values). Preventing further lowering of riverbed and low water levels is also important in order to preserve the landscape potential, just as the application of solutions with ecological benefits and the minimization of interventions are important for natural values. However, the interventions planned to create a shoal free navigation channel could also have local adverse effects (e.g. disruption of water-related recreational activities). ☺/☹
I/b PRESERVATION OF VALUE: halting the loss of biodiversity and the damage to ecosystem services, restoring degraded ecosystems	
Halting the loss of biodiversity and the damage to ecosystem services, measurable improvement in the legal status of species and habitats covered by EU legislation	The effects of the interventions planned to develop the navigation channel, as well as the effects of the increased shipping traffic are mostly unfavourable on wildlife. At the same time, the Program also has positive elements in terms of biodiversity, such as the prevention of further riverbed and low water levels lowering in order to ensure ecological water demand, minimal interventions, or the application of innovative technical solutions that comes with ecological benefits. ☹/☺
Protection of protected natural area of national significance, Natura 2000 areas and natural values	The interventions of the Program are fundamentally unfavourable to the protected values. However, according to its objectives - e.g. the principle of minimal interventions, minimized natural damage – it seeks to protect the species and habitats associated with the Danube ecosystem as much as possible. The advantages include the prevention of riverbed and low water level lowering, the minimal increase of low water levels, and the improvement of the water supply of side channels. ☹/☺
Integrating biodiversity conservation aspects into decision-making, strategies, and programs in certain sectors	One of the fundamental goals of the Program is to minimize the natural damage, to apply innovative technical solutions that comes with ecological benefits (notching of spurs, Chevron dikes) and compensatory interventions (to preserve and improve the water supply of the side channels). The Program strives for a compromise that is acceptable from a nature conservation aspect, thus integrating the goal into the planning process. ☺
Preservation and development of ecosystem services during the implementation of infrastructural developments that directly affect the quality of ecosystem services	The preservation of ecosystem services can be facilitated by implementation that requires minimal intervention, but individual interventions and the increase in shipping traffic can also cause adverse local (possibly over a larger stretch of river) changes. At the same time, the prevention of further lowering of riverbed and low water levels is favourable in this respect too just like in the case of the landscape potential. ☹/☺
Restoration of degraded ecosystems through the development of green infrastructure, protection of the most valuable ecosystems and endangered animal species	This goal can be helped by preventing the lowering of the riverbed and low water levels, and by preserving the water supply of the side channels. The "principle of minimal interventions" can help reduce the impact on valuable ecosystems and endangered animal species, but adverse changes cannot be completely avoided. ☹/☺
Supporting the restoration of wetlands and floodplains (restoration of degraded ecosystems, e.g. side channel rehabilitations, protection of wetlands and water-dependent habitats)	In some places, the Program aims to improve the hydro morphological conditions of the side channels as a compensatory intervention. It can also directly contribute to the conservation of riverine wetlands by preventing further riverbed and low water level lowering. ☹/☺
Increasing the possibility of ecological passages, reducing obstacles that interrupt the migration of fish in the Danube River basin, or the water continuity	The interventions included in the Program do not fundamentally affect the passage, however, some elements (e.g. demolishing and notching of spurs) help the passage to a small extent, others (new stone structure) worsen it for certain groups of organisms.☺/☹
Promoting sustainable management: floodplain landscape management and the promotion of a comprehensive water management system in suitable areas	In principle, even small improvement in the conditions of floodplain management (water supply) can be achieved by technical solutions that meet the goal of "preventing further riverbed and low water level lowering and improving the water supply of side channels", but the Program has no direct impact on this. **NM**
Sustainable forest management based on natural processes, preservation and increase of forest areas, improvement of the multifunctional role of forests	The objectives of the Program are in line with the forest protection objectives through the "principle of minimum interventions", but in case of some interventions there may be forest land use. However, preventing further riverbed and low water level lowering is also favourable from forestry aspect. ☺/☹
Control of invasive, exogenous species	The Program has no direct impact on this purpose. In the absence of adequate rehabilitation, the vegetation clearance can contribute to the spread of invasive species.

Merged environmental objectives	The connection of the Program to the goal
	The spread of stone structures, the changes in the subsoil/ riverbed/ bank can also impair the viability of native species in case of aquatic invertebrates and fish and help the spread of (already typical) exogenous species. ☹
I/c PRESERVATION OF VALUE: Preserving Europe's water resources, providing good quality and quantity of water for all legitimate water uses	
Preservation of the **good ecological, chemical, and quantitative status and potential of surface and groundwater bodies**, reduction of their hydro morphological load, achievement of the WFD objectives, **implementation of the river basin management plan**	The Program has been prepared in accordance with the measure "Adaptation of navigation to river or standing water conditions" and the principle of "minimal disturbance" of the national river basin management plan. According to the assessment that can be carried out in the present phase, the classification of the status of the water body (category degradation) is not expected to occur, but interventions will have a locally unfavourable effect (e.g. ecological status). ☹/☺
Responsible water management, integrated water management, development of land uses in accordance with water resources, water retention	The Program defines the interventions required for the implementation of the shoal-free fairway by taking into account the integrated water management. Water resources are expected to have a positive impact on preventing further riverbed and low water level lowering. ☺
Reducing water abstractions, raising awareness of water consumption, **economical water use,** improving the efficiency of water use	The Program has no direct impact on the amount of water abstractions or the economical use of water, however, an important aspect in the planning was the consideration of water abstraction sites (both for industrial and drinking water supply purposes). 😐
Maintaining the invariability of the natural riverbed during the development of navigability on the Danube, the principle of **minimal intervention and disturbance**, adaptation of navigation to the conditions of the river	One of the basic objectives of the Program is to implement a shoal-free navigation channel with the least possible interventions in accordance with domestic and international standards. Minimizing these interventions is definitely positive. However, the planned interventions are not equal to the adaptation of shipping to the conditions of the river. ☺/☹
I/d PRESERVATION OF VALUE: preservation and development of cultural heritage	
„Creative management of cultural landscapes and cultural heritage", **general protection of cultural heritage**	The Program also takes into account heritage protection aspects. The involvement of archaeological sites affected by earthworks and dredging may be unfavourable, but at the same time the risk may be reduced (e.g. performing river site diagnostic tests, archaeological supervision). 😐
Strengthening sustainability values, **reviving cultural traditions,** recognizing cultural diversity, preserving intellectual, material and built heritage, developing its values, using it sustainably	The Program does not have a direct impact on cultural traditions, however, the prevention of further riverbed and low water level lowering is also favourable for the water management of the related areas, e.g. may have an indirect beneficial effect on traditional agricultural and forestry activities in the floodplain. **NM**
II. RESOURCE-EFFICIENT ECONOMY WITH LOW ENVIRONMENTAL LOADS: Improving resource saving and efficiency, greening the economy	
The carrying capacity of environment must be enforced as a barrier to farming: a shift towards a more sustainable and resource-efficient economy, economic growth and the decoupling of environmental damage.	Transport, efficient transport of goods and passengers are essential for the economy. The Program contributes to the improvement of the conditions of navigability on the Danube, thus to the development of a more sustainable transport system than at present, and to increase the share of water transport. This - although it comes not only directly environmental benefits- indirectly has other positive environmental effects too (e.g. shifting some of the road freight traffic to waterborne freight). ☺/☹
Avoidance of endangering the environmental condition of infrastructural developments, minimization of spatial use, landscape utilization based on landscape conditions (liveable landscape – liveable settlement – wise landscape utilization)	The objectives of the Program are in line with the objectives of the National Landscape Strategy, such as with the "landscaped infrastructures" and "landscape utilization based on landscape features" through the "principle of minimal interventions". However, it should be emphasized that changes in riverside land use will be primarily influenced by related investments (e.g. port development, expansion of rail and road links), not necessarily by the construction of the waterway itself. (As an indirect effect, the inevitable surplus of road transport may also be beneficial due to the increase in road transport.) ☺/☹
Efficient, **environmentally friendly transport system** that respects the principles of sustainability, **encouraging low-emission modes of transport,** reducing mobility needs	The Program supports the improvement of the conditions of water transport, which is an environmentally friendly and accident-safe mode of transport. Together with the objective of the National Port Development Master Plan Strategy, the ultimate goal is to encourage the change of transport modes by establishing multimodal junctions (e.g. diversion from road to water transport). ☺
Modernization of the transport sector (resource-efficient, energy-saving, low-CO_2 emissions), development of modern and fully interconnected transport and energy	The Program supports the improvement of an environmentally friendly mode of transport, the conditions of water transport of goods and passenger. Thus, it also contributes to the increase of the share of water freight transport and tot he improvement of the conditions of passenger transport in the long run. ☺

Merged environmental objectives	The connection of the Program to the goal
infrastructure, reduction of CO_2 emissions of watercrafts	
Reasonable, moderate management of non-renewable natural resources	In terms of freight tons, the energy consumption of waterborne freight transport was considered more favourable than the road freight transport. Thus, a more favourable management of natural resources can be achieved by changing the share of modes of transport. ☺/☹
Increasing the share of renewable energy to at least 21% of gross final energy consumption and to at least 14% of transport **by 2030.** Curbing the growth of oil consumption for transport.	The Program has no direct impact on the increasing of the share of renewable energy sources. There are ideas to replace marine fuels based on renewable resources (e.g. liquefied biogas, electric propulsion from renewable energy sources, hydrogen propulsion), but these are outside the scope of the Program. The implementation of these ideas is definitely recommended. 😐
Energy saving, improvement of energy efficiency, reduction of primary energy consumption (Hungary's final energy consumption in 2030 should not exceed the value of 2005, or if it exceeds it, it should come from a carbon-neutral source.)	The main objective of the Program is in line with the improvement of energy efficiency (which aims to develop inland waterways), as waterborne transport is also recognized as an energy-efficient mode of transport in the White Paper on Transport Policy. Significant energy savings can be achieved by shifting part of road freight to waterborne freight. The Program has no real impact on the energy efficiency of the watercraft themselves (it states that the development of an "environmentally friendly fleet" is the responsibility of other projects). ☺
III. ENVIRONMENTAL LOADS – HEALTH PROTECTION: Improving the environmental conditions of life quality and human health	
Reduction of emissions and burdens endangering human health and life quality (including all types of pollutant emissions to soil, water, air, etc., as well as noise pollution)	From human health aspect, the implementation of the Program may cause problems primarily due to noise pollution, air pollution and surface water load during both the construction and operation. At the same time, in case of abducent effect of road traffic, it can reach more people by reducing noise and vibration loads and air pollution. During the planning, the aim was to avoid water reserves as much as possible, so the overall quality of human life and health is not endangered by the implementation of the Program in the local environment, and diversion from public roads can improve it. ☺/☹
Meeting air quality standards, reducing air pollution, **achieving air quality that does not cause a significant risk to human health and the environment**	In terms of air quality protection, in the event of the implementation of the Program, the expected increase in ship traffic - operated with the current conventional fuel - will increase the air load in the areas along the Danube. At the same time, traffic diversion- by reducing road traffic - reduces air pollution in the vicinity of road infrastructure. Freight transport by ship is much more favourable in terms of emissions than road transport. ☺/☹
Making water and hygiene, energy supply accessible to everyone and their sustainable management	During the preparation of the Program, the protection of water reserves was a key planning aspect. "Preventing further bed and low water level lowering" is beneficial for the water supply of water bodies. 😐
Preventive flood protection and drainage, quality water and water utility services	One of the aims of the Program is to preserve and improve the conditions of ice and flood conveyance. The requirements of the large-water riverbed management plans were taken into account during the planning of the Programme's interventions. ☺
Halting soil degradation, restoring it, improving soil water retention capacity, increased protection of the quantity and quality of soil stocks, long-term maintenance of fertility	The Program aims for a minimum land use in accordance with the minimum interventions, thus taking into account the protection of the amount of soil. There is only a minimal occupancy, mostly in the riverbed. The "prevention of further riverbed and low water level lowering" has a positive effect, which contributes to maintaining the groundwater table along the Danube, thus preserving the soil fertility. ☺/☹
Sustainable waste management: e.g. prevention of waste generation, reducing its hazardous character; selective collection; recycling; safe disposal, landfill reduction	The Program has no impact on waste management. However, this is a goal to consider during the implementation of interventions. During the riverbed dredging, demolition of the shoal, the extracted gravel remains in the riverbed. Waste is expected to be generated e.g. from vegetation clearance works or the demolition of certain facilities, the former will require the practice of composting and the latter the practice of selective demolition. ☺
IV. CLIMATE PROTECTION AND ADAPTATION: improving the conditions of investments related to environmental and climate policy and addressing environmental externalities	
Reducing GHG emissions, using less and cleaner energy in general, **a reduction of around 5% in the transport sector by 2030**	The main objective of the Program is the development of the Danube waterway, which also contributes to increasing the share of water transport within freight transport. This - if a reduction in the share of road freight transport is achievable - will also help to achieve CO_2 reduction targets. ☺
Promoting adaptation to climate change, risk prevention and management, making the management of regional and global environmental and climate change challenges more effective, territorial coordination of policies	The Program emphasizes that the navigation sector must be prepared to adapt to the effects of climate change, and that technical design is made with this taken into account. ☺

