Waterway Transport on Europe's Lifeline, the Danube

Impacts, Threats and Opportunities

Part A: River Ecosystem

Part B: Waterway Transport Needs

Vienna, January 2002

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Preface

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The Danube, one of the lifelines of Europe, has been a unifying element not only for flora and fauna but also for the people living in the region despite all geographical and political borders.

Over the course of centuries, all important European rivers have been massively manipulated and severely damaged. However, the Danube has not been as affected as severely by these changes as other rivers. Virtually untouched natural areas with an amazing diversity of species remain. It is a responsibility for all Europeans to protect and conserve this heritage of remarkable biodiversity for future generations especially in times of strong political and economic changes.

The political situation in Europe and especially in the Danube riparian states has been subject to dramatic changes. In the successor countries of former Yugoslavia, normality is now returning after years of war. Above all, the process of accession to the European Union is bringing the countries along the Danube closer together.

Along with the political changes, a dramatic process of economic development is beginning in the Central- and Eastern European states accompanied by their closer integration with the economies of the present EU member states. The closer economic links will have significant consequences for European traffic and for waterway transport .

Waterway transport has played an important role on the Danube for centuries and has led to considerable intervention in natural processes to expand shipping further. As a result, huge transportation capacity on the Danube already exists. This capacity is largely unused and requires no additional investment or development.

Recently, greater attention has been devoted to shipping on the Danube by upgrading the waterway, both on the national and international level. Until now, however, these discussions have largely focused on economic factors. Only very recently have the ecological consequences of recent and past interventions on the river ecosystem been given some attention. Furthermore international political guidelines, in particular, the EU's Water Framework Directive require a holistic approach to the river ecosystems.

Currently, along the entire length of the Danube, from Germany to the Danube delta, there are a number of – in most cases as yet unapproved – projects for the large-scale engineering of the waterway. However, an integrated, comprehensive evaluation of waterway transport on the Danube, especially its ecological aspects, is still missing. Without such a perspective, it is not possible to assure the economically and ecologically prudent development of waterway transport, in which shipping and the requisite waterway infrastructure are adapted to the natural environment and not vice versa.

This study seeks for the first time to present knowledge regarding the effects of waterway transport on the natural environment of the Danube river as well as to provide the basis for achieving ecologically adapted river transport.

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The impacts, threats and development opportunities of Danube waterway transport have been assessed from two perspectives:

- *Part A* **Ecological Assessment** deals with the status of Danube riverine landscape and the impact of waterway transport both in the past and potentially at conflict sites in the future; this part was completed in January 2002.
- *Part B* **Technical Assessment** examines the status of European inland waterway transport and future market needs, with a focus on the Austrian Danube east of Vienna; this part was completed in April 2001 and slightly updated in January 2002.

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This report can also be obtained at: http://www.panda.org/europe/freshwater/

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Abbreviations and Acronyms

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A	Austria
asl	above sea level
BG	Bulgaria
BiH	Bosnia i Hercegovina
CEE	Central and Eastern Europe
CZ	Czechia resp. Czech Republic
D	Germany
dm	Decimeter
Draught*	The vertical distance measured from the waterline of the floating vessel to its lowermost underwater point
ECE	UN Economic Commission for Europe
EIA	Environment Impact Assessment (EU Directive 97/11)
EU	European Union
FFH	Flora Fauna Habitat Directives (92/43/EEC)
FRY	Federal Republic of Yugoslavia
GIS	Geographical Information System
H	Hungary
ha	Hectares
HR	Croatia
HWL	Highest navigable water level, defined by the Danube Commission
IBA	Important Bird Area
IFI	International Financial Institutions (e.g. World Bank, EBRD, EIB)
ISPA	Instrument for Structural Policies for Pre-Accession (EU Regulation 1267/1999)
IUCN	International Union for the Conservation of Nature
LNRL*	Low Navigation and Regulation Level, defined for the Danube (= the water level available for 94% of the navigable season)
mio.	million
NP	National Park
rkm	river km
RMD canal	Rhine-Main-Danube canal
RO	Romania
SEA	Strategic Environment Assessment (EU Directive 2001)
SK	Slovakia resp. Slovak Republic
SLO	Slovenia
SPA	Special Protected Areas (sites protected under the EU-Birds Directive)
TEN-T	Trans-European Transport Network
Terminal*	A port section or zone where the modal change takes place (e.g. from a tanker to a truck)
TINA	Transport Infrastructure Needs Assessment for EU Accession countries
Waterway depth*	The minimum vertical distance between the water surface and the river, canal or lake bed on the respective site or sector
WFD	EU Water Framework Directive (2000/60/EC)
WSD	Austrian Waterways Authority (Wasserstraßendirektion)
WWF	World Wide Fund For Nature

* Source: Glossary of EUDET 1999

Introduction

Starting Point

The political situation in Europe and in particular that of Danube states has been, especially since 1989, undergoing a process of change. This refers also to changes in the framework conditions for waterway transport on one of the "life lines" of this continent, the Danube river. In the successor states of the former Yugoslavia, the situation is normalising slowly, and waterway transport along the river's full length should be possible again from spring 2002 onwards. Hungary and Slovakia will probably join the EU Member already in by 2005. Croatia, Romania and Bulgaria will also be integrated into the European Community in the medium term.
It must be expected that these Central and Eastern European countries will experience a marked upswing in their economic development and, in particular, become increasingly integrated with the current EU Members economcially. This will have noticeable consequences on the transport sector and thus on shipping on the Danube.

In nearly all of the states along the Danube, improved conditions for waterway transport are a topical issue. When looking at some of the solutions discussed such as the building of dams near Straubing/Vilshofen in Germany or the plans for a 3.2 m-deep navigable channel in Austria east of Vienna, the enormous importance of the decisions facing the Danube ecosystem becomes clear. As far as the future EU Members from the CEE area are concerned, above all the question arises whether old concepts will be continued or if new ways at a European level are chosen, such as the targeted promotion of new types of ships.

A new waterway transport strategy in the frame of the EU transport policy is required. This shipping strategy has to integrate the new political framework conditions and the changing economic conditions with the prevailing ecological conditions to assure a lasting conservation of the remaining riverine landscapes of the Danube region.

Objectives of the Study

This study aims to show whether and how the goal of a sustainable river ecology are compatible with the requirements of passenger and goods transport on the Danube, which will surely rise in the future. The following issues will be addressed:

- To what extent is the Danube natural area already affected by waterway transport?
- How will waterway transport on the Danube develop in the future?
- Where does a capacity increase on the waterway stand in contrast with the preservation and improvement of the Danube's ecosystem?
- Which are the framework conditions and requirements for an ecologically acceptable and environmentally sound waterway transport on the Danube?

Against the background of the Water Framework Directive, which entered into force in December 2000, the results of this study shall serve as a contribution for developing the future waterway transport policy of the European Union. Already today, many (river engineering) development and extension plans stand in contrast to requirements of water and floodplain ecology in many places. Only if timely steps are taken to counter such anachronistic and economically unacceptable development projects and if there is a clear new agreement on a ecologically sound improvement of the Danube navigation route, can serious conflicts with riparians and environment organisations be prevented and the few remaining natural landscapes of the Danube be preserved.

Part A: RIVER ECOSYSTEM

Part A: RIVER ECOSYSTEM

Executive Summary

The Danube and its tributaries host a diverse system of riverine habitats with a rich and unique biodiversity, such as gravel islands, sand cliffs, networks of side-arms, wet meadows, floodplain forests and more-over the Danube delta at the shores to the Black Sea. Biodiversity in the Danube basin is extremely high. However, since the 19th century in particular, in part drastic interventions into the Danube natural system and the surrounding land for flood protection, agriculture, power production and waterway transport have destroyed over 80% of the original floodplain area along the Danube and its main tributaries, thus greatly reducing the biodiversity in the region.

A variety of legal and political instruments have been agreed upon over the last decades to protect and save the remaining natural habitats of national and international importance. There are some 50 large protected areas along the navigable routes of the Danube and its tributaries as remnants of the former extended floodplains. The new EU Water Framework Directive (2000/60/EC) and the Flora Fauna Habitat (92/43/EEC) and Wild Birds Directives (79/409/EEC) with their Natura 2000 network are new binding regulations which aim at banning the further deterioration of riverine landscapes in EU and EU accession countries.

The Danube with its 2,780 km is navigable from Ulm (Germany) over 2,588 km all the way down to the Black Sea. The Danube stretch of 2,414 km between Kelheim (Germany) and Sulina (Romania) is part of the Rhine–Main–Danube link between the North Sea and the Black Sea as an important international waterway route (Pan-European Transport Corridor VII). There are also some other navigable tributaries (especially the Tisza and the Sava rivers) as well as artificial navigable canals (the largest being the Rhine-Main-Danube and the Danube-Black Sea canals).

Waterway transport on the Danube has numerous effects on the riverine ecosystems. Interventions can be differentiated in general in river re-construction (regulation works, impoundment) and in operational activities (maintenance of the navigation channel, emissions from ships, accidents).

River Regulations

River regulation serve to provide stable conditions in the river bed mainly for waterway transport and flood protection. Concerning matters of ecology, however, unbalanced conditions (varying water levels, erosion and sedimentation) secure the existence of a large variety of rare habitats and species. Unregulated rivers boast a richly structured system of main stream, side-arms and oxbows, with a dynamic balance between the new formation and disappearance of river branches, islands and banks. But the major regulations (mean, low and high water regulations realised from the 19th century until today) brought about a fundamental shift from braided and meandering reaches of the river to a single, straightened, navigable channel, stabilised by fixed embankments and lateral groynes. Many former arms of the original, braided system and the meandering bends were cut off. The artificial embankments reduced the hydrological interaction with the floodplain, and the new, high levees cut off parts of the former floodplain to gain protected land for agriculture and settlements.

The immediate effects for the river ecosystem were:

- A loss of natural riparian structures, affecting for example the crucial biotopes of river fish, insects and birds;
- Reduced hydrological connectivity both with the groundwater and with the floodplains;
- Strongly reduced geo-morphological processes in the floodplain, concentration of the erosive forces on the main channel bed;
- Lowering water tables both instream and in the floodplain due to permanent bed incision.

With lateral distance from the main channel, sedimentation and water retention increase, while erosive processes, hydrological connectivity and the flood-pulses decrease. Outside the flood protection dikes these changes are even stronger.

Impounded River Sections and Dams

Among the many factors leading to the degradation of river ecosystems, dams and barrages - built mainly to improve waterway transport and power production - are the main physical intervention, fragmenting and transforming the river continuum with the aquatic and terrestrial habitats, resulting in a range of effects that vary in duration, scale and degree of reversibility. Each dam disrupts the natural flow regime, the key driving factor for downstream aquatic ecosystems. Dams dissect the lateral and longitudinal continuity of the habitats with the organisms living in and near the river. Riverine biotopes separated by such installations suffer from changed abiotic conditions (e.g. morphological and hydrological processes) and contain merely residual or secondary biological communities of the original riverine landscape.

Each weir or dam causes a lasting change in the natural transport of solid matter. Major consequences include:

- A deepening of the river bed downstream the dam with a corresponding lowering of the groundwater level, and
- An increasing tendency of downstream aquatic habitats and wetlands towards draining and drying out.
- Upstream in the impounded section, fine sediments are trapped and start glogging the permeable interphase in the river banks and bed (unless the reservoir was already sealed for the safety of the impounding dikes): On the Danube, large sediment accumulation has been measured in many reservoirs. Over time, this process hampers navigation and makes regular sediment excavation or flushing necessary which both pose new environmental problems.
- Conventional dam construction goes hand in hand with the building of fixed, linear, monotonous structures, eliminating or drowning the natural river banks, bed and islands in deep reservoirs.
- The upstream lateral and vertical water exchange between the river, the groundwater and the floodplain ceases. The former characteristic water fluctuations between inundation and low water periods (causing an exchange of the soil air: the "breathing" of the floodplain) and the species migration (for reproduction, feeding, sheltering) are stopped. The once dynamic habitats with many floodplain specialists turn into monotonous areas dominated by ubiquists.
- The natural river system capacity for self-purification processes of water pollution is much reduced.