Merged environmental objectives	The connection of the Program to the goal
Preserving ecological water discharges, ensuring ecological water demand, reducing the risk of floods and droughts	The principle of "Prevention of further riverbed and low water level lowering" contributes to the provision of ecological water demand, just as the management of extreme conditions expected due to climate change is a priority in the planning. The interventions planned in the Program take into account the flood protection aspects, do not deteriorate the conditions of flood conveyance. ☺
Increasing natural surface coverage to absorb emissions	The objectives of the Program will minimize the vegetation clearance through the "principle of minimum interventions", however, it will be a necessary corollary of some interventions. The Program does not contribute to the goal of increasing natural plant coverage. 😐

The Program has a mixed relationship with most of the merged objectives of EU and Hungary i.e. has advancing and supporting elements related to them. We consider it favourable that a shift that is favorable or relatively favorable in terms of the goal is achievable in 21 of the 35 aspects. We found a clearly unfavourable shift in terms of the target in only one case ("control of the spread of invasive species"), however, the Program clearly helps to achieve the goals at almost a third of them (10 out of 35 cases).

7.2. DIRECT AND INDIRECT ENVIRONMENTAL IMPACTS

7.2.1. Direct impacts

The examined direct impacts and impact processes are summarized by presenting the impact flowchart applied in many cases in environmental impact assessments. The environmental study evaluated the processes presented on the figure. The structure of the conceptual impact flowchart is the following:

- The first column shows the relevant environmental element, system and the second column shows the reference number;
- The expected environmental impact factors of the planned activity are listed in the third column. A given impact factor always appears for the environmental element on which it acts directly, without transmission. An environmental impact factor can affect several environmental elements directly at the same time, of course in different ways, in which case it is presented for all the environmental elements involved. See e.g. area reservation, traffic growth;
- The expected direct impacts are listed in the fourth column and the indirect effects are presented in the following column;
- The arrows indicate the spill over of impacts toward the final affected. The spill over can take place through numerous phases, mostly with decreasing, rarely with increasing efficiencies;
- The ultimate affected are mostly the ecosystem, humans and landscape. These ultimate affected are shown in the penultimate column because the effects on the environment, so that the changes in the state of the environmental elements and systems can be interpreted / evaluated from their point of view.

In the environmental study, we analysed the direct and indirect effects both on the implementation of the developments as well as on the existence of the developed fairway and the increasing vessel traffic. In the following short summary, we would like to emphasize what direction (favourable or unfavourable) and what significant effects are expected to cause by the processes at this stage, paying attention to the uncertainties and issues to be examined in detail in the further planning process. (The ultimate affected elements, i.e. impacts on wildlife, humans, and the landscape, are listed in Chapter 8.)

8. figure Possible environmental impact pathways of the implementation and operation of the developed navigation channel

Environmental element /system		Impact factor		Direct impacts	Indirect impacts	Final affected elements
Air	1	Construction / demolition activities involving structures	→	Temporary deterioration of air quality in the vicinity of the intervention area		Health effects, disturbance and its decrease
	2	Dredging	→			
	3	Placement of dredged material in the bed, construction of bendway weirs	→			
	4	Construction/demolition related road traffic/ transfer	→	Temporary deterioration of air quality along transport routes		
	5	Construction/demolition related shipping traffic	→			
	6.	Increase in vessel traffic	→	Permanent deterioration of air quality along the navigation channel Sustained improvement in air quality in the vicinity of traffic diversion		
Surface and groundwater	7	Dredging, construction / demolition of stone structures	→	Possibility of involving bank-filtered water reserves Changes in runoff conditions on the affected river section Temporary deterioration of surface water quality	Changes in groundwater status	Possibility of local supply problems e
	8	Placement of dredged material in the bed, construction of bendway weirs	→	Riverbed stabilization		Changes in uses
	9	Notching of spurs, creation of a secondary near-shore low water level riverbed	→	Formation of a flow field protected from wave action		
	10	Existence/ operation of structures, condition resulting from dredging	→	Stopping low water levels and riverbed lowering Stopping shoal creation Improving flow conditions		
	11	Increase in vessel traffic	→	Increased wave generation		
	12	Accidents during construction and operation	→	Temporary, local deterioration of water quality		
Land	13.	Dredging, dredging material placement in the riverbed, stone structure works	→	Riverbed morphological changes		Changes in uses
	14.	Existence/ operation of structures, condition resulting from dredging	→			
	15.	Waste management during implementation	→	Possibility of soil and bed contamination		
	16.	Possibilities of accidents during construction and operation	→	Need to dispose of contaminated materials		
Wildlife-ecosystems	17.	Dredging, dredging material placement in the riverbed, stone structure works	→	Loss of habitats, destruction of individuals and populations	Improving living conditions Deterioration of living conditions	Changes in the possibilities of legal value preservation, change in ecosystem services
	18.	Vegetation clearance, reduction	→			
	19	Existence/ operation of structures, condition resulting from dredging	→	Habitats, diversity changes		
	20	Interventions to improve water supply of side channels	→	Improving living conditions		
	21.	Increase in vessel traffic	→	Disturbance of wildlife		
Artificial elements - Urban environment	22	Dredging, dredging material placement in the riverbed, stone structure works	→	Developing an improved waterway Temporary noise level change near the affected areas		Discomfort, confusion, mental strain
	23	Construction/demolition related road traffic/ transfer	→	Temporary noise level change near the transport roads		
	24	Increase in vessel traffic	→	Noise level increase		
Landscape	25	Construction / demolition works, clearance of riparian vegetation	→	Temporary disturbance of landscape uses		Landscape potential change
	26	New structures	→	Landscape change		
	27	Increase in vessel traffic	→	Changes in land use possibilities		Improving opportunities, creating conditions for traffic diversion

In terms of environmental impact assessment, the predicted traffic changes have the greatest importance as a result of the development, which is the consequence of the increased utilization of the fairway and the hoped-for (expected) road traffic diversion effect. It is important to mention that the planned development is a necessary but not a sufficient condition for the actual growth of shipping traffic on the Danube. A number of other interventions (among others, the project on the Danube stretch between Szob and the southern national border, the implementation of port developments, the application of modal shift incentive tools, measures and other regulatory tasks, awareness-raising, etc.) are also essential to take advantage of the increased capacity provided by this development. The field summaries are given assuming the fulfilment of these other conditions, as the traffic may increase the most if they are implemented together, which is considered to be the most critical change in the long run from environmental aspect. (Exceptions to this are the impacts on wildlife, where the implementation of interventions, then the existence of a developed fairway will have similarly significant impacts.)

Surface water

The **dredging** -although minimized in the design process[6] - locally and transiently burdens the status of the surface water (mixed sediment, decreased transparency, locally increased suspended solid concentration). The condition of the water body can be affected by dredging in the long run due to the changes of water level (changes in bed morphology, flow, and slope conditions) and the influence of the sediment transport capacity.

The already recognizable unfavourable processes can be mitigated by the declared objective of planning, **the prevention of riverbed deepening** during low water periods on the Danube. Based on the model investigations a water level rise of 0.5-1.5 dm is expected between Dunaföldvár and Harta. The planning aims to increase the low water level above Bölcske, to stop the water level decrease in the area of Paks and below it, and to keep the water level increase below Baja. At the Göd shoal, the height of the 3 bendway weirs was increased in order to increase the level of the water level, and this is also the case at the Budafoki shoal.

River training works could potentially even worsen the morphological status of the water body (see Chapter 8 for changes in ecological status), so it was necessary to carry out the first steps of the WFD 4.7 study. Based on the study, it can be concluded that the regulation rate on the water bodies is not expected to change significantly. The planned new structures have been placed to the already trained sections due to the supplementation of the previous regulations, the improvement of the resulting riverbed conditions and the improvement of the harmful riverbed erosion. They locally affect such a short riverbed section that their implementation cannot be considered as a modification of the riverbed that would cause category deterioration.

The principle of the planned interventions is that the planned training structures must not worsen the movement of bedload, must not cause velocity decrease in the navigation channel since it would generate suspended load deposition. This is helped by the fact that construction works begin with the construction of stone structures, progressing from the top to the bottom in stages, just like in case of dredging works. The construction of the bendway weirs -prior to dredging- is designed from the bottom in stages, so that the lowest bendway weir has already provided support, preventing sediment trapping under the higher bendway weirs built above them.

The dredged bed and rock material are placed in the bed (in the foreground of the bendway weirs, in the sections of the river between them, to fill the well formation caused by spurs, in the dead storage of spurs, in dead storage of flow). This solution is expected to avoid the need for mechanical stabilization (which has been identified as a problem several times during the review of the strategic environmental assessment of the preceding design process). It is also important to keep in mind the importance of preventing drift in later investigation phases.

[6] In the planning phase around 2010, much higher dredging volumes were expected.

During implementation, a possible **major accident** may be caused by the release of hydrocarbon derivatives into the water. This can be periodic and - depending on the flow- local hazard, which can have a detrimental effect, but the probability of occurrence, and thus the risk is low.

The interventions performed well in the 2-dimensional and 3-dimensional models. The **realized structures** and the **dredged bed** had an overall beneficial effect on the flow conditions; however, it is not uniform, in terms of the state of the water of the Danube in the function of certain kinds of structures. (For instance, by using bendway weirs, hydraulic gradient decreases; using chevron dikes help to reduce shoal creation, however sedimentation may form behind the spurs, demolishing and notching stone structures reduce the training of the riverbed and has a positive effect on the water quality of downstream side).

According to foreign experience, the selected structures do not cause an adverse effect on **ice- and flood conveyance** conditions. The Danube stretch between Szob-Budapest is basically managed in terms of flood and ice conveyance. Based on the calculation of the design flood level, a water level increase of up to 3 cm is expected above 1540 rkm. In the case of the Szob and Dunaföldvár reach, the situation assessment also emphasizes that excessive water level rise should be avoided, because the section affects many parts of the interior area. The selected variant creates a uniform bed that helps with both ice and flood conveyance.

Increased traffic could have an impact on the river with increased **wave action** and increased **risk of water pollution** from ships. The extent of this depends on the increase in traffic, which - as shown previously- is expected to increase gradually (number of vessels is estimated at the current 35-50%).

Pollution of surface water and the bed material can be expected primarily in **the event of an accident or disaster** in connection with navigation. Hydrocarbon derivatives may have the most adverse effects on water quality and wildlife of a river, as they mostly have hydrophobic properties. They float on the water surface, or dissolve in the water phase and bind to suspended sediment, then they can deposit and accumulate in the bed sediment. Accidental pollution (e.g. oil spills, falling/spilling of transported freight, soluble, liquid material into water) and navigation-related hydrocarbon pollution (e.g. discharging of oily bilge water into water, vessel cleaning) can be highlighted.

Groundwater

If the planned structures and interventions are able to effectively reduce the ongoing harmful bed intrusion process and raise the level of low waters, then a favourable indirect effect on groundwater may occur too. The stabilization of the water level, the increase of 0.5-1.5 dm in some sections can also have a positive effect on the groundwater level and on the groundwater-dependent ecosystems.

18 perspective and 25 operating water reserves are affected between the 1708-1433 rkm section of the Danube, of which, only 5 operating and 4 persective water reserves need to be examined due to the planned works. **The interventions were designed to affect the designated protection profiles of the water reserves as little as possible**. According to the relevant Governmental Decree No. 123/1997. (VII.18.) in the area of the hydrogeological protection zones “A” and “B” of the drinking water reserves, activities that affect the top or aquifer layer may be permitted depending on the results of the environmental impact assessment or the individual examination with the corresponding content. One of the most critical activities planned in the protection zones is riverbed dredging, as this inevitably involves the removal of the biologically active zone that forms the top 15-20 cm of the aquifer gravel layer, which affects the bed. Due to the involvement of the riverbed, all other construction activities can only be carried out depending on the results of the environmental impact assessment carried out as part of the permitting process.

Based on the preliminary study carried out in the SEA, as the level of dredging in the case of the Solt Island and to a lesser extent in case of the Solt-Harta perspective water reserves exceeds 1% of the part of the affected hydrogeological protection area in the medium water bed, thus the intervention may have an impact on the quantity and quality of water that can be extracted from the water reserve. The extent of this should be checked in the next planning phase according to individual examination, taking into account other interventions planned on some sections in addition to dredging. In the course of individual studies, the indirect impact processes, e.g. causing an increase (sedimentation) or a decrease (washing-out) in the amount

of bed material by changing the flow velocity should also be considered. Both sedimentation and washing of the bed material require further detailed studies in order to find out the actual extent and significance of the effects and to develop possible mitigation proposals. From this aspect – according to the best of our knowledge - the involvement of the Tököl, Szigetújfalu water structure, the operating Foktő-Baráka and the perspective Solt Island Solt-Harta water reserves should be investigated.

Based on our current knowledge and investigations, **it can be concluded that no intervention is planned on the section of the Danube between 1708-1433 rkm that would be contrary to the provisions of Governmental Decree 123/1997 on the protection of water resources or the environmental objectives and measures defined in the River Basin Management Plan or it would mean a significant threat to the safe operation or perspective use of water reserves** that would hinder the implementation of the project.

Geological medium, soil

The **planned interventions** may have an effect on the soil and geological medium (on the Danube riverbed and the riparian zone) due to the construction and demolition of the planned river training structures, the bed material transfer, the use of machinery, the transport activity and land use).

As a result of the **training works carried out in the riverbed** - interventions designed primarily to maintain water levels- the morphology and sediment equilibrium conditions of the riverbed, as well as the flow conditions and consequently the quality and morphology of the subsoil may change. The further loweing of the riverbed and the degree of washing-out are expected to be reduced by the planned bendway weirs. This helps maintain the proper width of the fairway and the number of regular maintenance dredging works, also reduces the amount to be dredged. In the vicinity of the planned chevron dikes, a dynamically changing bed section develops; there may be a deepening of the bed inside the chevron dam, below it there may be a shoal, island formation.

The island-forming effect can be reduced by breaking down the height of existing spurs. By demolishing their end from the shore, the sediment movement can restore along the shore, thus increasing the degree of coastal erosion, but also reducing the island-forming effect, the filling of intermediate areas. On the other hand, spurs placed closer to each other, can increase the degree of sedimentation and island formation, so this effect can be reduced by placing them farther away.

Lowering of the riverbed, widening of the navigation channel and the breaking of the riverbed material can be done by dredging. In contrast to the upper section of the Danube (above Szob), the so-called phenomenon of riverbed armoring is becoming less common due to the decreasing gravel and increasing sand content, still it can potentially occur in many locations. By removing the armoured bed material, a finer granular material can appear on the bed surface, which can change the exposure of the bed surface to flow. This can cause faster erosion compared to the previous natural state, thus changing the surface and shape of the bed. If the rock or sediment prone to further erosion, the local lowering of the bed may continue at the dredging site, as well as excess sediment may be formed.

Material from the demolition of existing stone structures and dredging activities can be used to construct new ones and to strengthen bank protection works. The dredged material is relocated in the bed to prevent further bed lowering.

As a result of the planned interventions, only temporary and small-scale **land occupancy** is expected outside the Danube riverbed, as most of the interventions can be carried out from water during favourable water level periods. Of course, it depends on the construction technology.

During **demolition and construction**, the soil destructive effect of the applied machines is unfavourable from wildlife protection aspect. In terms of geological medium, it should be taken into account that the intervention should not involve greater bank erosion than necessary.

The **existence (operation**) of the developed waterway and the **effects of its maintenance works** are essentially the same as the effects of construction, since maintenance and dredging activities of the

constructed works can be expected during the operation of waterway. The annual maintenance dredging accounts for ~ 20% of the dredging planned during construction.

As a result of **the waving caused by water transport**, a more intense flow velocity appears on the riverbed near the shore, which presumably also means higher bottom shear stresses. This causes erosion of the shore in the natural sections of the river and the formation of a greater sediment entrainment. The concentration of suspended sediment increases in the vicinity of the shore. As shipping traffic increases, these effects intensify, which needs to be taken into account during planning.

We have already mentioned the vessel-related **accidents** at surface waters.

Air quality, noise

During the implementation of the navigation channel development program and the subsequent maintenance of the developed waterway, temporary, shorter-term emissions of air pollutants and greenhouse gases and noise pollution are expected in the vicinity of the sections affected by the development. Their extent can be and should be reduced as necessary with appropriate work organization and technological solutions (e.g. mobile noise barrier).

The increased vessel traffic as the consequence of the development - the realization of which also depends on the fulfilment of several other conditions - will have more significant and lasting effects. Increased air pollutant (and carbon dioxide) emissions and increased noise levels are expected due to increased vessel traffic along the navigation channel. However, along those elements of the transport network from which water transport can divert traffic, a reduction of emissions, even an improvement of air quality and a reduction of noise levels can be assumed.

Interventions outside the framework of the Program (e.g. engine replacement for older watercraft, installation of particulate filters, especially ensuring the main power supply of port ships in Budapest, noise protection regulations for waterborne transport, etc.) are also needed to mitigate the adverse effects along the Danube, also in order to maximize the beneficial effects (e.g. the greatest possible diversion of traffic from the busiest networks, preferably roads etc.).

Urban environment

With the development of the navigation channel, the sensitivity of the built heritage known and “utilized” by tourism along the Danube may increase because of mass tourism. The extent and significance of this also depend on the geographical location of other investments related to the development of the fairway, as well as other potential effects of the realization (e.g. locally existing cultural and built heritage), which are not fundamentally related to the present development. **As a result of the fairway development, the built heritage cannot be considered directly affected**. **Rather, other investments related to the fairway development - e.g. port constructions, developments - and their effects on other traffic and shipping habits will likely have an impact on the built heritage.**

The main goal of the planned intervention is to expand the possibilities of water freight transport, to which no significant risk to the **built heritage** can be identified at this stage. (We have to mention that in terms of personal and tourist navigation, this is all the more the case, but it is also just an indirect effect and is expected to be realized without development in connection with other tourism developments.) Proposals have been made for the protection of **archaeological and aqua-archaeological sites** located directly on the shore or in the riverbed.

Waste generation and treatment

A significant amount of waste is expected during construction; to a lesser extent expected during operation. Due to predictable traffic growth, larger volumes of shipping waste - especially bilge water, which is classified as hazardous waste - are a concern. Construction and demolition related waste, municipal and hydrocarbon-containing waste are expected to be generated during the construction works. In some locations, the eradication of significant amounts of vegetation also requires green waste treatment. (It is advisable to

prepare the green waste for transport by shredding with mobile shredder on site and transport it to the nearest composting plant).

Minimal generation of conventional construction and demolition waste and municipal waste are expected as the material generated during the reconstruction or demolition of existing water structures is totally reused during the investment: the resulting material is recycled to build new water structures. By notching the existing spurs and demolishing the water structures, approx. 34 thousand m^3 of reusable material is generated.

The dredged 309 thousand m^3 of material is planned to be used in the shoals, spur gaps and spur fields of the main riverbed, as well as to strengthen the bank protection. The remaining sludge, sand or gravel material are relocated in the bed so it does not count as waste.

The expected increase in traffic also means an increase in the amount of waste generated on vessels. In extreme cases the traffic could increase by 75% compared to the current level, which could lead to a significant increase in the amount of waste. In particular bilge water, which is considered hazardous waste is a problem, as it is generated in relatively larger quantities. Currently it can be deposited and professionally treated in one place, on the Green Island of Budapest between the Szob – southern national border Danube reach. All this requires the development of a waste management system (either by implementing the planned "Green Islands" near the border, or with a more modern, more manoeuvrable solution that can also serve large cargo ships more easily). An increase in the amount of recyclable fraction is also expected, which should be collected separately and handed over for treatment.

7.2.2. Indirect effects

This chapter is based on the aspects summarized in the point 3.6.2 of Annex 4 of the Government Decree No. 2/2005 (I. 11.) and it presents the relevant aspects.

The emergence of new environmental conflicts, problems, the intensification of existing ones

- The **increase in shipping traffic** may have an adverse effect on certain riparian land uses (e.g. residential and recreational areas) and water-related recreational activities (e.g. risk of accidents, noise, waves). However, this is expected to happen gradually based on the traffic prognosis, so it will not cause a perceptible change for those affected, however, existing conflicts are expected to intensify in the long run.
- **Some planned facilities** (new stone structures) may have unfavourable effects for **water sports** (e.g. rowing, kayaking, canoeing), especially in those locations where the stone structure starts from the edge of the riverbed (e.g. spurs, chevron dikes in some locations), whereas in such a case, athletes are forced towards the middle of the river, which increases the risk of accidents. These is no new conflict, as there are already many spurs in the examined section of the Danube, however, an increase in their number and the appearance of chevron dikes may exacerbate the existing conflict for instance in the area of Dömös and Dunaföldvár- Solt. . Another conflict in terms of water sport could be caused by the increase in ship traffic, which could have a partly disruptive effect, but could also increase the risk of accidents.
- **Other developments are expected in parallel with the improvement of shipping conditions** - such as port developments, construction of logistics centres, infrastructural improvement of port access, possibly the establishment of new ports - all of which can be a potential source of conflict for the local population and wildlife, but they already go beyond the indirect effects of this project.

Weakening or limiting the possibilities and conditions of environmentally conscious behaviour and lifestyle

- Changes in cultural ecosystem services (e.g. sights, water-related recreational activities) that greatly affect the quality of life of local residents can lead to potential conflicts. At the same time, the opportunity opens up for the development of water freight and public transport due to the improvement of water transport conditions. This is an environmentally friendly mode of transport

compared to individual car use, the possibility of which is therefore not limited but expanded by the Program. Shifting freight transport from road to water can also be an important form of environmentally conscious behaviour.

Maintaining or creating a deviation from the optimal spatial structure and land use according to local conditions

- The planned interventions do not directly cause a change in land use. However, in parallel with the development of the waterway, other developments are expected to appear along the Danube, such as infrastructural improvement of port developments, logistics centres, port developments, establishment of new ports. Based on our current knowledge, such locations may be in the examined Danube section: Győr-Gönyű, Komárom, Esztergom area. Furthermore, based on the county spatial planning plans (2020), several regional ports are planned, e.g. in Ács, Almásfüzitő, Dunaalmás, Neszmély, Süttő, Lábatlan, Pilismarót. (The latter are probably not specifically for the purpose of transporting goods.)

Weakening local socio-cultural and economic traditions that adapt to the carrying capacity of the landscape

- In the area, traditional farming can be partly linked to the Nature Parks (Szigetköz and Gerecse Nature Park), the operation of which is not expected to be directly affected by the planned interventions or navigation.

7.2.3. Transboundary effects

The significant effect -in our opinion- assumes that it cannot be temporary, but it causes a **permanent change or a long-term status deterioration.** This is not the case if a significant impact of the activity occurs, for example, only as a result of a suspected accident event, during the implementation and maintenance, and its consequences do not cause permanent damage. Significant effects must be sought primarily among the effects of normal operational activity (in this case, an increase in shipping traffic) and the possible one-off but damaging effects (possibly from accidents). **The estimated impact zone of a significant effect extends beyond the border, and the significance also applies for this part of the impact zone. The significant effect**, if the circumstances to the contrary are not officially known from the territory of the neighbouring country (contained in a bilateral agreement, based on information provided by official information, etc.), **must be applied to the most sensitive impactor according to Hungarian practice.**

In the present case, in the SEA preparation phase, the environmental impact factors can only be assessed in a general way. However, it is certain that due to both the **implementation of the planned developments** (construction, demolition, dredging, etc.) and **the existence and operation of the developed navigation channel** (basically creating the possibility of traffic growth) it is necessary to examine the possibility of cross-border environmental changes. In the following, therefore, we examine these two groups of essential environmental impact factors.