The first 1,000 km of the Danube have been developed into an almost uninterrupted artificial waterway by a chain of 59 hydropower dams. Along the Bavarian (Germany) navigation route, there is only one large free-flowing section left (between Straubing and Vilshofen: 70 km long). In Austria, two free-flowing sections of the Danube have been preserved thus far, in the "Wachau" region (35 km) and between Vienna and Bratislava (47 km). Downstream from the Gabcikovo hydrodam system in Slovakia, the more than 1,800 km long free-flowing section of the middle and lower Danube up to the Black Sea is interrupted only by the large impounded section of the two hydro dams at the Iron Gate (270 km long).

Dredging and Channel Maintenance

Low-flow river regulation and/or dredging ensures stable and convenient navigational parameters such as waterway depth and width for most of the year.
On the upper and middle reaches of the Danube, lateral shifting of the navigational channel in free-flowing sections is prevented mainly by groynes; regular dredging guarantees minimum draught for ships. Despite some uncertainties, the river Danube is nowadays considered as very convenient for waterway transport.
Along the unregulated stretches of the middle and lower Danube, many fords can still be found, which are being cleared for waterway transport by regular dredging.
Since the construction of dams and the continuous regulation measures have lastingly changed the natural sedimentation regime, dredging further increases the deepening of the riverbed in all free-flowing sections. This progressive erosion of the river bed has become the major problem for preserving the natural state of the free-flowing sections of the Danube and their aquatic habitats. Their ecological function can be safeguarded in the long term only by means of a sustainable stabilisation of the riverbed. This can be achieved by recharging the missing bed load, as is presently being applied at the Upper Rhine at the Iffezheim dam or at the Danube east of Vienna.

Physical and Mechanical Impacts of Regular Ship Traffic

Ship traffic, specifically the whirling up effect of ship engines, can lead to a re-suspension of finer sediments. This can impair many aquatic organisms which are not adapted to such unnatural conditions. Fine sediments can damage the respiratory organs of the larvae of many water insects. The increased turbidity reduces light penetration which, in turn, decreases the photosynthesis rates of plankton, benthic algae and vascular plant species.

Further, the waves caused by ship traffic can de-root many plant species along river banks that are vital for the reproduction of many fish and for the zoo-benthos. Young fish can be directly affected by waves.

During shipping, various species can also be transported over unnatural distances and beyond natural borders. In this process species may be introduced in areas where they would naturally not exist (e.g. from the Danube into the Rhine system via the Rhine-Main-Danube canal). Such distortion of biodiversity can have various negative effects on local populations.

Chemical and Material Impacts of Regular Ship Traffic

Mineral oil contains a variety of hydrocarbons, which, once in a body of water, may have damaging effects on amphibians, fish or birds. The photosynthesis of plants can also be reduced. Oil slicks affect the oxygen supply of many water organisms and natural biochemical processes (self-purification).

Mineral oil is introduced into navigable waters mainly as bilge oil. This mixture of water, lubricants, engine oil, etc. is - illegally - disposed of into the river. For the Danube river, the regular controlled disposal of bilge oil is an issue still to be improved. Also the direct disposal of wash waters from tank cleaning works is repeatedly being observed.
Tensides are used for the cleaning of ships and frequently end up untreated in waters. Many of the tensides widely used today are not easily degradable and partly have a toxic effect on aquatic organisms.
Other inputs of problem substances into rivers originate from ship paints that contain anti-foulants which serve to prevent the growth of organisms on the hull. Some paints contain biocides which, over time, are dissolved out of the paint matrix and released into the surrounding water.

With regard to energy consumption and the resulting emissions that impact the climate in waterway transport in comparison to other transport modes, the results found differ in their details. Still, all studies have in common that the emission of pollutants as well as energy consumption in regular inland ship traffic can be considered less harmful to the environment than the transport of goods on roads or in the air. In comparison to rail-bound traffic, however, inland waterway transport does not offer, by any means, any significant advantages.

Impacts Caused by Accidents

The probability of accidents in inland waterway transport depends mainly on traffic density, on nautical conditions, the travelling speed, the training and reliability of the crew, the technical state of the ship and the availability of effective and reliable navigation systems.
While the ecological effects of ship accidents vary case by case, the environmental hazards are clearly a serious threat to river ecosystems. In case of a spill or loss of a load, the ecological impacts can pollute large river sections: Mineral oils, oil products and other chemical goods are most risky types of freight commonly transported on ships.
In spite of all the safety measures taken, accidents occur repeatedly in the Danube region. Their prevention would require improved crew training, communication, technical standards and transport restrictions.

Case Studies of Ecological Conflict Areas

While in general waterway transport should be supported as an environment-friendly means of transportation in the Danube region, there are repeated disputes over new waterway transport routes as well as over the ecologically destructive expansion of year-round navigability in existing routes.

The study presents *11 conflict areas* presently under discussion where a strong dispute and opposition over major ecological impairments already exists or will be inevitable in case of realisation. These plans would suggest to impound the last free-flowing sections of the upper Danube and to reconstruct river sections of highest ecological value in the middle and lower Danube and on some tributaries:

- Straubing – Vilshofen (D)
- Wachau (A)
- Danube east of Vienna (A)
- Danube-Oder-Elbe Canal (A, SK, CZ, P, D) with the Port at Devinska Nova Ves (SK)
- Gabcikovo (SK, H)
- Navigation route upstream of Budapest (H, SK)
- Danube between Paks (H) and Beograd (FRY)
- Danube-Sava-Adria Canal (HR, BiH)
- Danube Islands (BG, RO)
- Danube Port of Moldova
- Ukrainian Danube Delta

Conclusions

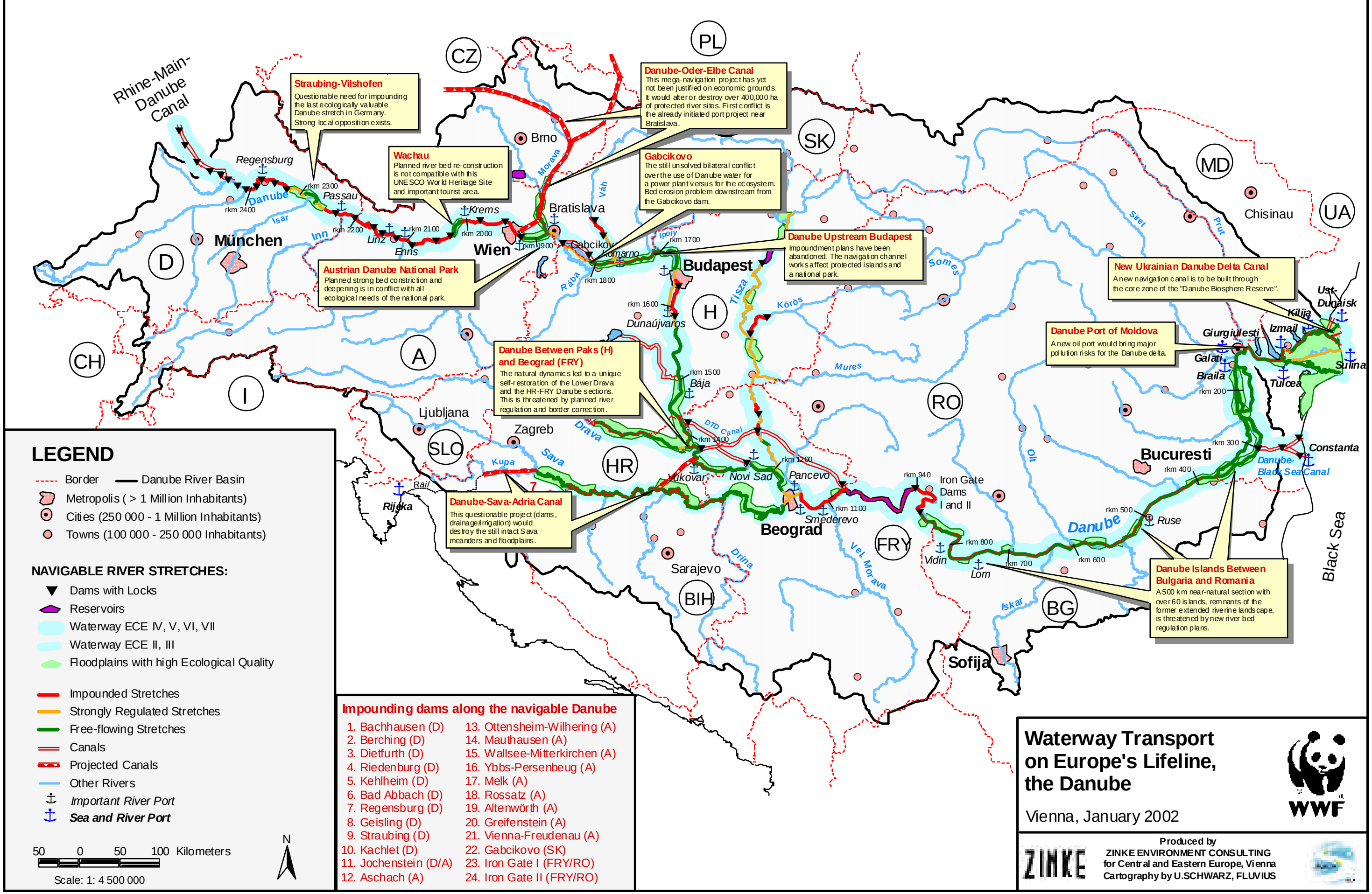
This comprehensive assessment presented a long and serious list of waterway transport-related interventions and impacts. Due to the fact that this waterway transport mode is usually happening in the core zones of sensitive freshwater ecosystems, the ecological state of most stretches of the Danube is already highly deteriorated.

In addition, new waterway transport projects constitute the largest threat for the few remaining natural areas in this part of Europe. Their future implementation is unrealistic and unacceptable from both the environmental, social, political and economic perspective.

Still, waterway transport was and can be performed in an ecologically acceptable way along the Danube. European transport ministers voted in their *Rotterdam Declaration* (6 September 2001) for the environmental sustainability, safety and efficiency of inland waterway transport. They want to foster the growth of inland waterway transport by improving many institutional co-operation problems (legal and economic conditions, administrative procedures, safety and transport efficiency, logistics and information service, etc.). Rather than further re-engineering our rivers according to certain types of ships, this upgrading of transport intelligence is the opportunity to make waterway transport in Europe competitive and ecologically sustainable.

Map 1 (opposite page): Ecological Conflict Areas in the Danube Basin Affected by Waterway Transport Development. (map credit: U. Schwarz)

Ecological Conflict Areas in the Danube Basin Affected by Waterway Transport Development



1. The Danube Natural Area

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1.1. The Danube - the Pulsing Lifeline of Europe

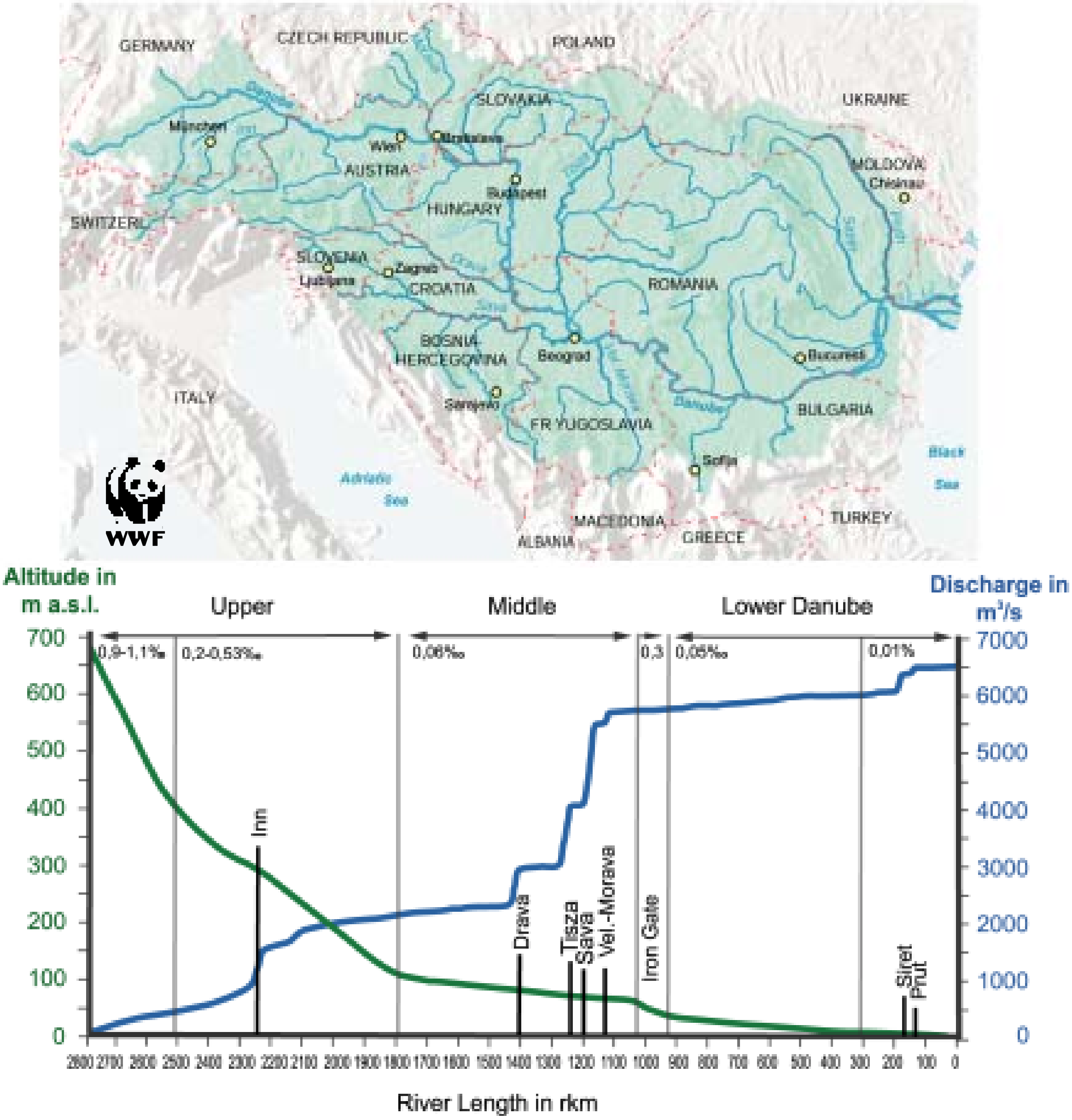
With a length of 2,780 km (without its source rivers), the Danube is - after the Volga - the second longest river in Europe (for comparison: Volga 3,531 km, Rhine 1,320 km). Its catchment comprises 817,000 km² and flows through all major landscape forms of Central and Eastern Europe. From its source in the Black Forest to its mouth at the Black Sea, the Danube covers a difference in altitude of 678 metres. The "upper Danube" stretches from the source at Donaueschingen (confluence of Brigach and Breg rivers) up to the Rába near Györ (Hungary), the "middle Danube" includes the Pannonian plain up to the Iron Gate (Carpathian mountains), and the "lower Danube" ends at the Danube delta. It transports an average of 6,500 m³ of water per second into the Black Sea. A number of other large rivers (e.g. the Inn, Morava, Drava, Tisza, Sava, Siret, Prut) flow into the Danube and contribute with their peculiar sub-basins to the overall extraordinary diversity of the Danube region.

En route to the Black Sea, it passes through several climatic zones (atlantic, sub-mediterranean, and continental climates). This goes hand in hand with a rich structure of natural regions in different faunal zones (Alpine, Pannonian, Balkan and Pontic faunal zones).
In the Danube basin, unique ecosystems can be found such as large lakes and wetlands and floodplain forests on the upper and middle Danube, karst landscapes in the areas surrounding some tributaries, and more-over the Danube delta at the mouth into the Black Sea. Biodiversity in the riverine ecosystems, as different as gravel islands, sand cliffs, side-arms or wet meadows, is extremely high. An estimated 5,000 different animal and over 600 different plant species alone in the Austrian Danube Floodplains National Park illustrates the great value of the Danube's ecosystems regarding species protection and gene pool preservation. For some species, the Danube and its wetland areas constitute their main or only habitat: for example 70 % of the world population of white pelicans (*Pelecanus ornocratolus*) live in the Danube delta; also the rare Dalmatian pelican (*Pelecanus crispus*) as well as the white-tailed eagle (*Heliaaetus albicilla*) find an important habitat here. However, 223 plant and 668 animal species are endangered and can therefore be found on Austria's Red List. Some of them, such as the tamarisk and water chestnut and various river fishes (e.g. the sturgeons) are even threatened to become extinct.

In comparison with many west European rivers, the degree of technical development of the entire Danube is still relatively low. However, this applies to the section downstream of Vienna, in contrast to the upstream section which is an almost uninterrupted cataract of technical impoundments.
Since the 1950s, altogether 15-20,000 km² of the Danube floodplains were cut off from the river by engineering works (Konold & Schütz 1996). An assessment of WWF (UNDP/GEF 1999a) has shown that over 80% of the original floodplain area along the Danube and its main tributaries has been lost since the beginning of the 19th century greatly reducing the biodiversity in the region. For instance, spawning grounds for fish, such as the five species of sturgeon traditionally found in the area, have been largely destroyed.

Within the *Austrian* Danube basin, a total of 5,265 river kms exist with a catchment larger than 500 km² (including the Danube itself). According to WWF (1998), only 3.7 % of this area are still in a natural state and 17.4 % in a semi-natural state. 78.9 % have been changed drastically by human interventions in the form of regulations and hydro dam impoundments. Still, various regulated sections have a considerable restoration potential.

Fig. 1: The Danube river basin and its longitudinal profile (with slope differences) of the Danube river. (figure and map credit: U. Schwarz)



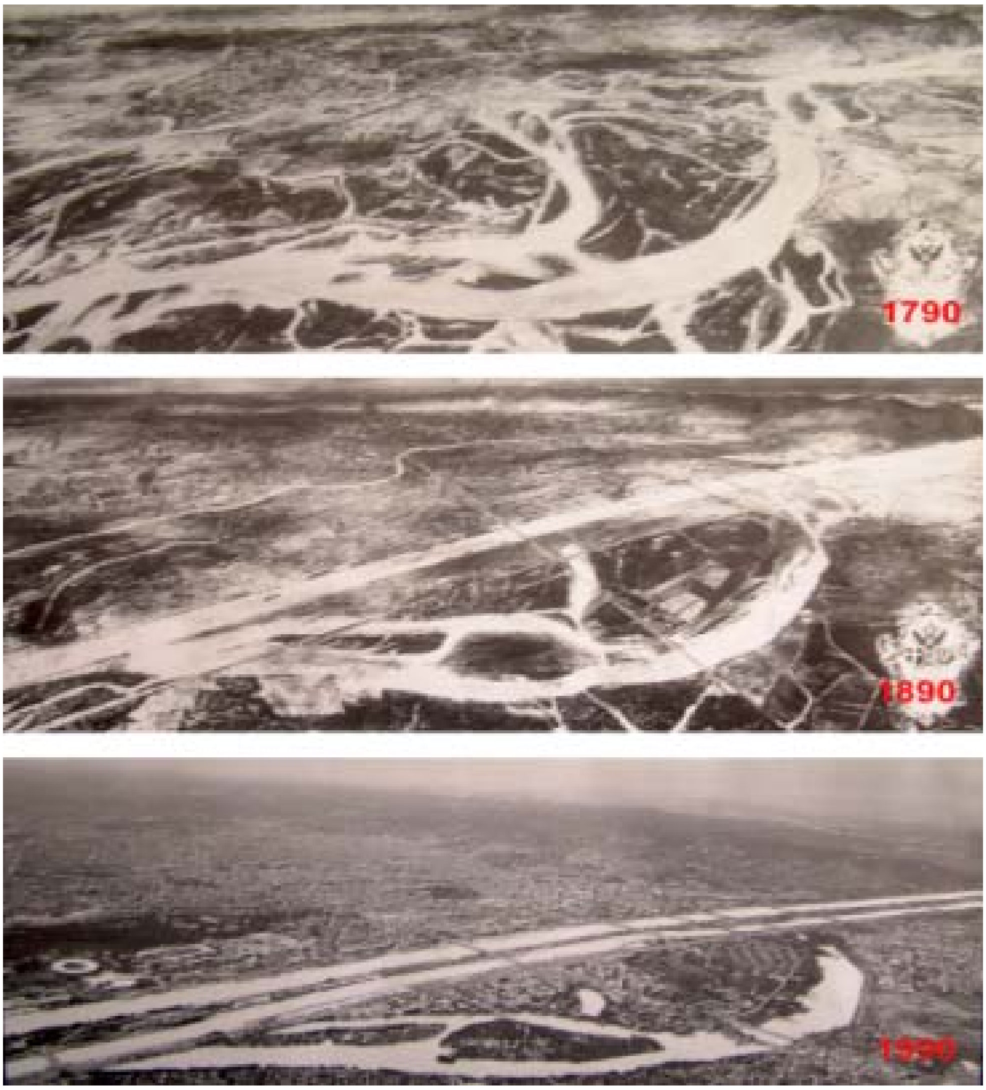
From a social perspective, the Danube area is characterised by a great linguistic and cultural diversity of its inhabitants. The population of the 13 countries in the catchment area totals 83 million people and the 10 states along its banks makes it the most international river world-wide (Zinke 1999). Many of them live directly in one of the big Danube cities (e.g. Vienna, Bratislava, Budapest, Belgrade) or at one of its tributaries (such as Munich, Zagreb, Sofia, or Bucharest).

For many inhabitants of the Danube basin, the river is their major resource. About 20 million persons get their drinking water from the Danube itself or from bank filtrate. At the same time there are other natural resource requirements: Large amounts of surface water are used for industry and mining, for irrigation in agriculture, as well as for energy production (cooling water for caloric and nuclear power plants). As a transport route the Danube has a high importance dating back at least to Roman times.

1.2. The Danube Then and Now

Up to the middle of the 19th century, the Danube was a free-flowing wild river in most parts. Maps, pictures and travel reports from that time show a varied river landscape with narrow gorges and wide basins. The Danube consisted, apart from the largest stream, of a water network with various large and small branches and extended riverine woodlands. This natural river system was fairly wide, not too deep, and characterised by unstable banks. Large-scale floods occurred in regular intervals. In correspondence with the water channel, also the location of gravel banks, islands, etc. used to change continuously. In case of floods, several branches merged, islands and banks were reshaped, while new alluvial deposits emerged in other places. The river was in a state of dynamic balance, in which this system could regulate itself.