The planned activity is listed in point 9 of Appendix I. of Governmental Decree No. 148/1999 (X.13.) on the transposition of the Convention on environmental impact assessment in a transboundary context, done at Espoo (Finland) on 25 February 1991. According to the Regulation, planned activities listed in Annex I which are likely to have significant adverse transboundary effects must be subject to an environmental impact assessment procedure which allows for public participation and the preparation of the environmental impact assessment documentation described in the Appendix II.

Phase of the implementation of planned developments

During the construction /demolition phase, as the middle and lower sections of the Danube do not flow at the border thus, border crossing should be considered only in the immediate vicinity of Szob and the southern border. The northernmost intervention is planned under Pilismarót, **more than 7 km from the border**, thus, the spread of construction related air or noise pollution is not expected to reach the Slovak side. Dredging has no landscape-shaping effect, and the habitat-influencing effect extends downwards. Thus, no cross-border

effect is to be expected for this environmental impact factor neither. The same is true for a possible accidental contamination.

The southernmost intervention is at Mohács, **13 kilometers from the border**, with the construction of a chevron-type structure. The chevron dam improves the navigability of the fairway by narrowing the riverbed and ensures the riparian water flow, but its effect is local, **it does not affect the distance indicated above**. (The direct effects of the construction also affect only a few hundred meters away.)

Existence and operation of the developed navigation channel

On the Danube as an international waterway, with the implementation of interventions in order to improve the navigation conditions- provided that all other countries along the Danube also meet the required navigation parameters - a uniform navigation channel will be developed. This, and the related infrastructure developments (ports, accessibility of ports with other modes of transport) create an opportunity to increase the volume of water transport. (A significant diversion is also conditional on the establishment of a legal and institutional framework for achieving the objectives set out in the EU White Paper, and on strict compliance with the restrictions imposed on road transport, and deviations from this will be severely penalized.)

As a result of the Hungarian development, the growth of long-term water transport traffic is expected in the northern direction to Slovakia, Austria, Germany, the Benelux states, and in the southern direction to Serbia, Romania and Bulgaria. The affected countries can benefit from both the economic benefits and the positive and negative environmental effects of this increase in traffic. (Positive effects are expected along the roads affected by the diversion, unfavourable effects are expected along the waterway, i.e. the Danube).

Currently, there are narrow sections along the Danube in other places as well similar to the Hungarian ones (in Germany, in Austria under Vienna, on the Romanian-Bulgarian section under Vaskapu), and the potential for increasing water transport demand is limited (i.e. the transport performance is determined not only by the parameters of the provided waterway, but also by the quality and size of the economic relations determining the transport demand) these effects are unlikely to be significant, i.e., will not fall into the significant category.

According to traffic growth prognosis, passenger transport may increase by 75%, and optimistic estimates for freight transport do not indicate more than 30-40% growth. However, if the increase in traffic approaches this, it will cause a significant adverse effect on certain critical sections that are still heavily congested, for instance air pollution or noise pollution. However, this is EU interest, and also it may result in a decrease in traffic on public roads farther from the Danube, more precisely it can result in the alleviation of traffic growth and a lower rate.

In our opinion, the only environmental impact factor is the increase in shipping traffic in which the need to apply the Espoo Convention may arise. However, the increase in load is not expected to be significant, **so we do not consider it necessary to examine the planned development under the Espoo Convention.**

7.3. SUSTAINABILITY INVESTIGATION

In Table 9, we evaluate its content on the basis of the system of sustainable development criteria developed for the Program. The following rating symbols were used in the table:

Sign	Description	Occurrence
☺	In terms of criteria, clearly favourable displacement can be expected based on the Program	**17**
☺☺	In terms of criteria, a clear, significant favourable impact can be expected.	**4**
😐	In terms of criteria, there may be positive developments, but either their extent is likely to be small or we must reckon with adverse effects that may neutralize the result.	**6**
☹	In terms of criteria, clearly unfavourable displacement can be expected	**4**
☹☹	In terms of the criteria, a clear significant unfavourable impact can be expected	**0**
? ?	There is considerable uncertainty about the criteria, lack of knowledge at the time of the evaluation, but it cannot be missed due to its importance.	**3**

Sign	Description	Occurrence
nr	Beyond the scope of the Program, it is not relevant.	**3**

9. table: Sustainability criteria

Sustainability criteria in relation to the Navigation Channel Development Program	Evaluation
(a) Overall, improvements need to reduce transport related emissions and burdens across the country (in addition to the wider affected area). However, the reduction of the burden on all relevant actors must be considered during the shaping of transport structure and networks. (b) Efforts should be made to meet the minimum international standards regarding to navigation channel in order to keep the adverse environmental effects to a minimum that will inevitably occur due to the development of the navigation channel and the increase in shipping traffic to a minimum. (c) When choosing technical solutions, the development of the status of the water according to the River Basin Management Plan should be a primary decisive aspect. (d) Protection of existing and perspective water reserves must be a primary consideration and a strict limit. (e) A shift towards lower specific energy consumption modes of transport needs to be achieved. (f) The use of recyclable materials from demolition, the application of low-waste solutions and the prevention of waste generation must be pursued during the implementation of the navigation channel development. (g) Preference should be given to solutions with the least space requirements. (h) The elimination of natural and near-natural habitats and the incorporation of such areas should be avoided, but at least minimized. (i) In order to mitigate ecological damage -that can be detected in the present state- river training works should aim to correct the errors arising from the previous regulations as well as the main riverbed and the side channel system should be treated uniformly.	(a) The ultimate goal of the Program is to increase the growth of waterborne transport at the expense of road traffic, and the positive effects of the environmental improvement measures of the implementation should outweigh the environmental and natural damage caused by the intervention and the increase in traffic. ☺ (b) According to the Program: *„it is not justified for Hungary to set a level higher than the minimum international requirements*." The characteristic of the intervention alternatives is that they are not independent of each other but represent individual steps of an optimization process and they are built on each other. The selected variant involves the least amount of intervention at all stages while complying with the regulations. ☺ (c) The goal is minimal river training intervention, minimal dredging, minimal land, and riverbed use during the construction of structures, and minimal vegetation clearance on the shores. Improving the water supply of side channels. The chosen variant is the best in these respects as well, so it will hinder the realization of the goals of the RBMP the least. The Program points the planning in the right direction, but the result is neutral at best case scenario, i.e. the positive and negative effects largely equalize each other. 😐 (d) During the evaluation of the alternatives, those were excluded, that did not comply with *Governmental Decree No. 123/1997 (VII.18.) on the protection of freshwater stocks for drinking water distribution*. During the optimization of the variants, the aim was to keep the protection area of the water reserves untouched as small as possible, but there is still the possibility of conflict. 😐 (e) Achieving traffic diversion is a fundamental goal of the development. The EU's White Paper recognizes inland waterway transport as an energy-efficient mode of transport, encouraging the increase in its share of the division between sectors. Water transport of materials is preferred during implementation. ☺☺ (f) The stones from the demolition of the stone structures can be used for the construction of new stone structures, the striving for this can be seen in the plans. Reconstruction of some of the planned stone structures will be done by levelling the stone material, and the hydraulic quarry stone from the demolition of some stone structure will be installed in the same place. ☺☺ (g) The selected variant typically has the lowest need of land use, which is mainly manifested in the number of stone structure units to be installed and the amount of dredging. ☺

Sustainability criteria in relation to the Navigation Channel Development Program	**Evaluation**
(j) Efforts must be made to apply more ecologically favourable solutions and ecological water demand should be ensured during the reconstruction of existing structures and construction of new ones. (k) Those kinds of solutions should be avoided, that would put the side channels at a disadvantage compared to the current state, also water supply of side channels is a priority. (l) Damage of protected (natural) values, areas, Natura 2000 and Ecological Network areas must be avoided as much as possible as well as the deterioration of the connectivity of their spatial network and the deterioration of the conditions for their management. (m) Ensuring ecological passages must be taken into account during the planned interventions, and passages must be improved if possible (e.g. by reconstructing structures, notching spurs). (n) The increase in traffic must be in line with the capacity of the affected natural values and natural areas, while maintaining at least the current level of ecosystem services. If necessary, a framework for the possibility of traffic restrictions should be established. (o) The use of market-preferred services cannot go to the detriment of other services not perceived by the market, as this will lead to a steady decline of natural capital. (p) Developments must not endanger the values that are part of the cultural heritage and important to local stakeholders. (q) The planned interventions must not lead to a decrease in landscape potential (e.g. tourist, ecological, holiday potential) or endanger landscape values. (r) Improving the capacity to adapt to climate change during the planning is also an important task, as it is an important condition for the future effectiveness of interventions.	(h) The variant optimization process also minimized the use of natural and near-natural habitats by reducing the number of interventions and thus the areas to be used. ☺ (i) According to the Program: *„Mitigation of ecological damage will force the consideration of technical interventions even without a navigation objective. In connection with the river training works, the main aim is to correct the errors arising from the previous training works, to treat the riverbed and its side channel system with a uniform approach, and to take into account the interaction of the interventions. Preventing the further degradation of side channels is an important goal."* ☺ (j) Those kinds of innovative solutions, such as notching a set of spurs close to shore (this way creating a secondary channel) or the chevron dikes can also bring ecological benefits. ☺ (k) According to the program: *„Solutions that would result in less favourable conditions for side channels than at present should be avoided, and even improving the water supply of side channels and side channel systems is an important consideration, without harmful reduction of WWL 2018 water supply level and in accordance with ecological and environmental protection requirements."* 😐 (l) Efforts to minimize land use, the number and amount of interventions also lead to a reduction of the involvement of protected values. However, complete avoidance of unfavourable processes cannot be solved as the whole Danube is under multi-level nature protection, ☹ (m) Both favourable (notching of spurs, improving water supply of side channels) and unfavourable (new spurs) processes occur, but it is expected that the majority will be favourable. 😐 (n) The chosen variant has the least impact on ecosystem services. However, any intervention can adversely affect complex systems such as ecosystems and its services. It is therefore essential to strive for minimum interventions, focusing on ensuring and improving the water supply of side channels, conserving native habitats and species, and minimizing the adverse effects of the investment. ☹ (o) Although positive changes are expected due to developments in certain ecosystem services (e.g. growth in tourism), these values will only be sustainable if other services - that are not necessarily directly valued on the market - are preserved, which is fundamental for other services (e.g. aesthetic beauty, biodiversity and healthy habitats are essential for tourism). Ennek érdekében törekedni kell a lehető legtöbb ökoszisztéma szolgáltatás jelenlegi szinten való tartásához, ill. fejlesztéséhez. 😐 (p) Archaeological sites classified in the priority category are avoided by the works. According to the Program: *In case of additional sites with lower risk categories (islands, shoals, known river sites), additional special, non-destructive river site diagnostic tests should be considered during the planning process.* **? ?** (q) The planned interventions and the expected increase in vessel traffic may have an adverse effect on some forms of recreation (e.g. water sports) in the long run. In terms of tourism potential, the improvement of passenger shipping conditions can be beneficial. There will be both beneficial and unfavourable changes in terms of ecological, holiday and landscape potential. 😑

Sustainability criteria in relation to the Navigation Channel Development Program	**Evaluation**
(s) Further lowering of the Danube riverbed and low water level - which is already a problem - must be prevented. (t) Only those training structures can be applied, that do not deteriorate flood conveyance conditions and do not worsen the hydraulic condition of ice conveyance. (u) Interventions that support the spread of exogenous and invasive species should be minimized and their impact should be reduced. (v) Interventions that lead to siltation in spur/structure gaps thereby reducing aquatic habitats, should be avoided and efforts should be made to stop the on-going harmful processes. (w) The results of these developments should contribute to the reduction of greenhouse gas emissions. (x) The protection of existing and perspective water reserves is a strict barrier to interventions. (y) Under no circumstances may the state of the environment or any of its components change to a degree that is harmful to health in the vicinity of ports and their access routes due to the increased traffic along the waterway. (z) The interests of other direct water users (rowboat, bathing, and fishing tourism, residual beach uses etc.) and those living close to the shore (air quality, noise, etc.) should also be taken into account during the design of the interventions.	(r) As a result of the interventions planned in the Program, the minimum navigation parameters are also ensured during low water periods, thus improving the adaptability of the shipping sector to the changing conditions resulting from the changing climate. ☺☺ (s) The most important conditions to be taken into account during the design of the Program: "*The aim is to prevent undesired further lowering of the riverbed and to stabilize the riverbed. The current low water levels and the riverbed cannot lower due to the planned interventions.*" ☺ (t) The planned training structures must not worsen the hydraulic conditions of flood and ice conveyance. ☺ (u) Both favourable (reducing the height of spurs) and unfavourable (new stone structures) processes occur, but it is expected that the majority will be favourable, but the predominance of unfavourable processes is expected to be unavoidable. ☹ (v) The water flow and sediment movement can be restored along the shore by notching a set of spurs at one location, this way creating a secondary bed between the spur gaps. During the design, the aim should be to create a bed with a diverse structure, varying depth and bottom width, not a straight and homogeneous channel. It is also planned to remove sediment accumulated in the areas between the guide banks. ☺ (w) The planned developments will allow better and greater utilization of the waterway, thus shifting part of road transport to energy-efficient, CO_2-friendly inland waterway transport. ☺☺ (x) It is a design condition that the protection of existing and perspective water reserves should be considered as a strict barrier. ☺ (y) Measurement data is not available on the impact of current ship traffic on air quality and noise status along the Danube. No significant deterioration is expected due to the increase in traffic, but the modernization of the fleet in terms of air pollutant emissions is necessary regardless of the Program. ☺ (z) Striving for the necessary minimum during design also means the minimization of disruptive effects. The increase in freight and passenger traffic does not lead to a significant increase in the number of vessels (30-50%). In order to avoid harmful wave formation, it has been suggested to introduce speed control for large vessels. Fish stocks that can be exploited for fishing purposes can survive in the long term if a further decline in the diversity and connectivity of aquatic habitats can be halted, which is partly beyond the scope of the Program. However, unfavourable processes cannot be ruled out. ☹

(aa) The development of inland navigation and transport must also serve local economic development, and the promotion of regional relations and the expansion of cooperation opportunities.	(aa) The possibility of greater utilization of the waterway creates an opportunity for the establishment of new plants related to goods that can be transported on the water, and can potentially contribute to greater cooperation between the settlements along the Danube (e.g. in connection with tourism). ☺
(bb) It is necessary to expand the range of residents who can be considered winners as a result of the developments	(bb) Such aspects have not yet emerged at the current planning stage, but the goal depends on the existence of job-creating effects and on the working conditions and composition of the workforce to be employed. **? ?**

Sustainability criteria in relation to the Navigation Channel Development Program	Evaluation
(cc) Interventions must not cause new environmental problems on other stretch of the river or on side channels.	(cc) The most important conditions considered during the designing process serve to avoid these problems. An additional goal of the proposed technical interventions is to produce a low navigation water level that will also facilitate side channel rehabilitation efforts. ☺
(dd) The change in the transport system should be an incentive for society and economic actors to make environmentally conscious transport and transportation to a daily norm (ee) The active participation of society must be ensured from the very beginning of planning. (ff) Developments must have the support and acceptance of the presumed majority of local society.	(dd) The final goal of the development is to reduce the car use in transport, as expected by the EU's 2011 White Paper on Transport Policy. This must also be made clear to society and economic actors. ☺ (ee) Stakeholders (NGOs, municipalities, authorities) were involved from the beginning of the planning (finalization of the situation assessment study). ☺ (ff) Achieving this is partly the task of the present SEA, but this can only be assessed after public involvement **? ?**
(gg) Developments should serve the increase of social well-being, without increasing social differences.	(gg) Development has direct environmental and public health benefits depending on the traffic diversion. Obstacles to fishing and water sports must be kept to a minimum. In this respect, the selected variant is also better than the others, but disadvantages are expected to remain. Navigation is a cheaper mode of transport than road transport, the project will help to reduce the price of certain products, slow down its growth, reduce inflation, which is a great advantage for the poorer. ☺

21 out of the 31 evaluated criteria received good ratings. At first glance, this seems very favourable, but it should be noted that this qualification refers to the objectives and content of the Program and the actual implementation may hide many more problems. The Program contains such aspirations that we are now actually expecting to be realized, but there is no guarantee for that, we can only see the current trends. Thus, it is very important that both in during further planning and in the national and EU decision-making of the transport policy should move to the direction described in the Program.

Each of the negatives was connected to ecological, conservation criteria, which means that we aim to minimize the possibility of damage, but there is no such solution that would make this completely avoidable.

8. SUMMARY OF IMPACTS IN RELATION TO THE CUMMULATIVE EFFECTS ON THE FINAL AFFECTED

Cumulative impact is the aggregated, cumulative, collected effect of different interventions that reaches the final affected elements directly and indirectly through various environmental elements and systems. Cumulative effects can be interpreted both in time and space. We can talk about a cumulative effect over time if the individual environmental impact factors result in processes that are becoming more and more severe over time. An example is cumulative soil pollution, when it prevents water withdrawal from groundwater drinking water reserve beyond a point. The spatial cumulative effect means an addition in which local interventions change the state of an entire system - in our case the national reach of the Danube. The two types of effects can occur simultaneously, so the effects may add up in space and become increasingly significant.

8.1. CUMMULATIVE IMPACTS IN THE PLANNING PROCESS

From water management aspect, the interventions aims to achieve a spatially cumulative effect, ie to ensure the navigation parameters by stopping and increasing the low water levels for the entire Hungarian Danube

section. The specific impact zone of a facility or a structure is typically a few hundred meters, but the structures built or developed one after the other already involve and change a longer section. In this way, the basic goal can be achieved; the planned / developed training works do not adversely affect the movement of sediment in addition to preventing undesired further loweing of the riverbed and stabilizing the riverbed. The combined effects of the entire system to be built should achieve these navigation objectives.

During the planning process, the width of the fairway was reduced from the planned 150 - 180 m width to 120 - 150 m according to the Danube Commission's recommendation. In many places - where water protection, geological and technical considerations made it necessary - the planned alternatives provided for a further reduction in the width, up to a width of 60 m providing one-way navigation. In addition, the training line has been modified to **facilitate optimal flow along the entire length of the river** when constructing structures.

During the design, dredging works were minimized to maintain water levels where possible, and the water level was increased by using bendway weirs, spurs and chevron dams. These interventions increase the water level by narrowing the riverbed cross section without reducing the flow velocity, while diverting it to the center of the bed. It was a basic principle - as mentioned earlier - that the lowest navigation water level, the riverbed, and consequently the groundwater table, should not sink anywhere. **These favorable conditions are cumulative on the Hungarian Danube section as a result of the series of the planned interventions.**

To verify the above, 2D and at some critical sections 3D modelling were performed during the preparatory work of the design process, which show the aggregated, cumulative effects. GEOMEGA Kft carried out a geophysical riverbed survey on the rocky riverbed sections of the Danube, the results of which were also taken into account during designing of the variants. These investigations (morphology, 2D, 3D hydrodynamic model, geophysics) made it possible to determine the cumulative local effects caused by the interventions on the entire Hungarian Danube section. As well as designers had the opportunity to desing such interventions that promote optimal, smooth flow and minimize bank erosion by applying these state-of-the-art research methods. It is important to emphasize that the implementation of the planned development will help to increase the water levels. Without it, further water level drop may occur in the river section as a result of climate change.

8.2. CRITERIA FOR INVESTIGATION OF CUMULATIVE EFFECTS

Cumulative effects need to be assessed from three perspectives in the environmental investigation:

- a set of mutually reinforcing effects, that directly and indirectly (through different environmental elements) affect the final affected.
- the combined effect of the changes on the two, independently[7] examined Danube sections,
- other effects combined with other known interventions in the impact zone at the same time as the planned development.

The most important of these is to examine the effects together on the final affected. In this case the final affected elements are:

- The wildlife of the Danube and its surroundings
- The urban environment and landscape
- The population affected by the positive or negative effects and the users of waterfront (including the use of water reserves)

[7] This is necessary due to the division mentioned earlier, the water management approach of addition was already discussed at the beginning of the chapter.

The wildlife, human and landscape are **not affected by a single effect through the various environmental elements, but indirect and direct effects acting together through the environmental element**. The joined combined effects, change the living conditions of living organisms.

In the framework of the present assignment, the Danube (as the Slovak planning process has not yet started on the Slovak-Hungarian joint section and the planning process can only completed with the acceptance of the joint design of the two countries) had to be examined **in two stages**. Thus, a set of effects on different environmental elements and systems must be examined as a cumulative effect along the whole Hungarian Danube stretch. This can basically be interpreted from wildlife aspect, as the wildlife of the Danube can be changed for the whole water body. Such changes in the wildlife are also influenced by the flow conditions, riverbed formation and sediment rearrangement. So it had to be considered whether there are, or could be, cumulative effects on the downstream sections. Thus, as a background effect, the changes, that took place in the other Hungarian sections were also taken into account by individual fields during the evaluations.

The third aspect to consider are the cummulative impacts **realizing with other projects in parallel**. The most directly related to these projects are the already planned side channel rehabilitation projects and the "National Port Development Master Plan Strategy". We also have knowledge about these.

Cumulative effects should be further investigated in the environmental impact assessment procedure if e.g. the development planned by the Program and the given development affect the same water reserve or change the landscape elements, it may have a detrimental effect on the quality of surface water, affecting habitats.

8.3. SUMMARY OF CUMULATIVE IMPACTS ON FINAL AFFECTED

Wildlife

The interventions **typically have unfavourable effects on the affected groups of organism during the construction phase.** The extent and nature of adverse effects will vary depending on the types of intervention and the groups of affected organisms.

One of the typical works, the **dredging** takes place in the main stream channel. **Macroscopic aquatic invertebrates and fish will be the most affected species** during the dredging of water-covered riverbeds, even in low water periods. The majority of the macroscopic invertebrate organisms living in the main stream channel of the Danube are benthic species that live on the surface of the sediment or in its upper layer. Stocks on dredged riverbed surfaces are significantly damaged or destroyed, this is especially true for slow-moving species such as aquatic molluscs. The species affected by the adverse effects include both protected species of community importance (e.g. theodoxus danubialis, theodoxus transversalis, esperiana esperi, unio crassus) and non native invasive species (e.g. corbicula fluminea species). Construction related harmful effects are expected.

In case of construction damaging effects are expected basically during the winter dormancy period and during the reproduction and the immediately following period in terms of fish, as breeding individuals as well as eggs and young offspring are the most vulnerable. Direct damage and destruction of fish due to construction can be reduced by limiting the time required for the work. If the time limits are adhered to, the effects will be decisively disruptive, with no significant rate of direct damage or destruction. Direct damage is expected for species that hide in the upper layer of softer sediment or flee there in the event of disturbance, despite compliance with the time limit. These species include spined species (e.g., spined loach, Balkan loach), Ukrainian brook lamprey, whose larvae typically reside in the upper layer of soft sediment.

Along the Szob and southern national border Danube reach, there dredging works planned in the main channel concentrated on the waterway further offshore and do not affect riparian bed areas. Consequently, at this stage, we do not have to reckon with the involvement of higher vegetation in connection with the dredging works.

Another typical type of intervention in the construction phase is the construction of **stone structures.** During this, stone structures are currently being built from quarry stone on bed surfaces with natural bed material.

The nature of the expected effects during the construction are very similar to dredging, as the organisms attached to the affected bed surface and unable to escape quickly are significantly damaged during the construction, in many cases they are perished.

The demolition of the **existing**, but improperly functioning **stone structures** affect the populations of non-native species to a greater extent, as a larger proportion of non-native and in many cases invasive species can be found on the surface of the quarry stone.

The construction works take place mainly in the midwater riverbed. For the most part, the impact on the habitats at the edge of the mid-water bed will only occur if the **planned intervention at the edge of the mid-water bed is implemented from land.** In this case, the narrow riparian habitats along the riverbed of the intervention sites may be affected by the use of workspace. These are a significantly softwood grove habitats, where removal of woody vegetation may be required in the event of work area use. In this case, the species assemblages associated with these habitats should be considered as affected, including the bird species associated with forest and shrub fringe habitats; the populations of xylophagous and saproxylophagous beetle species associated with old, decaying and dead trees; and the tree-dwelling bats living in old, suitable nests of trees. In the case of riparian interventions, it is not yet possible to determine the exact ratio of water and land-based work at this planning phase, and thus the extent of the expected effects.