Fig. 2: The Danube regulations at Vienna over the last centuries. (from: Donauatlas Wien, 1996)

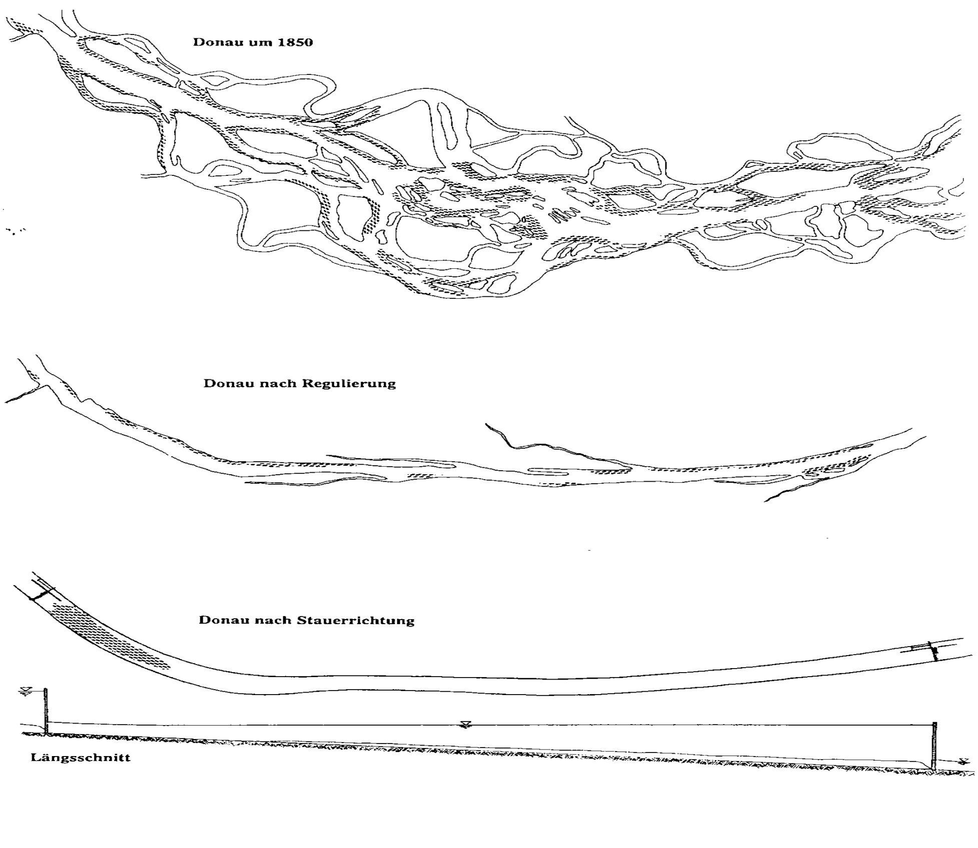


Many-fold land-use needs have led especially since the 19th century to partially drastic interventions into the Danube system and the surrounding land. The building of flood protection dike and drainage canal systems allowed intensive, industrial development but also contributed to the overall loss of some 80% of the former Danube floodplains during the last 100 years.

Already in Roman times, the Danube was used for waterway transport. Historically, this played a key role in the settlement of the Danube area. The first massive interventions into the natural balance of the river systems were carried out in Hungary already before 1840 (500 km of dikes protected 2,000 km² of land) and then extended within the Austro-Hungarian empire in the course of the so-called "Main Regulation of the Danube" (launched with the "Vienna cut" 1869-1875 through which several braided river branches were confined into one large bed) with the aim to improve both flood protection and navigability (see figure 2). These regulation measures were continued after World War II and ended only in 1997 with the opening of the Vienna-Freudenau dam.

These works brought about important changes of major river-morphological parameters such as the river length (e.g. the Bavarian Danube was shortened by 21%), the gradient, the flow volume, the bed structures, the width and depth structures, above all in the upper reaches of the Danube. For that reason, the living conditions of aquatic organisms were subject to drastic changes. Today, original river landscapes with richly structured streams and their floodplain forests can hardly be found, neither along the Danube nor along most other river systems in Europe (Schiemer 1994).

Fig. 3: Potential habitats of *Zingel streber* in the Danube before (1850) and after river regulation, and in impounded sections (top view and cross-section). (from: Zauner 1991)



One of the most important effects of such construction works is the reduction of the total water surface. This was most significant in the plains in Hungary (3.7 mio. ha of wetlands diked in) and Romania (loss of 435,000 ha) as well as in the upper reaches of the Danube. A study of the river section east of Vienna (Schönau to the mouth of the March river), comparing historical maps with current data, found that the total water surface was reduced from 23.7 km² in 1860 to 13.1 km² in 1988. This is tantamount to a decrease by 45 % (Weber 1989). The main reason is that the water artificially confined in the main bed for year-round waterway transport is blocked at mean and low water levels from spreading into the floodplain. This is aggravated by the incision effect of the main bed due to the lack of upstream supply of sediments, and this results in lower average water tables and a dominating drainage of the floodplain where dry lands take over many former wetland habitats (see also A 2.1.1.1). This further results in a recession of specialised wetland species and a spreading of ubiquitous and drought-resistant species (see i.a. WWF 1997).

A natural body of running water transports great amounts of solid matter depending on the shape and structure of its water channel. This solid load may come from several sources (Scheuerlein 1996):

- from the stream's own catchment area;
- from the catchment area of the tributaries;
- from collapsing river banks;
- from its own river bed sediments (due to erosion).

Today the transport of bed-load within the Danube catchment and its tributaries is largely stopped. The reason for this is the nearly continuous chain of dams and weirs with their impounded sections (alone in the Austrian federal province of Salzburg, about 2,000 mostly small dams have been built). Nowadays the input of solid matter from collapsing river banks is also prevented by fortified embankments on the upper Danube system. Therefore the remaining main source for bed load transport is river bed erosion. This is connected with the tendency of progressive abrasion of the substrate. The composition of the bed material has undergone pronounced changes. This has an impact not only on the upper reaches of the Danube, but also on the downstream sections. The reduced new supply of bed-load and the change in the composition of bed sediments have the result that only in the long term natural stabilisation of the river bed can take place.

1.3. Commitments for Protecting Danube Natural Areas

The international environmental significance of the Danube natural region is reflected in a number of agreed legal obligations and political commitments of Danube basin states which aim at the lasting protection and restoration of this unique river ecosystem, including many key sites and its hydrological system.

Danube River Protection Convention

On 29 June 1994 the Danube River Protection Convention (DRPC) was signed in Sofia (Bulgaria) by representatives of Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Romania, Slovakia, Slovenia, Ukraine and the European Union. The Convention entered into force on 22 October 1998. For the implementation of the Convention, the International Commission for the Protection of the Danube River (ICPDR) was founded with its Secretariat based in Vienna. ICPDR members are the contracting parties; several international governmental institutions as well as NGOs (WWF, Danube Environmental Forum) have observer status.

The preparation of the DRPC was supported since 1991 by the Environmental Programme for the Danube River Basin (EPDRB). Its main objective was to strengthen the operational basis for environmental management in the region and to support the Danube countries in implementing the DRPC. Phase 1 of the EPDRB provided an institutional base and technical support for developing a Strategic Action Plan (approved in December 1994 in Bucharest). Phase 2 (1995-1999) focused on the Danube Strategic Action Plan Implementation Programme (SIP) which realised demonstration projects for transboundary water and related natural resources management.
The development and implementation of the EPDRB as well as the tasks of the ICPDR was mostly supported by national contributions as well as by EU-Phare/Tacis and UNDP/GEF funds.

The aims of the Convention include in particular:

- conservation, improvement and reasonable use of the surface and ground waters of the catchment area;
- improved control for accident risks;
- reduction of the disposal of pollutants into the Black Sea.

The Convention parties commit themselves to take all required legal, administrative and technical measures to at least maintain the water quality of the Danube and of the waters within its catchment area and to improve it, if possible, and not to take any measures with contrary effects.

The ICPDR discusses a number of special issues in its Expert Groups, such as EMIS (pollution emission into waters, from point and diffuse sources), AEPWS (accidental emission prevention and warning system), MLIM (monitoring, laboratory and information management, including a Transnational Monitoring Network), RBM (River Basin Management) and ECO (ad-hoc ecological expert group): The latter two expert groups also deal with the implications and implementation of the EU Water Framework Directive in the Danube river basin. See also the webpage: http://www.icpdr.org

EU Water Framework Directive

On 22 December 2000 the EU Water Framework Directive entered into force. It aims to preserve and improve the aquatic environment within the Community and to promote a sustainable use of water on the basis of a long-term protection of existing resources.

Correspondingly, the European Union specifies clear environmental objectives for its Member States:

- no further deterioration of the state of all Community waters (i.e. both surface- and ground waters, including coastal waters, throughout the EU);
- protection and improvement of all surface waters with the aim of achieving a "*good status*" by 2015;
- improvement of all artificial and considerably modified water bodies with the aim of obtaining a good chemical status by 2015;
- reduction or termination of contamination (introduction, emission) of priority (dangerous) substances.

To achieve these goals, Member States have to draw up and implement integrated programmes of measures for each “river basin district”. In the case of river basins located in more than one country, the basin-sharing States concerned are called upon to co-operate through transboundary management programmes.
In the case of the Danube basin district, the number and size of sub-units has not been officially determined yet but they were already pre-defined in 1999 during the Danube Pollution Reduction Programme (part of the EPDRB) and respective co-operation steps are already under way (e.g. in the Tisza and Sava sub-basins).
Since the protection of waters must be integrated into all relevant policy areas (incl. transport, energy, and agriculture), waterway transport will play a substantial role in the framework of river basin management plans. The ecological deterioration ban (see also below "Natura 2000") for riverine wetlands, which became effective with the entering-into-force of the Directive, is - in fact - already binding for all EU member states and, informally, also for the EU accession candidates, thus also regarding *any* new development of the "Danube Waterway". Therefore, any current or new activity leading to the deterioration of wetland ecosystems in Accession Countries should be planned with particular caution since, upon accession, the Water Framework Directive’s requirement for “good water status” could lead to sanctions for non-compliance.

Natura 2000

Natura 2000 is an instrument of the European Union for the conservation of nature. All Member States are obliged to report areas they have been selected according to specific criteria and to place them under special protection. The legal basis for the Natura 2000 programme are the EU- Directives concerning the Protection of Wild Birds (79/409/EEC) and Fauna-Flora-Habitat (92/43/EEC). A major objective of these legal standards is the conservation of biodiversity in Europe. For this purpose, both "improvement demands" and "deterioration bans" regarding environmental quality have been provided for.

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Photo 1: Sturgeon (photo credit: WWF-Austria)

Areas notified as Natura 2000 areas along the Danube navigation route include the sections of Straubing-Vilshofen in Bavaria and, in Austria, the Danube wetlands at the mouth of the Traun, the Wachau, the Danube wetlands of Tullnerfeld, and the Danube floodplains east of Vienna. Preparations for the Natura 2000 network are also underway in Accession Countries, which have to identify sites of European importance and include them in the Accession Countries *Emerald Network* based on the Bern Convention (Convention on the Conservation of European Wildlife and Natural Resources, 1979).

Ramsar Convention

This Convention was adopted in 1973 in the Iranian city of Ramsar and aims at protecting internationally significant wetlands which host animal or plant species being rare or threatened by extinction. Each of the signatory states (currently 124) is obliged to declare at least one Ramsar area and give it special protection. The management of the sites is to adopt the principle of "*wise use*".

Most states along the Danube have declared Ramsar sites (e.g. Danube wetlands in Bavaria/D, trilateral site of the Morava-Dyje wetlands in Austria, Czechia and Slovakia, the Gemenc floodplain forest in Hungary, the Danube delta in Romania). For Ramsar sites along navigable routes in the Danube basin see also Table 2 (page 31).

Important Bird Areas (IBA)

IBAs are those sites where a significant part of bird species' populations can be found on a regular basis, and where a network of such protected sites effectively ensures the survival of these species across their biogeographical distribution area. The first European-wide IBA inventory with over 2,400 sites was completed in 1989, and in 2000 the revised IBA inventory listed 412 Important Bird Areas in the 10 EU accession countries. These IBAs serve as a basis for the designation of Special Protection Areas (SPAs) as part of the future Natura 2000 network in the accession countries.

Already in 1995, BirdLife International and the World Conservation Monitoring Center assessed the potential impact of the TEN-T (Trans-European Transport Networks) in EU countries on IBAs and found that the EU failed to do this step. A recently published, new assessment of the potential impact of the TINA network (Transport Infrastructure Needs Assessment) on Important Bird Areas in the 10 accession countries (BirdLife International 2001) found that, out of 85 IBAs potentially affected by TINA developments, as many as 34 IBAs are threatened by waterways (some having international importance or even globally threatened species) and, more specifically, 19 IBAs potentially affected by the Danube corridor (TINA Corridor VII). This is by far the highest number of IBAs threatened by transport corridors (see Table 1 on page 26). BirdLife stresses that the TINA network can potentially threaten a very significant part of bird diversity, both on European and global scale (e.g. the Dalmatian pelican). It should be noted that this study lacks complementary information of IBAs in EU member states (Germany, Austria) and non-candidate countries (especially Croatia, FR Yugoslavia and Ukraine).

BirdLife sees a clear conflict for these areas, fully meeting the criteria of the EU Birds and the Habitat Directives - eventually forming the Natura 2000 network -, with EU-funded infrastructure projects aiming at rapidly and better connecting these countries with the EU. Accession candidate states are obliged to identify, and in the case of Special Protection Areas (SPAs) designate, all sites that satisfy the requirements of the two Directives. The EC repeatedly stated that a pre-condition for the use of pre-accession funds, including ISPA, is that these investments respect Community legislation, including nature conservation directives (BirdLife International 2001).