The expected effects after the construction works are more differentiated. As a result of the planned interventions, the flow regime will not change. The flow conditions and flow velocities do not change significantly in the majority of the riverbed compared to the current initial situation. Apart from the fairway in the side channels and at the edge of the main channel, the accumulation of finer bed sediment is expected, while the depth conditions change somewhat in the inner part of the main channel as a result of dredging. But the nature and fraction size of sediment typically remain the same. On the riverbed surfaces affected by dredging, a colonization process begins from the direction of the adjacent riverbed surfaces, as a result of which the riverbed surfaces became populated. The colonizing species are not expected to differ significantly from the characteristic of species of the current initial state.

A colonization process will also begin on the new stone structures, but survey results suggest that the aquatic macroinvertebrate and fish species established here are expected to contain a higher proportion of non-native and invasive species and their numbers will be more significant. This can be considered as a long-term negative impact and adversely affects the life community of the affected Danube section. At the same time, natural riverbed would be created on the riverbeds affected by the demolition of the existing stone structures, which could be taken over by species groups containing more diverse, native fauna elements typical of natural riverbeds. This is evaluated as a beneficial effect. Unfortunately, the construction of new stone structures affects a proportionately larger riverbed area than the demolition of existing works.

By notching the existing spurs, the possibility of the formation of a secondary low water flow near the shore is ensured. Current experience shows that during low water periods, these flow-free parts protected by spurs are less and less submerged. Due to sediment accumulation, the duration of water coverage decreases continuously as succession processes progress and then afforestation begins at better filled, higher terrain levels, thus gradually losing its habitat function for aquatic organisms. This process may cause diverse riverbed morphological conditions in the short term, but in the longer term it will clearly cause a decrease in habitat diversity for aquatic organisms. The above effects adversely affected the aquatic community in the Danube stetch. Unfortunately, this type of intervention is planned only in one site between Szob and the southern border. As a result of which the secondary riparian flow creates such a habitat lane, which will have parts that are not reached by the waves caused by shipping. So, the damage and mortality caused by shipping related waves will be reduced in these habitats. This effect is definitely considered to be improving in the post-construction period.

Along the Szob – southern national border Danube stretch the planned interventions are not expected to have a significant direct impact on the flow conditions of the side channels, as the planned interventions do not

affect the stone structure at the connection points of the side channels of the main river channel. However, preventing further riverbed lowering is also important for side channels.

In the post-construction period, the differentiated, favorable and unfavorable effects are expected to be basically local, it may be the colonization of an intervention area. No significant cumulative effects can be expected here for the two sections. However, interventions conducted in other impact zone can significantly modify the extent of favorable or unfavorable processes (E.g. tributary rehabilitation can help, a port development can hinder the beneficial effects). Therefore, known interventions in the impact zone should be considered in the environmental permitting phase.

According to the traffic growth prognosis, the vessel traffic on the affected Danube section could increase by 75% in extreme cases in terms of the number of ships (i.e. assuming the worst-case scenario for wildlife) by 2050. According to the available literature data and sporadic observations, the waving caused by ships has an unfavourable effect, mainly in the Danube riparian regions, even with the current shipping traffic.

With the increase in shipping traffic, the shoreline eroding effect and enchanting effect of larger sediments intensify due to waving caused by ships. The continuous eroding effect on the natural shores of the Danube can lead to the washing out of soil, or the detachment of the shoreline, embankment, as well as the movement of the riparian riverbed material. These effects are ecologically harmful, and excess sediment enters to the river.

Adverse effects mainly affect aquatic insects, including amphibious insects flying out of the water during the last larval shedding, and mainly the fish offspring, which are more common in the shallower parts of the bank. Waves running to shore can cause physical injury and resulting mortality on both shoreline riprap and natural material bank. In parallel with the increase in ship traffic, the intensification of the unfavourable, damaging effects of wave action can be expected along the riparian regions of the riverbed, which has a direct and indirect negative impact on the aquatic and water-related communities of the affected Danube section.

As a result of the planned **bendway weirs**, after construction, the low water riverbed lowering affecting the main river stream along the northern section of the Danube, above Harta between Szob – southern national border reach is expected to cease, which has an indirect positive effect on the water regime of wetlands and side channels of the affected Danube section, thereby to the community of life associated with the habitats concerned. This indirect positive effect is practically not manifested in the improvement of the condition, but in the absence of the deterioration without the implementation of the planned interventions, thus in the avoidance of further deterioration.

Urban environment, landscape

The implementation of the development will have temporary adverse effects on the surroundings of land uses, especially near the location of the planned interventions (e.g. Vác, Dunakeszi, Ercsi, Kulcs, Dunaföldvár, Mohács) where residential or recreational areas are located directly along the waterfront. From a landscape point of view, these interventions can be considered local, so cumulative effects hardly can be expected. (Rather, this can only occur during other, unknown interventions in the impact zone.)

There will be no direct landscape change associated with any of the planned interventions, as the works are largely planned in the riverbed, so the use of the affected areas will not change. Other investments related to the development of the fairway are much more related to the change of landscape use - e.g. port constructions and developments - which can be considered as an indirect effect of the development of the navigation channel. Developments that help to prevent further bed intrusion process - mainly bottom sills - are favorable, as they also indirectly contribute to the prevention of groundwater level decrease in the areas along the Danube, which is a basic condition of typical agricultural and forestry activities along the river.

Among the water-related forms of recreation, mainly water sports may be adversely affected (mainly due to new stone structures connected to the shore), the basic conditions of other forms of recreation are not expected to be damaged in the long run (apart from the expected temporary disturbance during construction). The change in the holiday and tourism potential may be mainly related to the increase in ship traffic, but if

the increase is assumed to be gradual, it is not expected to be felt by holidaymakers. The improvement of basic passenger transport conditions is expected to have a positive effect on tourism potential, because more tourists are expected in the area.

From landscape protection aspect, the construction of new stone structures may have an unfavorable effect. The construction of some new stone structures is planned in places that are particularly sensitive from landscape protection aspect (spurs planned in the area of Dömös).

Developments that also affect tourism processes in the long run and their attractive effects of their traffic can have an indirect adverse effect on the current state of cultural and built heritage (e.g. the growth and intensity of mass tourism) if potential risks are not properly assessed (e.g. adverse effects of the phenomenon of mass tourism on local communities) or addressed.

Human health

During the construction period, local and intermittent, but unfavourable impacts on human health can be expected in the areas close to the riverbed, where the effects can reach. As a result of the works, the tourism potential may decrease in the given period.

An essential condition for human health is that the interventions do not affect the water reserves of drinking water withdrawal and do not impair water quality. Thus, from this point of view, the involvement of groundwater must also be examined from human aspect, as final affected element. Based on the investigations, the following essential statements can be made:

- As a result of the interventions that cause the decomposition of the cover layer in the protection area of the water reserves, the pollutants in the Danube can enter directly into the aquifer and reach the wells due to the violation of the biochemical filtration membrane. Because of this, the quality of the water produced may deteriorate periodically. In the case of a single effect (dredging), there is a chance of re-formation of the filter layer.
- Removal of the formed silt is an adverse effect when the level of removal approaches the top of the gravel layer, especially if it notches into it. In this case, the surface protection of the aquifer is ceased until a filter layer similar to the main channel is re-formed. The danger of this is determined by the level to which the deposited sediment is removed. If this effect occurs, there may be a periodic deterioration in the quality of the extracted water, similar to the demolition of the cover layer.
- In those locations where the flow velocity decreases as a result of the interventions, the bed material may settle. Prolonged deposition can cause compaction and the formation of reductive conditions. The formation of a new, thick layer of sediment could be a new source of pollution, as the sediment of the Danube is found to contain substances that endanger the water reserve. The infiltrating sediment can also reduce the leakage factor of the bed and thus the amount of replenishment.
- In those locations where flow conditions influenced by hydraulic structures and interventions locally result in higher velocities than at present, bed material may be washed-out. The washing-out may be to such an extent that it affects not only the topsoil but also the aquifer gravel layer.

The identified potential impacts require further detailed studies in order to find out the actual magnitude and significance of the impacts and to develop possible mitigation proposals, which should be carried out in the context of detailed plans of the environmental impact assessments

During operation, the targeted traffic rearrangement around the roads will be accompanied by noise, vibration and air pollution reduction. Greater waterborne transport potential can contribute to the development of the economy of riparian cities, both due to the transport of goods and due to the increasing traffic of large passenger ships. At the same time, the growing ship traffic is not beneficial to water sports, water hiking (in the case of small boats, whether motorized or hand-powered) or fishing recreational activities, which means that the side channels can be given more emphasis, to the conditions of which the project can contribute through the rehabilitation of the riverbed.

Summary

At the beginning of the work, we formulated some questions and sought to be able to answer these questions by the end of the study. ***In case of the implementation of the planned developments of the Program:***

A) How can coherence be ensured between navigation, fairway standards and EU standards for the protection of natural values?

During the development of the Program, the European Commission's 2012 guideline was taken into account in the planning process "***Sustainable inland waterway development and management in the context of the EU Birds and Habitats Directives***", which seeks to answer the questions below. The integrated nature of the design process is shown by the way of creating the variants, the building of the individual variants on top of each other, and the reduction of the number of interventions in the consecutive variants. It was implemented in the planning iteration process, the individual interventions were monitored by the experts of the working group dealing with the environment, nature and landscape protection and they tried to find solutions that reduce the unfavourable environmental processes and damages in addition to the workload. (e.g. see filtering out the impact of water reserves as much as possible, applying innovative technical solutions, etc.)

Így ugyan a kedvezőtlen hatások teljes mértékben nem zárhatók ki, de az integrált tervezés lehetőséget adott arra, hogy a tervezett fejlesztések a lehető legkisebb mértékű környezeti-, természeti- és tájvédelmi károkozással valósulhassanak meg. A következő fejezetben szereplő javaslatok betartásával a kedvezőtlen folyamatok minimalizálhatók, a kedvezőek hatékonyabbá tehetők, tehát az összhang jórészt biztosítható.

The aim of the Program was therefore to develop a multimodal transport corridor that integrates the environmental and ecological objectives in addition to inland navigation and takes into account other - socio-economic - functions of the waterway (primarily, the protection of water reserves, flood control and the interests of river basin management). Accordingly, the Program states that it is not justified for Hungary to set a higher level than the minimum international requirements, so the technical interventions included in the Program are still **acceptable at a minimum level but ensure a shoal-free fairway.** The variant with the lowest environmental and ecological burden was chosen.

Although adverse effects cannot be completely ruled out, but integrated planning has made it possible for the planned developments to be carried out with the least possible damage to the environment, nature and landscape. By following the suggestions in the next chapter, unfavourable processes can be minimized, favourable ones can be made more efficient, so consistency can be largely ensured.

B) Is it probable, and if so to what extent, the reorganization of traffic (freight) trends and, as a result, can we expect a reduction in adverse environmental impacts?

The ultimate goal of the Program is to increase the growth of waterborne transport at the expense of road traffic, and the positive effects of the environmental improvement measures of the implementation outweigh the environmental and natural damage caused by the intervention and the increase in traffic. With regard to road freight rearrangement, transit and export-import traffic in particular can have environmental benefits as a result of reduced space requirements and other reduced environmental damage resulting from the reduction of emissions, energy consumption and the constant development needs of motorways. (A condition for a positive shift is the development of traffic diversion legislation and increased controls and sanctions to minimize long-distance road transport. In this case, the 80% increase in freight transport capacity estimated by 2040 could be largely at the expense of road transport. As a result, significant CO_2 savings are expected, and air pollution from inland waterway transport causes significantly less environmental damage per tonne-kilometre of goods than emissions from commercial vehicles.)

At the same time, in addition to the shipping route, the increase in emissions and loads can be estimated as a function of the increase in traffic.

C) Whether the measures or the expected increase in traffic as a result of the implementation are a problem for existing water uses (drinking water bodies, abstractions, water sports, fishing, etc.), river management (harmless drainage of water, sediment and ice; shore protection; management of side channels and oxbow) and for habitat? If so, how manageable they are?

When answering this question, we have to start from two bases:

- During the development of inland waterways, adverse environmental and nature impacts are unavoidable. In this respect, the only goal can be to develop the inland waterway infrastructure in an ecologically sustainable way, in line with the European Union's environmental policy, in particular with EU nature protection legislation.
- At the same time, in case of freight transport, no significant daily increase in traffic can be expected. This is due to the better utilization of the transport capacity of the vessels and the significant increase in the number of navigable days (from 240 days to about 340 days), which makes it possible to transport much larger quantities of goods. Thus, the number of ships is expected to increase by just over 30% by 2040.

From water management aspect, the fundamental goal was to prevent the undesired further lowering of the riverbed as well as to stabilize the riverbed. As a result of the intervention, not even a small drop in water level is acceptable, so the current low water levels and the riverbed cannot be lowered due to the planned interventions. Only those training structures can be used that **do not have significant water level gradient increasing effect on the channel**, whose effect appears only in low discharge periods and that do not deteriorate flood conveyance conditions. The planned training structures must not worsen the movement of bedload, must not cause velocity decrease in the navigation channel since it would generate suspended load deposition, and must not worsen the hydraulic conditions of ice conveyance.

Among the existing water uses, it is not possible to endanger **drinking water reserves** due to legal requirements. Thus, during the planning, the aim was to avoid the protection zone of water reserves as much as possible. In the next phase, the quantitative and qualitative involvement of the wells should be further investigated, but preliminary estimates at this phase suggest that the risk can be minimized with possible minor modifications. In the case of **other utilization** of the Danube, only minor disturbances are expected, and the utilizations can be maintained.

The wildlife of the river is affected the most significantly by the implementation of the planned interventions and the existence of the navigation channel and the increasing boat traffic. The reduction of adverse effects is the fundamental goal, also the interventions have been supplemented with nature conservation interventions, which can mitigate the unfavourable processes. From this point of view, it is also advantageous to significantly reduce the workload of the intervention, especially the number of dredging and new stone structures, to reduce the height of the existing ones, to notch the sets of spurs in the planning process.

D) Can adaptation to climate change improve, or can the expected climate change reduce or increase the effectiveness of measures?

The aim of the planned interventions is to improve the navigability of the Danube at different water levels. The positive effects appear the most during floods and low water levels as a result of droughts, in addition to current discharges. The impact of the expected decrease in future discharges - considering the expected, estimated rate of decrease (5 - 7%) - is considered to be mitigated by the means of operation by the designers, therefore climate change may lead to an increase in the need to maintain the navigation channel. The stone structures planned in the Program are less vulnerable to climate change.

However, in order to ensure the adaptation of the inland waterway transport to the changing climate, additional measures are essential that are outside the scope of this project (including improvements of watercrafts to increase their efficiency and their carrying capacity at low water levels).

E) How do the completed interventions relate to the feasibility of the objectives of National Water Management Plan for the water bodies (including targets for the status of water bodies and related WFD protected areas, in particular drinking water bodies), whether mitigation measures are required?

Based on our analysis of compliance with the Water Framework Directive, we can expect local effects on the protection of the planned development, mainly on aquatic macroscopic invertebrates and fish species. In addition to the protection of wildlife, an important emphasis was placed on the assessment of the indirect effects on the bank filtered water reserves along the Danube, the examination of which was also very emphasized on the basis of the expected effects of the interventions.

Based on our previous studies, the planned interventions are not expected to cause category degradation on the affected water bodies, and do not impede the achievement of good status so the performance of test 4.7 has not been considered justified at this design stage. This conclusion needs to be supplemented with detailed impact assessments and supported by the following tests:

- Recording the baseline conditions for the examination of the biological elements in the affected sites, their evaluation on the basis of the previous examinations performed on the given water body.
- According to the above, a more accurate assessment and specification of the expected effects depending on the interventions
- Accurate localization of each intervention based on more detailed hydraulic plans
- By specifying the construction technology required for the specific intervention.
- By specifying the quantities of material to be extracted and installed.
- Detailed examination of interventions in the vicinity of water reserves by consulting with each water reserve operator.

As the planned interventions are considered to be environmental impact assessment activities therefore, in connection with the investment, the performance of the above assessments should be justified in the environmental impact assessment.

Due to the fact that we also validated the aspects of compliance with the WFD in the iteration process, by taking into account environmental aspects during the planning process, the developed variant proposed for implementation did not remain such effects, for which we would propose specifical mitigating measures in the current planning phase. However, as a result of detailed studies carried out in a subsequent environmental impact assessment there may be effects which may necessitate the application of measures.

F) can the completed interventions be connected with the ideas and goals of the local improvement of the environmental, natural and landscape condition?

When looking for solutions to be developed, it is an advantage if the interventions can also bring ecological benefits, such **as notching a set of spurs near the shore**, this way creating a secondary channel, where a flow protected from secondary wave actions can be formed during low water period which can serve as a drinking space or habitat. Or **chevron dike**, which functions as a valuable gravel bed / island in the mid-water bed. Inside the chevron dam, washing out develops where the water velocity is low, making it a good wintering place for fish, while behind it a dynamically changing bed surface is created.

It was one of the conditions for the design, to avoid solutions that would result in less favourable conditions for the side channels than at present, and even the water supply of **side channels and side channel systems** according to ecological and environmental needs is a priority after consultation with

stakeholders. An additional objective of the proposed technical interventions is to produce such a low navigation water level - in addition to improving navigation conditions- that **promotes side channel rehabilitation efforts**, produces increased or at least not decreased water levels where the side channels join the main channel.

9. PROPOSALS

9.1. PROPOSALS FOR MEASURES TO AVOID OR REDUCE THE ADVERSE EFFECTS

In addition to measures to avoid the adverse effects identified during the environmental assessment, or at least to reduce their extent, we also made proposals for strengthening the efficiency of the beneficial effects both for the construction and for the operation of the developed waterway. These are included in detail in the environmental assessment. **We present the most important proposals in this summary.**

General proposals

- In order to facilitate the diversion of freight traffic from roads, it is necessary to introduce significant regulatory and incentive measures for the creation of a framework of freight transport reorganization, in addition to the development of inland freight transport infrastructure. Otherwise, the investment will not fulfil its intended purpose, which will make it less favourable from an environmental aspect than at present. (Note, that the Program **assumed that traffic diversion regulations would be introduced in the future at both EU and Hungarian level in order to achieve the objectives set out in the White Paper on Transport Policy.)**
- Consideration should be given to setting a **maximum traffic capacity** for the Danube as a waterway, taking into account environmental considerations, and using it as an upper limit. This capacity value needs to be reviewed from time to time in parallel with technical developments (e.g. the spread of low or zero emission watercrafts).
- To reduce the traffic related loads, **attitude formation and dissemination of knowledge** related to transport are extremely important. All projects related to transport development, including the program for the development of the Danube waterway, should be supplemented with such measures.
- In parallel with the expected increase in tourist boat traffic, an increase in the load of the tourist destinations of the region is also expected. It must be planned and organized in such a way to ensure the experience for tourists, taking into account the landscape capacity of certain sites, the capacity of certain facilities as well as taking into account cumulative effects.
- In order to facilitate the organization of tourism-related events during the construction as well as to avoid accident-prone situations, **timely information should be provided to each municipalities affected by intervention sites about the exact location and time of the construction works.**
- **It is essential to ensure coherence with other, not necessarily technical measures in relation to the improvement of navigation conditions**, both with the ongoing ones (e.g. development of navigation information services, preparation of the construction of inland waterway infrastructure in Hungary and implementation of the first fixed and mobile filling station; maintenance master plan, etc.) and with planned developments (e.g. port development).
- An adequate distance must be ensured between the structures and the plants dealing with hazardous materials when planning and implementing investments. During the planning of investments, the general settlement planning **requirements must be taken into account according to the point 2 of Annex 7 of the Decree of the Government on Disaster Management.**
- A professional assessment of possible damage caused by extreme weather events related to climate change (storms, hail, heat waves, flood events, etc.) is recommended, so that the operational state can be restored and maintained as soon as possible.

Proposals for surface water protection

- During construction, it might be necessary to temporarily suspend dredging works in the event of a possible local water quality issue due to dredging (e.g. when oxygen balance deteriorates).
- Care must be taken during work to avoid accidental water contamination. It is recommended to use environmentally friendly - i.e. biodegradable - hydraulic oils and lubricants.
- In order to reduce the potentially undesirable sediment migration during the works, it may be necessary to develop certain additional methods and technologies specific to each site (e.g. granulometric bed repair, artificial feeding of gravel with the coarsest bed material size, naturally occurring at the intervention site).
- It is also important to keep in mind in the later stages of planning that the conditions of ice and flood protection should not deteriorate.
- Providing the resources needed for annual maintenance and carrying out the works once the improvements have been completed are even more important than at present. In the event of a failure of bed maintenance work, bottlenecks may re-emerge as a result of unfavourable bed changes during high water periods and / or ice conveyance.
- In order to treat the problems caused by wave action, it is recommended to examine the possible regulation of the shipping speed depending on the water level and the nature of the section, to supplement the 57/2011. (XI. 22.) NFM Decree on navigation regulation in force currently.
- In those places where the increased wave action will be a problem - in order to preserve the status of the water body according to the biological elements - additional solutions may be needed to help maintaining the good condition of the habitats (e.g. to create a gravel packing to reduce waving).
- As a result of the increased ship traffic, we recommend the development of a separate strategy for the effects of accident events with a higher probability and the possibilities for protection against them, as well as the need for increased equipment and human resources.
- In order to further prevention of water pollution, it may be necessary to supplement the regulation on oily bilge water of ships (currently in force 57/2011. (XI. 22.) NFM Decree on navigation regulation), consideration should be given to introducing a quantitative limit adapted to the specific parameters of the vessels.

Proposals for the protection of groundwater and water reserves

- In the environmental impact assessment phase – which is the next planning phase - the potential impacts identified from groundwater protection aspects require detailed studies in order to find out the actual extent and significance of the impacts and to develop possible mitigation proposals.
- The operating water reserves of Tököl and Szigetújfalu deserve special attention, where several significant interventions are planned (dredging, construction of chevron-dike, bendway weir). As a result, we can expect bed washing out and sedimentation in new locations compared to the current processes, exact area, extent of which should be subject to further investigation.

Geological medium and soil protection proposals

- Construction work must be carried out downstream in stages. The bed material washed out due to the interventions and swept away during demolition is transported by the flow of the river, so that excess material is deposited downstream, which can result in additional amount of dredging. Therefore, it is advisable to start the construction with the stone structures, then continue with the dredging activity.
- It is advisable to take a break between each intervention stages in order to evaluate the effects of the interventions and to settle the sediment equilibrium relations, leaving room for corrections of the interventions in the flow direction.
- During further planning, sediment transport processes should be examined in detail in the water rights permitting plans.

- In case of work carried out from land with soil involvement, care must be taken to ensure that the humus layer is professionally extracted and protected. After the construction work has been completed it should be used within the construction site as far as possible.
- In the case of work carried out from land, additional land for construction should not be used (e.g. as a deployment area or landfill site) in agricultural areas with good production conditions or in valuable wildlife and forest areas. Ideally the existing dirt roads should be used for deployment and transport. In such cases, the demarcation of the construction site is important to avoid possible accidental use.

Wildlife conservation proposals

- Proposed time limit for the protection of **nesting bird populations**: It is recommended to carry out the preparational works involving the removal of woody and higher order vegetation outside the nesting period of the birds (general nesting period: 15 March to 01 August).
- Proposal for the protection of **tree-dwelling bat**: It is recommended to schedule the felling of old trees inhabited by bats between 1 August and 30 October. Before felling old trees, it is necessary to survey the affected work area with an ultrasonic detector and identify the trees containing bat colonies as close as possible to the time of felling of the affected trees. The period from 1 April to 30 September is suitable for the survey. In case of felling of trees inhabited by bats, it is recommended to try to persuade the bat individuals to leave the nest before the construction. (A more detailed proposal on how to do this is included in the environmental assessment.)
- Proposal to reduce adverse effects on xylophage and saproxylophagous **beetle species**: To reduce the harmful effects on the potentially affected populations of the European stag beetle (*Lucanus cervus*), the saproxylic beetle (*Cucujus cinnaberinus*) and the hermit beetle (*Osmoderma eremita*) it is recommended to leave those old native tree specimens and dead trees within the work area, which do not make the construction works impossible.
- Time limit for the protection of **fish** species: It is recommended that dredging and works that disturb the natural bed material should be carried out between 15 July and 15 November.
- Time limit to reduce adverse effects on **amphibian and reptile species**: In order to reduce mortality, dredging and widening works planned in the side channels are recommended to be carried out between 15 July and 31 October.
- It is advisable **to limit the speed of vessels causing large wave action** on certain critical sections (to be determined later) (in order to reduce the rate of wave action) during that period when the offspring is unable to avoid sudden water movements caused by waves due to their poor floating ability.
- The relevant Natura 2000 conservation plans should be examined in the environmental impact assessment process in order to ensure that the defined conservation objectives are not jeopardized by the planned development.