BirdLife further recalls the EU efforts to integrate environment into sectoral policies and here specifically the *Vienna Declaration* from 1997 setting out key principles for sustainability in the transport sector. At the Helsinki Council in December 1999, an *EU transport strategy* was adopted ranking environmental concerns as important as social and economic factors in the development of the transport policy. For accession countries, support should be particularly given to less damaging transport modes. In 2001, the Guidelines for the development of TEN-T were revised and should also incorporate the TINA network. Further, the European Commission stressed that strategic environmental assessments (SEAs), providing information on significant effects for i.a. biodiversity, will be integrated in the TINA process (BirdLife International 2001).

BirdLife concludes that *"waterways, although seen as a more sustainable mode of transport, seem to have a disproportionately large negative impact on IBAs, especially wetlands"*. At the same time, BirdLife found that *"the priority setting, detailed planning, routing and funding for the TINA network lacks transparency, openness and consultation".*

BirdLife therefore recommends to *carry out a detailed strategic environmental assessment (SEA) of the likely impact of the planned TINA network* with special emphasis on existing and future protected areas, especially for the Helsinki corridors no. I, IV, V and VII identified as potentially affecting the most IBAs. BirdLife recommends that international (IFIs) or EU funding for TINA projects leading to the deterioration or destruction of IBAs should not be allowed to go ahead. The TINA strategy for waterway corridor development should be revised extensively, involving ecologists and considering the requirements of the new EU Water Framework Directive. The full potential impact of the TINA transport network development on all valuable sites and habitats deserving protection has to be urgently assessed using GIS methodologies. The impact of already existing transport infrastructure on key habitats and sites of high biodiversity should be monitored and regularly assessed for the planning of new transport infrastructure.

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Photo 2: Tern (photo credit: WWF-Austria)

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Table 1: Important Bird Areas potentially affected by the TINA transport network in EU accession countries. (compiled from BirdLife International 2001)

TINA Corridor *	Country	IBA Important Bird Area (English Name)	IBA Code	Inner Water -way **	Outer Water -way **	Compare WWF Waterway Transport study chapter no.
IV	Czech Republic	Confluence of Morava and Dyje rivers	12	x	x	A.3.4.1.
VI		Poodri	14	(x)	(x)	A.3.4.1.
VII / IV	Hungary	Moson Plain	1	(x)	(x)	A.3.5.
VII / IV		Danube between Gönyü and Szob	16	x	x	A.3.6.
VII / IV		Danube bend	17	x	x	A.3.6.
VII / V		Gemenc	10	x	x	A.3.7.
VII / V		Béda-Karapancsa	9	x	x	A.3.7.
VII	Bulgaria	Orsoya fish ponds	6		x	
VII		Ibisha island	7		x	
VII		Island near Gorni Tzibar	8	x	x	
VII		Belene island complex	17	x	x	A.3.9.
VII		Mechka fish ponds	24		x	
VII		Stenata	31		x	
VII		Pozharevo island	32		x	
VII		Srebarna lake	33		x	A.1.3.
VII	Romania	Iron Gate reservoir	32	x	x	
VII		Mehedinti fish ponds - Gruia	34	x	x	
VII		Ciocanesti fish farm	39		x	
VII		Little Braila island	43	x	x	
VII		Parches-Somova wetland	2	x	x	
VII		Danube delta	1	x	x	A.1.3., A.2.1.1.2.4.
IV	Romania	Lake Tasaul	6	x	x	

* TINA Corridors: IV (Berlin/Nürnberg - Praha - Budapest - Constanta/Thessaloniki/Istanbul)
V (Velence - Trieste/Koper - Ljubljana - Budapest - Ushgorod - Lvov - Kiev
VI (Gdansk- Warsaw - Zilina)
VII (Danube)

** BirdLife assessed the potential impact of infrastructure routes on nature sites by differing *likely direct effects* for IBAs located at a distance of 1 km from a TINA waterway ("*Inner Waterway*" with a buffer of 2 km) resp. likely indirect effects at a distance of 2.5 km from a TINA Waterway ("*Outer Waterway*" with a buffer of 5 km).

x indicates that an IBA's boundary is partly within the relevant buffer of the TINA corridor

(x) indicates that the TINA corridor serves mainly for road transport but that a waterway route is nearby (in the case of IBA Moson there already exists an impounded Danube waterway by the Gabcikovo-Cunovo dams, in the case of Poodri this is planned as a new Danube-Odra waterway transport route).

Declaration on the Co-operation for the Creation of a Lower Danube Green Corridor

On 5 June 2000 the environment ministers of Bulgaria, Moldova, Romania and Ukraine signed a declaration for creating a "Green Corridor" for the lower Danube. This "Green Corridor" is aimed at comprising nearly 1 million hectares (773,000 ha of already existing protected areas, 160,000 ha of areas to be put under protection as well as another 225,000 ha identified for restoration). A regular exchange of information has been agreed upon regarding water quality and the quality of the aquatic ecosystems, regarding the best available restoration technologies, and measures to prevent, control and reduce pollution. For implementing the "Green Corridor", it is aimed to find partners at local, national and international levels (e.g. other states, EU, UNDP, UNEP, World Bank). The costs caused by environmental pollution will be reduced by making them payable by polluters and thus creating economic incentives to environmentally friendly behaviour. Sustainable development should be reflected in the different sector policies. (See also chapter A.3.9.)

Declaration on Environment and Sustainable Development in the Carpathian and Danube Region

On 30 April 2001, in the framework of a governmental summit in Bucharest (Romania), Heads of State from the Danube and Carpathian region adopted a Declaration on Environment and Sustainable Development. The parties to the contract have agreed to intensify their efforts to protect nature in this region, to increase cross-frontier co-operation and to involve all social groups concerned. It has been specified that the integration of ecological considerations into the economic and social development of the region will be safeguarded. Furthermore the countries plan to produce a positive climate to mobilise more financial resources for technology transfer and for research with environmental relevance. The implementation of already existing international agreements (the Ramsar Convention, the Green Corridor on the lower Danube, the EU Water Framework Directive, the Aarhus Convention, the UN Conventions on Biodiversity and Climatic Change) is to be further fostered.

Photo 3: Head of States Summit on Environment and Sustainable Development in the Carpathian and Danube Region (29-30 April 2001 in Bukarest) (photo credit: WWF-DCPO)

UNESCO World Heritage

In 1972 the UNESCO (United Nations Educational, Scientific and Cultural Organisation) adopted the Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention). This agreement aims to protect landscapes of outstanding beauty and variety from destruction and to protect them as world heritage of the entire humankind for future generations. Landscapes may be classified as particularly important and thus be protected as world heritage either due to their uniqueness and authenticity or due to the integrity of their ecosystems.

So far, three landscapes on the Danube have been declared world heritage properties due to their extraordinary value for humankind: the Danube delta in Romania, the wetlands and nature reserve near Srebarna in Bulgaria (an expansion of this protected area to neighbouring areas in Romania is under discussion), and, since December 2000, the Wachau in Austria (for the Wachau, the Council of Europe already took over his patronage in the form of the Euro-diploma in 1995.) Currently the wetlands of Danube-Morava-Dyje are being considered to be designated as a cross-border World Heritage Site (Austria, Czechia, Slovakia).
Along the Danube waterway, there exist currently two World Heritage Nature sites, the Srebarna lake in Bulgaria and the Danube delta in Romania:

Srebarna Lake

This 902 ha wetland is located next to the Danube banks at rkm 391-393 from where it stretches south as a large lake-reed complex. Srebarna lake was protected in 1942 as a Bulgarian water bird sanctuary but later received highest international protection status both as a World Heritage Site (1983), a Ramsar site (1975), a UNESCO Biosphere Reserve (1977) and an Important Bird Area (1989). Its biodiversity includes approx. 3000 plant and animal species, including 179 birds (99 breeding; colonies of herons, terns and cormorants) and several *globally threatened animals*, including the Dalmatian pelican (*Pelecanus crispus*) 80 breeding pairs in 1998; the largest bird in Europe), the pygmy cormorant (*Phalacrocorax pygmeus*), and the ferruginous duck (*Aythya nyroca*), the two wintering birds red-breasted goose (*Branta ruficollis*) and lesser white-fronted goose (*Anser erythropus*), as well as the river otter (*Lutra lutra*) and the invertebrate medicinal leech (*Hirudo medicinalis*).

A dike built in 1948 disconnected and deteriorated the reserve from the Danube (water table lowered to only 1 m led to reed bed expansion). After it was listed in 1992 as an endangered Ramsar site, a channel connection to the Danube was built which resulted in temporary improvement.

Danube Delta

The mouth of the Danube into the Black Sea is recognised as one of the most important wetlands world-wide (largest reed bed with 1,800 km²), and with a size of 5,640 km² (4,152 on Romanian side, 18% on Ukrainian side) it is the most important wetland in the Danube basin. In 1991, 3,124 km² became designated as World Natural Heritage, the delta is also a Ramsar Site (1991) and a UNESCO Biosphere Reserve (1993). The delta consists of three Danube arms, a huge reed belt, various lake complexes (668 are larger than 1 ha), a 3,400 km long network of natural and artificial canals, as well as gallery forests and sand dunes. It is home to many other endangered species (e.g. 325 birds, 75 fishes), including several globally threatened birds (e.g. red-breasted goose, Dalmatian pelican and pygmy cormorant). After the former regime destroyed one fourth of the delta (9,741 km²) from 1983-1989 by building polders for farming, a number of major restoration projects started in the 1990s at polders near the Chilia and Sulina arms (ICPDD & WWF 1997). The delta is a rich economic resource of fish, timber and reed and home to about 80,000 people. It is a national tourist centre with a considerable potential for ecotourism. See also chapter A 2.1.1.2.4.

National Parks and Other Protected Areas

Several riparian states of the Danube have recognised the importance of preserving the Danube natural area and have, therefore placed several areas under special protection.

Danube Floodplains National Park (Austria)

After the conflicts and debates surrounding the construction of the power plant of Hainburg in 1984/85 (see chapter A.3.3.), the Austrian Federal Government set up an Ecology Commission. This Commission recommended to refrain from erecting the hydroelectric plant and to establish a national park for this river section east of Vienna instead. The dam was not built and the national park was established in October 1996 on a territory of 9,500 ha. It is the only intact floodplain habitat left of the upper Danube and includes since 1996 several large-scale restoration projects.

Duna-Drava National Park (Hungary)

This floodplain complex includes the largest Danube floodplain forest (Gemenc-Béda Karapancsa with about 27,500 ha) in central Europe (total national park area including the Drava floodplain complex is 49,500 ha). The wetlands with large old river arms and oxbow-lakes are a major breeding ground for the black stork (*Ciconia nigra*), the sea eagle (*Heliaaetus albicilla*) and approximately 110 other bird species. Other special features include heron colonies (*Ardea sp.)* and a high density of kingfishers (*Alcedo atthis*) and aquatic warblers (*Acrocephalus paludicola*). This area was declared a protected landscape already in 1977. In April 1996 it became a national park and in 1997 a Ramsar site. WWF then also successfully reintroduced the beaver (*Casto fiber*) from the Austrian Danube floodplains.

Under the initiative of WWF, these two Danube floodplain reserves became *sister national parks* in 1998.

Danube-Ipoly National Park (Hungary)

This young Hungarian national park comprises, apart from the wooded ranges along the Danube bend and the relatively untouched part along the Ipoly river, the narrow banks and river waters at the Danube gorge. From 1987 to 1989, this river section became the construction site of the Nagymaros hydro dam, being part of the Czechoslovak-Hungarian Gabcikovo-Nagymaros hydrodam project. After Hungary stopped construction in May 1989, it took until spring 1995 to again fully restore the construction site and to relocate the navigation route into the centre of the river bed.

Kopački Rit Nature Park (Croatia)

This protected area covers 23 000 ha and is situated in the Baranja region (Croatia) in the triangle formed by the mouth of the Drava river into the Danube. The area is protected under Croatian law as a nature park (IUCN category V). The ecologically most valuable part of 7,700 ha was protected in 1976 as a Special Zoological Reserve (IUCN category 1b). Later, the entire area (including the Danube floodplains east on Yugoslavian side) became a Ramsar and IBA site. The Croatian area was also proposed as a national park and a World Heritage Nature site.

The reserve is covered with extensive reed beds, willow, poplar and oak floodplain forests and interspersed by ridges, ponds, shallow lakes and marshes. Floods usually last 100 days a year. During extensive floods, the large area is inundated by shallow water. The abundance of food and underwater vegetation is ideal for fish spawning, which makes Kopački Rit, after the Danube Delta, the most important spawning ground along the entire Danube.

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Photo 4: The confluence of the Drava river (right) with the Danube (left) is protected by the Nature Reserve and Ramsar site "Kopački Rit". (photo credit: U. Schwarz).

The following table, based on the WWF evaluation of Danube basin floodplains (UNDP/GEF 1999a), lists major protected wetlands along the waterway transport route of the Danube and its tributaries, indicating their name, IUCN category, size and establishment:

* Abbreviations:	R	Ramsar site (wetland of international importance)
	IUCN category: I	Scientific reserve, strictly protected area
	II	NP (national park)
	IV	NR (nature reserve > 500 ha)
	IX	BR (UNESCO biosphere reserve)

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Table 2: Protected Areas along the w aterw ay transport routes of the Danube basin (note: for sites ow ning several designations, only the most important one may be indicated).

Country	River	Site	Category*	Area Size	Date of Designation
Germany	Danube	NR Riparian landscape Danube meadows	IV	1 090 ha	1976
		NR Pf atter	IV	680 ha	1991
		NR Mouth of Isar	IV	980 ha	1990
Austria	Danube	NP Danube Floodplains	II	9 300 ha	1996
		Lower Lobau	BR	1 039 ha	1977
		Danube	R	1 039 ha	1982
	Danube- Morava	Danube-Morav a-Dy je Floodplains	R	38 500 ha	1982
Slov akia	Morav a	Morav a floodplains	R	4 971 ha	1993
	Danube	NR Cícov old arm	R	135 ha	1990
		NR Súr	IV	568 ha	1952
		NR Súr	R	1 137 ha	1990
		Danube floodplains	R	14 335 ha	1993
Hungary	Danube	NP Danube-Drav a part Gemenc - Béda-Karapancsa	V V R	49 479 ha 27 500 ha 18 023 ha	1996 1996 1997
		NP Danube-Ipoly Part Danube:_Szentendre island	II II	60 314 ha 1 300 ha	1997 1997
		Ócsa	R	1 078 ha	1989
		NR Császártöltési Vörös-mocsár, NR Szelid lake, NR Kiskörösi turjános	IV		
	Tisza	Pusztaszeri	R	5 000 ha	1979
		Mártélyi	R	2 232 ha	1979
		NP Kiskunság	II BR R	35 860 ha 22 095 ha 3 903 ha	1975 1979 1979
		Lakitelek Töserdö	IV	600 ha	1975
		NP Hortobágy	II BR R	52 213 ha 53 099 ha 23 121 ha	1973/1996 1979 1979
		Tiszacsege	IV	1 263 ha	1996
		Tisza lake (southern part)	V	5 000 ha	1996
		Tisza lake (northern part = NP Hortobagy)	R	2 500 ha	1979
		NR Tiszatob	IV	1 000 ha	1977
		Tokaj- Bodrog- zug	R	3 782 ha	1989
		NR Tiszatelek- Tiszaberceli- ártér	IV	1 263 ha	1978
Croatia	Danube- Drav a	Kopacki Rit nature park Special Zoological Reserv e Kopacki Rit	R Ia	16 000 ha 7 000 ha	 1976
	Sav a	Lonjsko Polje nature park	R	50 650 ha	1990
Yugoslavia	Danube	Special NR Karadjordjev o	IV	2 955 ha	1997
		Special NR Kov iljsko- Petrov aradinski Rit	IV	4 841 ha	1998
		Nature Park Iron Gate	IV	63 608 ha	1974/1993
	Tisa	Special NR Stari Begej- Carska Bara	IV R	1 767 ha 1 767 ha	1986 1996
	Sav a	Special NR Zasav ica	IV	671 ha	1997
		NR Obedska Bara	IV R	9 820 ha 17 501 ha	1968/1994 1977
Bosnia	Sav a	Ornithological Reserv e Bardaca	IV	700 ha	
Bulgaria	Danube	NR Persina Island	IV	1 714 ha	1981
		NR Srébarna	IV R BR	1 143 ha 902 ha 600 ha	1948 1975 1977
Romania	Danube	NR Small Braila Island	IV	14 983 ha	1997
		a Danube Delta	BR	580,000 ha	1990
Ukraine	Danube	Dunaiskie Plav ny Danube delta	BR	46 400 ha	1998
		Ismail islands	R	1 366 ha	1996
		Kugurluy lake	R	6 500 ha	1995
		Kartal lake	R	500 ha	1995

2. Ecological Impacts of Waterway Transport

2.1. Development of the Waterway

"River regulations address the tension between ecology and hydraulic engineering in whose planning philosophy stabilisation and safety are in the foreground. In modern ecology, however, the significance of unbalanced relations and disturbances has been recognised and represents a major topic. It is not the stable conditions of regulated and dammed-up rivers that are characteristic of their habitats but continuous changes due to disturbances which, on a small scale, guarantee a mosaic of succession processes and a high biodiversity and, on a larger scale in terms of space and time, facilitate the ecosystem of river wetlands to have a variety of habitats." (Schiemer 1999)

The training and regulation of large rivers became technically feasible with the Industrial Revolution of the 19th century. Since then, each and every large river in Europe has been regulated for flood protection, land reclamation, energy production or the improvement of inland waterway transport. Today, the riverside paths are the only remains of pre-industrial waterway transport. (Lattermann 2000)

Rivers have been developed into waterways and interconnected by artificial canals to form inland waterway networks. Depending on the specific purpose of the stream, classic hydraulic engineering makes the following distinction (Schaffernak 1950):

1. **Mean water regulation**
   This serves to fix the navigation channel. In the alluviums of the filled-up valleys, a river would develop without any restraints and change its bed continuously.
2. **Low water regulation**
   It serves to achieve sufficient navigation channel depths by eliminating the moving gravel banks and determines the navigation channel in the river bed of the regulated mean water.
3. **High water regulation**
   This serves as a flood protection measure to regulate the amounts of water.

These river training works are particularly applied in free-flowing rivers where the annual discharge and bed load transport variations produce changing, sometimes difficult and unexpected conditions for navigation. Such works can also improve flood protection and land use options (drainage or irrigation of adjacent land).

The alternative to these rather soft interventions are impoundments of river sections by large dams, resulting in completely stable and controlled conditions (i.e. stopping of natural river dynamics). This fosters electricity production, local flood protection and intensive recreation activities. Such major engineering works, however, cause various important negative effects in river ecology, hydrology, morphology and chemistry.

Waterway transport is a traditional activity on the Danube, facilitating and much promoting the region's overall social, cultural and economic development. The first tow path was already built by the roman emperor Trajan in 100 A.D. at the Iron Gate. Oldest recorded works to improve the Austrian waterway transport date from the 14th and 15th centuries. The first regular shipping route was established in 1696 between Passau and Vienna, the first steam boat operated in 1818 on the Danube. In 1773 empress Maria Theresia established the "Imperial Navigation Office". Intensive waterway development works at the Iron Gate started in 1834 but the dangerous passage through the cataracts ceased with their impoundment over 270 km: In 1972, the Iron Gate I dam was completed, in 1984, Iron Gate II dam was added.

Planned regulation works started at the Austrian Danube in 1850. In the delta, the Sulina arm was made navigable for large sea ships between 1857 and 1902, shortening its formerly meandering route from 85 km to 62 km.

Danube countries have been co-operating on navigation since 1856. In 1948, the “Danube Commission” was founded in Beograd. In an annex to the Danube Convention on Navigation from 1988, further moderate expansion of the navigation route was recommended for the waterway between Regensburg and the delta.

Today, the Danube is navigable from Ulm (Germany) over 2,588 km all the way down to the Black Sea; however, the section between Ulm and Kelheim is navigable only for small ships (deadweight up to 250 tons). The international Danube waterway stretching over 2,414 km between Kelheim (Germany) and Sulina (Romania) is part of the Rhine – Main – Danube link between the North Sea and the Black Sea (Pan-European Transport Corridor VII).

Danube waterway transport is developed by 19 hydro-dams: Six in Bavaria/D, one German-Austrian dam, nine in Austria, one in Slovakia (including the Danube diversion dam and canal) and two at the Yugoslav-Romanian border. The largest are the Iron Gates I & II and the Gabcikovo dams. In addition comes the link to the Rhine waterway transport system in the form of the Rhine-Main-Danube Canal with another 5 dams within the Danube catchment area (the canal has a total of 16 dams). All Danube dams between Bad Abbach (near Regensburg) and the Iron Gate serve for both power generation and waterway transport.

Some Danube tributaries also serve commercial waterway transport in their lower and middle sections:

- the Drava river (up to Cadrice at rkm 105),
- the Tisza river (up to Dombrad at rkm 600),
- the Sava river up to Sisak at rkm 583 and
- the Prut river in a short section.

More important in terms of human intervention are three artificial waterways that were built along the Danube waterway transport route:

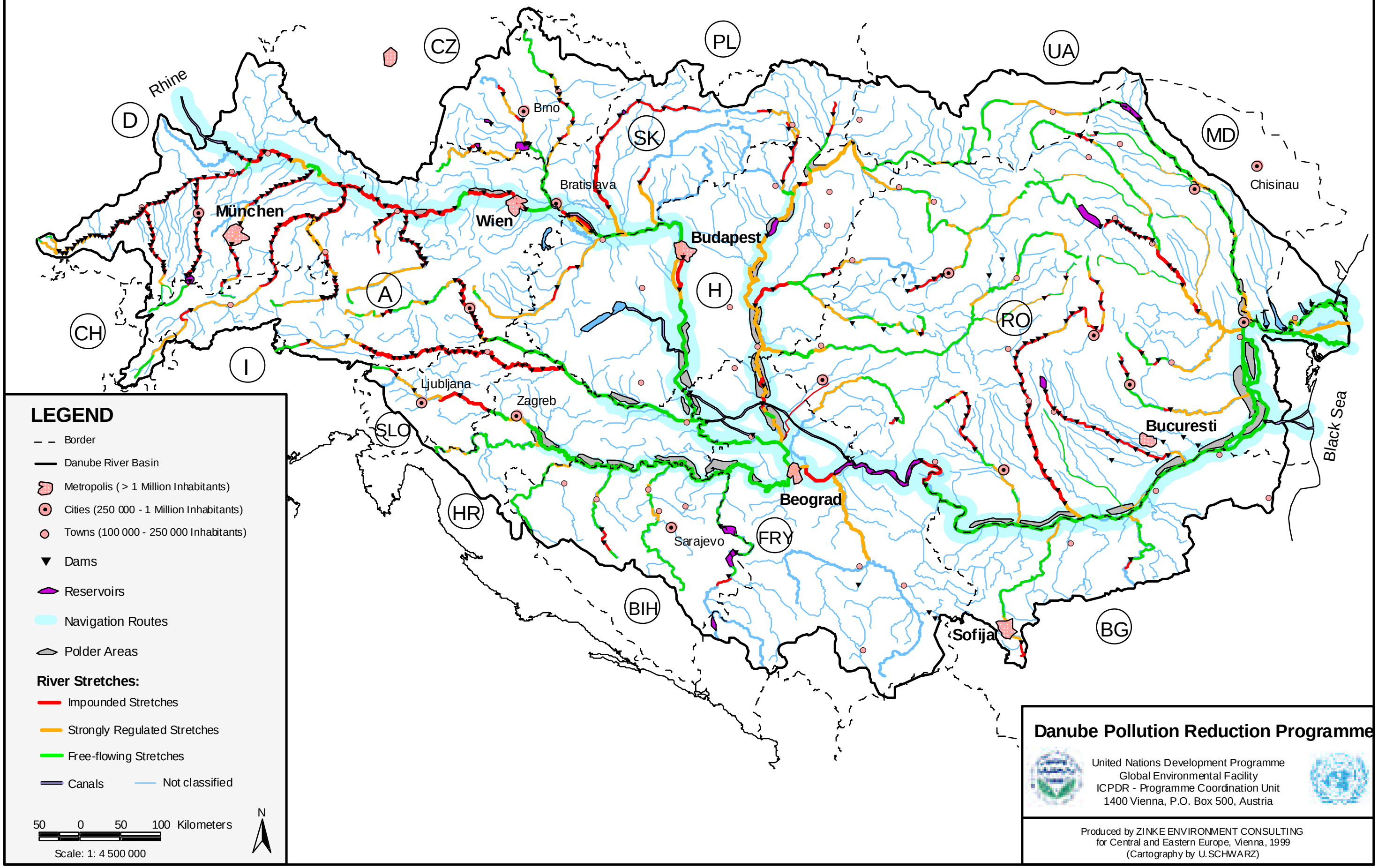
- the Danube-Tisa-Danube Canal (DTD) in the Vojvodina (northern FRY);
- the Danube-Black Sea canal (64 km long) between Cernavoda and Constanta (RO), opened in 1984;
- the Rhine-Main-Danube canal (altogether some 700 km), providing a link to the North Sea, opened in 1992.