Landscape protection proposals

- Vegetation clearance must be scheduled outside the vegetation period by taking into account the recommendations for the protection of wildlife.
- If shore-based work is carried out on the edge of forest and grassland, access routes must be designated on existing (dirt road) roads as well as material loading sites, shore-based work areas must be designated while ensuring the conservation of trees and grasslands.
- Interventions carried out next to recreation areas (e.g. Kulcs, Dunaújváros, Baracs, Dunaföldvár, Baja) should be implemented possibly outside the summer holiday season.
- Night and early morning works should be avoided in case of interventions near residential areas (e.g. Vác, Dunakeszi, Százhalombatta, Ercsi, Dunaföldvár, Mohács).
- In case of new stone structures to be established in landscape-sensitive areas, it is recommended to use dark coloured stone (e.g. andesite, basalt) in the parts that are visible above the water surface, so they will be less marked landscape elements (Such stone structures are the spurs designed especially in the

Dömös area around the middle of the Danube Bend).

- During the planned works on the edge of the protected natural areas, it is recommended to carry out the construction from the water side, in order to minimize the use of riparian habitats and disturbance of life communities (e.g. in case of the planned demolition of stone structures near Tahitótfalu, the affected area can only be approached from the shore of the area of the Danube-Ipoly National Park).
- If any intervention requires wood-cutting in a public area, it shall be carried out in accordance with 346/2008. (XII. 30.) Government Decree. Under the regulation it can only be done on the basis of a felling permit and with provision of wood replacement. However, further planning - and then the preparation of organizational plans - should aim to remove as few woody plants as possible.

Fishing proposals

- There is a need to improve lateral continuity between the main riverbed and the side channels.
- The improvement of the continuity and connectivity of the side channels must be implemented in each case by developing individual solutions applied to the given side channel.
- It is necessary to preserve and increase the diversity of aquatic habitats (to ensure the formation of shoals, islands; to create river bed cross section with different structures, varying depths, bottom widths and slope inclination during the notching of spur).

Waste management proposals

- It is important that demolition debris generated during the demolition and reconstruction of existing aquatic structures should be recycled as much as possible within the framework of the interventions. (So generated waste should be reused in the construction of new spurs, chevron dams, and bendway weirs.) It must be ensured that as little waste as possible is disposed of in landfills.
- The need for raw materials must also be minimized when constructing new structures. Efforts must be made to use decomposed, inert waste, thus reducing the use of new natural resources.
- Interventions should also aim to generate as little green waste as possible. The utilization of recyclable timber from waterfront vegetation clearance must be ensured. We recommend the on-site shredding of smaller plant residues and their transport to composting plants.
- The expected increase in traffic as a result of the planned interventions also means an increase in the amount of waste generated on ships. All this also requires the development of waste management system, the implementation of which is already outside the scope of the investment, but the implementation of the new “Green Islands” that are already planned, or other more modern waste disposal options are essential.
- The proposal to reduce and eliminate the possible load of oily bilge water generated during the normal operation of ships goes beyond the scope of the present planning task, however it is important that the process needs to be monitored in the future, also regulated and set up receiving points at appropriate intervals.

Proposals for air and noise protection

- During the implementation (construction) of the developments, we recommend the use of a modern fleet of construction machines with low fuel consumption and low emissions (noise, vibration, air pollutants and greenhouse gases). Energy efficiency and the minimization of transport needs must be taken into account when planning the organization.
- If the construction technology, the characteristics of the machine park to be used, etc. assume that the relevant limit value will be exceeded in certain locations, then local mitigation measures must be applied.
- The above suggestions can also be applied to the maintenance period.

9.2. EVALUATION OF MONITORING PROPOSALS IN THE PROGRAM, OTHER NECESSARY MEASURES

In order to monitor the objectives of the program, output, outcomes and impact indicators have been formulated, as well as additional RBMP indicators in order to monitor short- and long-term impacts on wildlife and monitor the compliance with the Water Framework Directive.

While the output indicators of the Program are only measure the physical implementation of the project, the environmental aspect (number and length of improved side channels) already appears among the outcome indicators. Among the impact indicators, there are those, that specifically measure environmental impacts: "Effects of increased vessel traffic on total emissions (noise, air and water load) in a given year" and "Effects of increased vessel traffic on energy consumption in a given year". In connection with the previous statement, the use of the word "total emissions" is considered to be somewhat misleading, difficult to interpret in terms of noise for protected objects (and humans), in addition to total emissions, it is important to monitor locally occurring pollutant concentrations in case of air and water.

In addition to the above mentioned two indicators, several impact indicators are closely related to certain environmental impacts, such as indicators following changes in traffic, the modernity of the fleet and the utilization of ports. In connection with these, it is recommended to quantify some environmental effects on the basis of indicator values (e.g. changes in emission of air pollutants with changes in traffic, fuel savings due to more modern ships, etc.).

On the basis of the system of environmental protection objectives defined in the SEA, those indicators can be provided, that could measure the actual environmental impact of provisions, and the implementation of environmental and sustainability-type objectives can be traced. Specific field proposals for the indicators are discussed briefly in the following section:

Surface water protection proposals

- As the works affect the flow conditions, it is important to monitor whether the flow regime behaves in accordance with the previously modelled results (shape of the riverbed, deepening etc.) as a result of the works, which could also have an impact on maintenance activities. Riverbed surveys need to be carried out regularly and also during the flood periods.
- In addition to monitoring of the water level and biological elements, we also recommend the examination of heavy metal concentration in the operational phase in order to accurately measure the development of the indicator in relation to the increase in traffic, thereby supporting any necessary regulatory changes and extensions.

Groundwater, geological, soil protection proposals

- In the next phase of the planning, in the impact assessment phase, the potential impacts related to water reserve protection require further detailed investigations, knowing this, the necessary monitoring proposals can be developed in some locations. (It is probable, that each water reserve that is affected by intervention will need quantitative and qualitative monitoring, even in the long run.)
- It is necessary to monitor the change of the groundwater level and the change of the quantity and quality of the soil along the Danube, possibly in those sections where the forecasts indicate a significant increase in low water levels, or for comparison in those sections where no change is forecast.

Wildlife conservation proposals

- We recommend developing a monitoring program for the group of organisms most affected to the best of our knowledge (at least higher ranked vegetation, macroscopic aquatic invertebrate species and fish). The results would provide very useful data for the monitoring of the affected Danube stretch according to the Water Framework Directive, for the monitoring of the affected Natura 2000 sites, for the fulfilment of the necessary EU reporting obligations and for planning of the necessary additional mitigation or compensatory measures in case of intensification of adverse effects.

Landscape protection proposals

- It is expedient to monitor the indirect consequences of the improvement of navigability conditions: how the number of visitors of the tourist destinations develops in the area, to what extent this is related to the increase in tourist traffic -which is expected on the basis of current estimates-, on the other hand, the possible transformation of waterfront use (especially the water-related recreational uses) and the land use of the Danube riparian zone (e.g. port developments, establishment of new ports and logistics centres).

Waste management proposals

- Continuous monitoring of the amount of waste delivered to the waste collection ports is recommended. If the trend of the results shows that the capacity of the waste collection points is not adequate in the long run, then it is advisable to implement their expansion.
- One of the biggest risks of hazardous waste is oily bilge water from vessels. Release into the watercourse may result in environmental damage. It is recommended to regularly sample the river after the implementation of the waterway development, in particular to monitor the amount of hydrocarbon derivatives.
- Increased control of vessel-generated waste records is advisable in appropriate shipping documents to encourage compliance.

Noise, air, and climate protection proposals

- It is advisable to assess the effects of noise, air and climate caused by water transport in the framework of a complex monitoring program along the navigation channel and on the designated sites near the ports. The monitoring program shall identify the measurement sites (preferably those where the effects of water transport dominate and where there are other significant sources at the same time) and the frequency of measurement. Among the air pollutants, at least nitrogen oxides, particulate matter and volatile hydrocarbons (benzene) must be measured as well as ozone at an appropriate distance, furthermore, a calculation of GHG emissions based on traffic data is required.
- In addition to tracing the changes along the navigation channel, it would also be important to show how the expected increase in shipping traffic has led to changes in noise and vibration loads as well as air pollutant and GHG emissions in terms of other modes of transport (especially road transport). In the absence of measurement data, the change can be inferred from the traffic data.

9.3. REQUIREMENTS, CONDITIONS AND ASPECTS -AFFECTED BY THE PROGRAM- TO BE TAKEN INTO ACCOUNT IN OTHER PLANS

In case of environmental studies, the above title usually means proposing the necessary modification of the plan above the plan/ program under consideration in the plan hierarchy and specifying what should be included in the ones below. In the case of the present Program, the plan hierarchy is less interpretable, given that there is no lower-level strategy within its remit. On the other hand, the results expected from the Program and the increase in inland waterway traffic have a number of consequences that may require changes in other strategies and even more so, in other regulatory backgrounds. These are not affected by the Program, but we consider it absolutely necessary to mitigate the potential adverse effects identified in the SEA, and to strengthen the potential beneficial effects and improve the efficiency of environmental protection solutions. In the following, therefore, we make proposals not only for the relevant other plans and strategies, but also for the required legal and economic regulatory background and, if necessary, we even make proposals regarding the infrastructural background.

Proposal for the modification of the freight transport system

Achieving the expected shipping traffic growth goals, the diversion of freight traffic from roads cannot be achieved only by infrastructural developments. To achieve it, regulatory and other measures - economic and legal - are also essential to encourage and facilitate modal shift.

Therefore, in order to help the diversion of freight traffic from roads to water, it is essential that the Hungarian Government becomes committed to these goals, thus creating a framework for freight transport reorganization by introducing significant regulatory and incentive measures, in addition to the development of inland freight transport infrastructure. Otherwise, the investment will not meet the target, making it less favourable from an environmental point of view than at present. In this respect, it matters what the European Union is doing to achieve the related objectives of the 2011 White Paper on Transport Policy. The Program assumed that more favourable traffic diversion regulations would be developed in the future at both EU and Hungarian level, due to the objectives set out in the White Paper.

Measures for air and noise protection, the promotion of the economical use of natural resources and the reduction of the rate and extent of further climate change in inland navigation

- Enabling and making mandatory the use of shore-side electricity for port vessels (instead of the continuous use of generators).
- Due to the ideas aimed at making greater use of the Danube as a waterway, it is important that the regulations -on load limits for noise from traffic and on strategic noise mapping- should be supplemented with water transport regulations.
- Continuous efforts should also be made to promote the use of energy-efficient vehicles with the lowest possible noise and air emissions, even it should be mandatory. It is proposed to encourage and support the modernization needed to reduce emissions from waterborne transport through economic incentives and regulatory instruments. These include:
  - Encouraging engine replacement and post-particulate filter equipment (e.g. providing support).
  - Enabling the spread of alternative fuels (building the necessary infrastructure), alternative propulsion methods (e.g. liquefied natural gas, biofuels, ammonia-fuelled or electric or hydrogen fuel cell watercraft) and encouraging their use.
- In terms of watercrafts, compliance with noise and air protection standards must be continuous and strictly monitored by measurements.

Necessary, non-development measures for inland navigation to adapt to climate change

- Improving forecasts, in particular for better preparation for low water levels and floods.
- Measures to improve intermodality (including cooperation).
- Logistical improvements in order to increase the transferred quantity or to reduce the transfer time (e.g. transition to continuous operation in case of small vessels, measures aiming the increase of the transferred quantity).
- Further developments of watercrafts in order to propel vessels more efficiently at low water levels and to increase their deadweight capacity.
- Preparing public transport for the effects of climate change.
- Modification of standards and technical specifications for waterborne transport, related infrastructure, facilities while taking into account projected changes in climate.

Tourism proposals

- In order to exploit the economic and tourism development opportunities, it is necessary to establish coherence with other plans and programs in the field (e.g. port development) and to encourage the development of the related service system.
- The increase of Danube tourism (hotel boats, international and domestic tourist boats) is proposed not only on the Danube, but also on the load capacity of the affected tourist destinations, focusing on the

extension of the tourist season and the increase of off-season demand.