The present situation of river regulation in the Danube basin is shown on the following map.

Map 2 (opposite page): Major Hydraulic Structures and Description of Rivers in the Danube Basin (from: UNDP/GEF 1999b).

Major Hydraulic Structures and Description of Rivers in the Danube Basin

Based on Information from National Level and Additional Research 1999



2.1.1. Regulation/Development in Free-flowing Sections

2.1.1.1. General Effects

2.1.1.1.1. Mean Water Regulation

The major construction works were undertaken at the end of the 19th century and aimed at building back (i.e. confining several channels into one), or re-building (i.e. constructing a new bed) the original river sections within the large basins.

Before their training, rivers in alluvial basins were richly structured in a system of main stream, side-arms and oxbows, whose runoff capacity constantly changed. The major regulations have led to a fundamental shifting of this balanced natural state.

The main hydrological changes due to training works include:

- the channelling of the runoff in between protected river embankments,
- the disconnection of side-arms,
- a reduction of the flood effect and
- a higher water retention in the side-arms due to the construction of impounding cross-weirs.

Technical obstacles allow a connection between the side-arm system and the main stream only during higher water levels. The effect is an accumulation of fine sediments and a progressive silting, reducing the sizes of original floodplain habitats and stopping the creation of new water bodies. The mean water regulation is an obstacle for natural fish migration between floodplain waters and the main stream.

The straightening of the water course and the volumes of water transported in the controlled bed accelerates the flow speeds in the main stream, increases the sweeping force, and intensifies increases in the flow of bed load.
In the confined bed of the main stream, the flow speed and sweeping force are increased, the natural shoreline with its bays, islands and many open gravel and gravel banks is straightened and blocked. The ecologically valuable shallow gliding banks and the steep banks are replaced by the straight-line rip-rap of the bank protections of the new controlled bed. Birds nesting on gravel (plovers, common sandpipers, little terns etc.) and birds nesting in caves (sand martins, kingfishers, bee eaters) lose their breeding grounds.

2.1.1.1.2. Low Water Regulation

Low flow rates and resulting low water tables are an obstruction, above all, for the ship traffic. Low water regulation works are, therefore, carried out above all on the navigable river sections of major streams to increase the water depth (Lattermann 2000). The water depth can be increased by installations in the river (groynes) and by narrowing the river width (lateral training walls) to concentrate water in the middle cross-section. This was undertaken in Lower Austria, for instance, from 1898 - 1927.

However, groynes increase the velocity and bed erosion which leads to a lowering of the water table in the main channel and the corresponding groundwater tables (see fig. 4). In the adjacent wetland, the hardwood floodplain spread at the expense of the softwood floodplain.

The stronger bed erosion may be countered by bed fortification and/or artificial bed load. While such regulation work affects the natural flow of bed load, scientific tests and applied works in river bed maintenance on the Upper Rhine and Danube have shown that groynes and bed fortification can both improve navigation conditions and maintain the lateral and longitudinal river continuum, i.e. the river ecosystem (see also chapters A 2.1.3.2., 3.1. 3.3.).

The Danube Commission (Budapest) defined the *Low Navigation and Regulation Level* (LNRL) on the Danube, based upon flow data from the period 1924 to 1963. LNRL is the w ater level that corresponds to the flow available for 94% of the duration of the navigable season, i.e. excluding the w inter periods w hen ice breaks river navigation (EUDET 1999).

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Fig. 4: River bed erosion (2-3 cm / a) subsequent to former low water regulation works at the Austrian Danube (gauges Fischamend and Wildungsmauer). (from: Zottel & Erber, 1999)

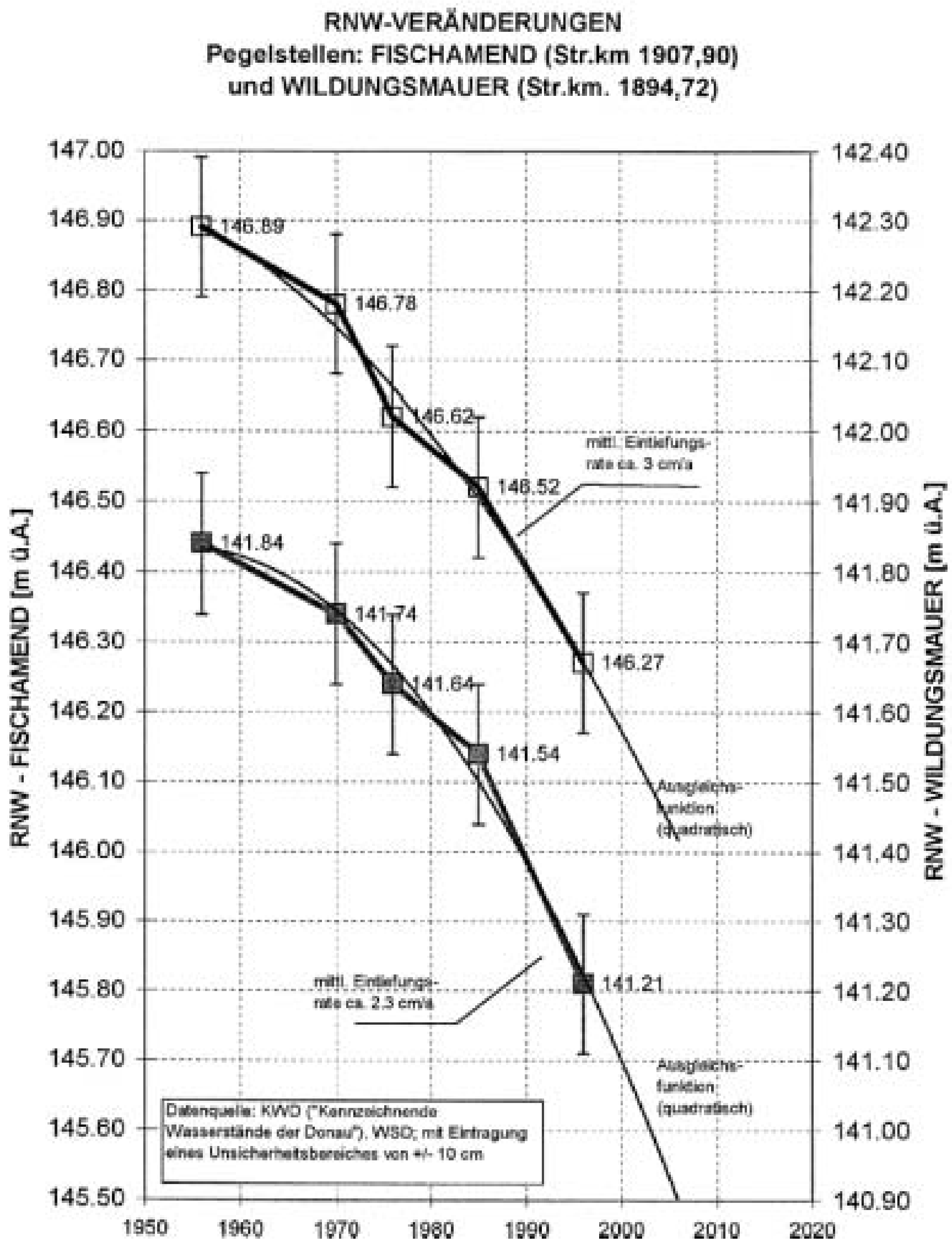


Photo 5: Example of river regulation by means of groynes and training walls at the Austrian Danube east of Vienna. (photo credit: B. Lötsch)

2.1.1.1.3. High Water Regulation

Flood protection dikes are the most extensive river engineering structures. Their negative ecological effects are inversely proportional to the distance from the river bank (from an ecological view point, the rule of thumb is: the further away, the better). Outside the dikes, succession processes alter the habitat structure of the dynamic floodplain. These habitats are lost as e.g. spawning grounds for fish (pike, carp, etc.).

The alluvial floodplains play a key role for the life of a river, which they are closely connected with. The reproduction and development of a major share of the river fauna takes place in these floodplains. They are areas of retreat and migration corridors (resting and migration posts) for many animal species. Alluvial floodplains, above all their hard- and softwood forests, are vital for natural processes of the nutrient and water cycles.

Along the upper and middle Danube, the flood protection dikes are more than 2 km away from the Danube banks at some places but on the lower Danube, these dikes are at an average distance of only 200 to 300 m from the main stream. Through this process, starting in the 16th century, the formerly extended floodplains along the Danube have been reduced drastically. This has decreased their retention capacity. The acceleration of the stream caused by the narrowing of flood runoffs increases the negative flood effects downstream.

2.1.1.2. Local Impact Examples

2.1.1.2.1. Upper Danube

Generally, the degree of regulation of the upper Danube decreases from West to East. When, in the early 20th century, the first power plants were erected on the Danube, its upper reaches were already entirely regulated for navigation up to Ulm. Today, the effects of the Danube regulation in the 19th century are overlapped by the impacts of hydropower plant impoundments and can no longer be analysed separately from them.

Growing economies have also changed the chemical and material nature of Danube water, which for decades is discharging loads of insufficiently treated industrial and communal sewage and of intensively applied agro-chemicals. While this pollution is now much reduced, the deteriorated self-purification capacities of regulated rivers did yet not recover.

2.1.1.2.2. Middle Danube

The riverine landscape of the central Danube was also changed by engineer constructions to improve navigation and flood protection. The Danube regulation works of the 19th century (since 1870 in Hungary, since 1895 in Yugoslavia) together with the nearly complete loss of sediment supply from the Upper Danube catchment in the 20th century, in particular caused by the chain of dams from the Alps down to the Gabcikovo dam system, increased the sediment deficit for the entire Danube stretch up to the Iron Gate I reservoir and beyond. The result is an ongoing channel incision for large stretches, for instance along the Hungarian Danube of about 1-3 cm p. a. (DELFT HYDRAULICS, RIZA, VITUKI 1993). The meander cut-offs carried out to improve the navigation route (e.g. for the Hungarian Danube a shortening from 472 km to 417 km: IHD 1986) have changed the water table and triggered a progressive silting of the many cut-off side-channels and oxbows.

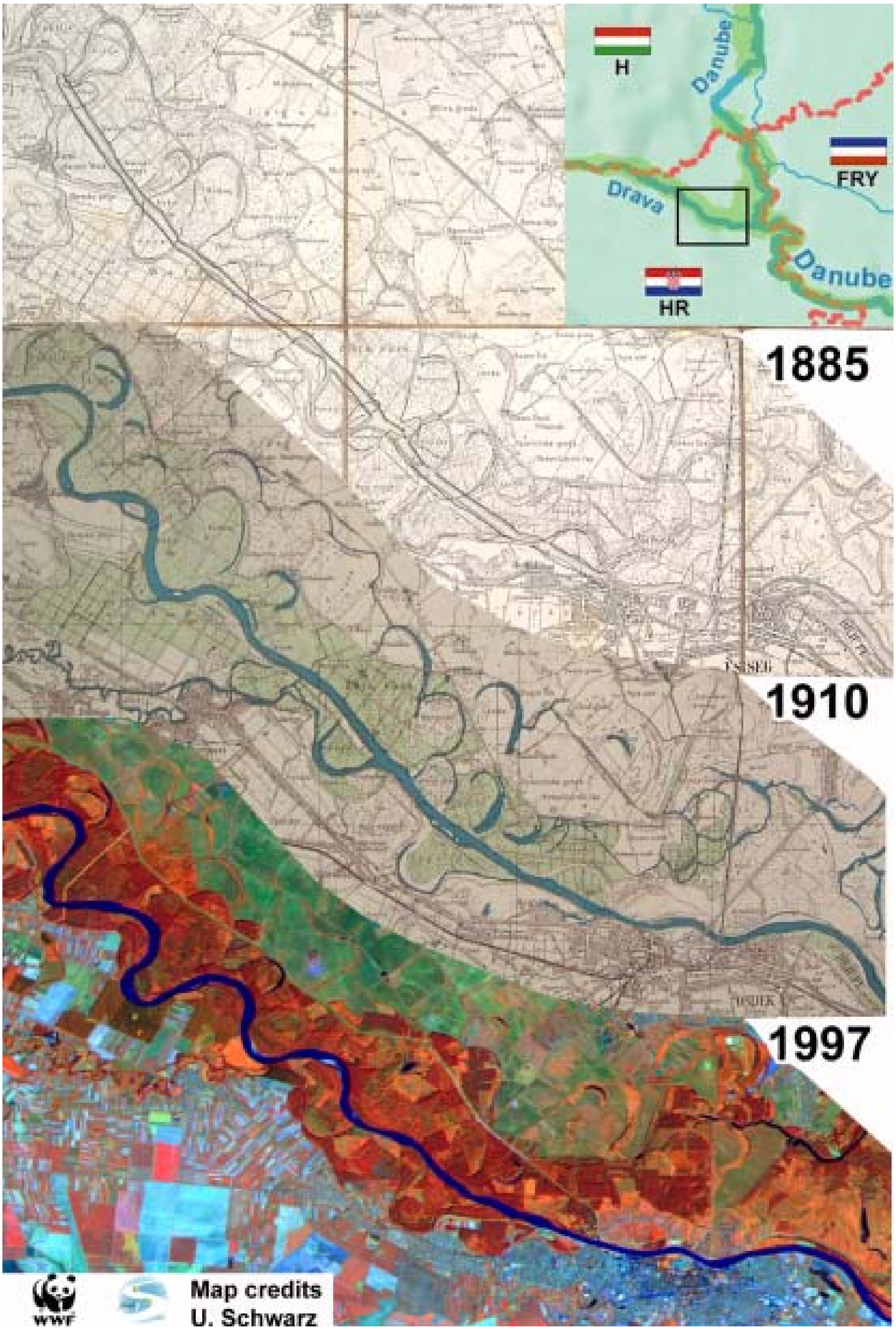
Most important floodplain areas, such as the protected areas of Gemenc-Béda Karapancsa and Kopacki Rit at the Hungaro-Yugoslav-Croatian border are already drying out. Presently, the local nature and water management authorities are starting to improve the water exchange by re-connecting the Gemenc floodplain area with the main channel.

Large floodplain complexes are already under protection (national parks, Ramsar sites, nature parks, Important Bird Areas). The most significant areas are the Danube-Drava National Park (H), the Kopacki Rit (HR), Gornje Podunavlje (FRY), the Koviljski Rit (FRY) and the Dunavski Lesni Odsek (high loess bank in FRY) on the Danube as well as on the Sava River in FR Yugoslavia Obedska Bara, Zasavica and Bosutske Sume (Puzovic & Grubac 2000).

While many side-channels are separated by rip-rap from the Danube, they are not well maintained; the same applies to groyne fields and bank protections (see Commission du Danube 1987). During the last 10 years the war and post-war impacts (e.g. mines) in former Yugoslavia inhibited the maintenance and reconstruction works in many areas. Consequently in the section between Baja (H) and Belgrade numerous ecologically valuable bank segments and islands are still preserved or have even self-restored over the last 10 years. The new joint dialogue between the water management and the nature protection organisations in Hungary, Croatia and FR Yugoslavia will decide if the future development will aim at an integrated, sound and transboundary floodplain and waterway transport management. See also chapter 3.7.

A remarkable self-restoration process from a straight regulated river built in 1900 back to a near-natural meandering river stretch can be found at the lower Drava River in Croatia: Under the Habsburg monarchy the stretch from Donji Miholjac to Osijek was fully straightened for flood protection and navigation purposes, thus reducing the river length from 80 km to 45 km. But after World War I all essential maintenance measures were stopped. Over the last 80 years the natural lateral erosion forces of the Drava reconnected most cut-off channels and created new meanders. Today the river length has increased again up to 68 km. This unique natural experiment in central Europe is threatened by plans for intensive sand and gravel excavation and for a stabilisation of the river bed, proposed for a new waterway transport link to the city of Belicse (HR) at rkm 35.

Fig. 5: The self-restoration process of the Lower Drava meanders after their regulation in the 19th century is a unique example of how even lowland rivers can restore their natural character if human intervention ceases. (map credit U. Schwarz)



The lower Drava is a special case compared with the lower courses of Tisa and Sava Rivers which have a different flow and sediment regime and are much more stabilised for waterway transport needs. These big tributaries still deliver fine to very fine sediment fractions into the Danube, different to the Drava with its much reduced bed-load transport (due to upstream dams).

The extended canal network in the Vojvodina (Northern FRY) with the DTD (Danube-Tisa-Danube) canal axis was built as a drainage and transport canal network for small ships but does not substantially affect the waterway transport and floodplains along the Danube.

In terms of water quality being deteriorated by river regulation, the central Danube lowlands are much different from the mountainous upper basin: While there exist until today many more and much larger industrial, municipal and agricultural pollution sources, the Danube mostly receives "pre-treated" discharges from its - often heavily polluted but much less regulated - tributaries and has gained itself a large diluting capacity. It is further the huge Iron Gate reservoir that acts as a major sink for parts of the nutrient and heavy metal discharges.

2.1.1.2.3. Lower Danube

Downstream of the Iron Gate II dam, the last (or first) 860 rkm run through the plains of the lower Danube. Here, flood protection dikes were built only in the 20th century at average distances of only 200 and 300 metres from the river while the actual floodplain along the left banks extends over 4-13 km (the right banks go along a cliff). The integrity of the floodplain ecosystems has suffered from this separation into small active and extended inactive zones (72,600 ha were destroyed in Bulgaria between 1930 and 1950; 426,000 ha in Romania from 1962 - 1975: this is 80% of its floodplains) (Schneider 1991; UNDP/GEF 1999a; Konold & Schütz 1996). These floodplains, partly far away from the Danube, once represented major spawning grounds and refuges for the fish populations of the lower Danube. Their loss contributed to the decline of fisheries on the Danube.

The braided Danube bed here up to Calarasi-Silistra (rkm 375) is characterised by shallow sections and many islands. Due to the immense loss of retention area, flood impacts within the flood protection dikes became more massive than ever before, with habitat losses mainly due to increased erosion of the river banks and islands. An EU study on the lower Danube (Phare-Report 2000) recommends a monitoring system for the river channel to observe the important morphological changes, like dredging, the shifting of navigation channels, changes in harbour areas, new obstacles (e.g. sandbars) and bank erosion.

However, this section suffers also from the reduced bed load transport retained in the Iron gate impoundment which leads to continuous erosion effects at the river bed, the islands and, subsequently, at the water tables. For details see chapter A 2.1.2.3.2.

The Danube between Calarasi and Braila (rkm 170) splits into two arms, thus forming four large islands ("inner floodplains of the lower Danube"). A major bottleneck for waterway transport is at the Bala arm where the water splits around the Balta Ialomitei island (rkm 345). For future development plans to improve waterway transport see the case study in chapter A 3.9.

The biggest engineering scheme of the Lower Danube is the Danube-Black Sea Canal which provides an important shortcut from Cernavoda (rkm 300) to the Black Sea harbour of Constanta. It was opened in 1984, has a length of 65 km, a depth of 7 m and two locks (EUDET 1999).

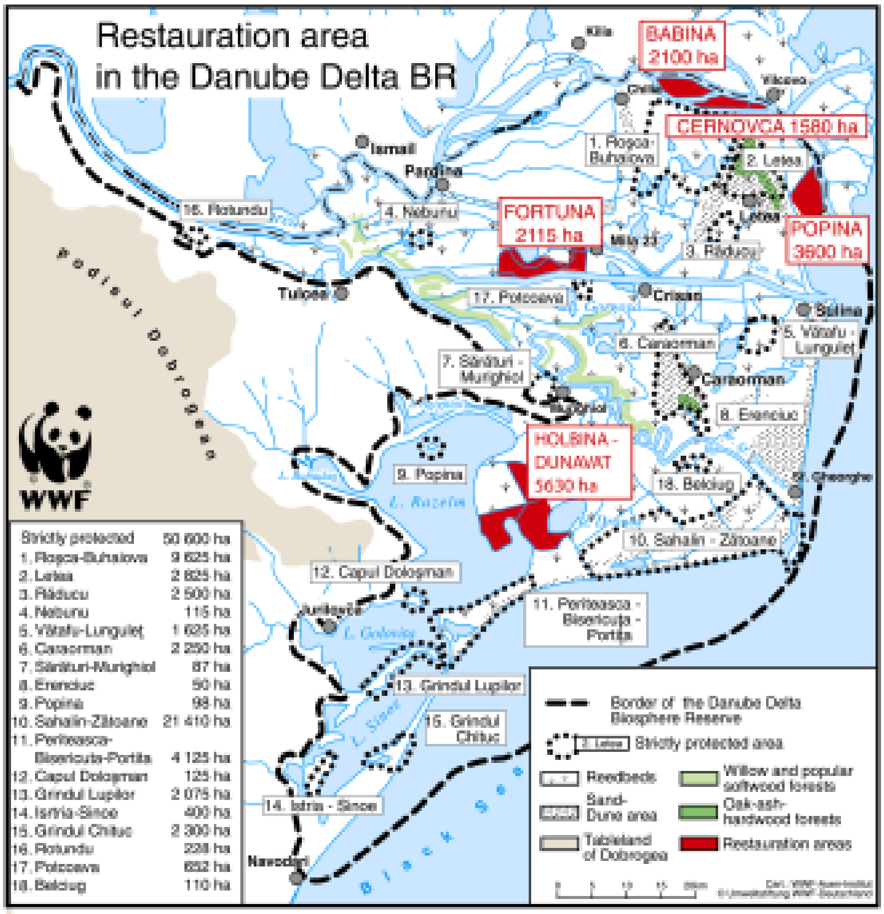
The Danube downstream from Braila is being dredged to allow maritime waterway transport (see also chapter A.3.10.).

2.1.1.2.4. Danube Delta

The Danube delta carries the Danube waters through three arms (Sfantu Gheorghe, Sulina and Chilia) into the Black Sea and acts as a big filter for sediments, nutrients and pollutants.

The major impacts on the delta ecosystems result from the changes both in upstream conditions, such as the manipulation of water discharge and pollution in the Danube basin, and from changes in the delta itself. The most significant activities in recent decades have been the artificial extension of the natural canal network (doubling their length from 1910 to 1990 up to altogether 3.400 km (Oosterberg et al. 2000)) to improve access and the circulation of water through the delta, as well as the re-construction of wetlands into huge agricultural polders and fishponds. The many canals bring more fine sediments and nutrient-laden river water into the lake complexes than before (the water discharge flowing through the delta lakes increased from approximately 160 m³/s in the 19th century to 620 m³/s in the period 1981-1990) (Bondar 1991). As a result, biodiversity (fisheries!) has been reduced and the fundamentally important natural water and sediment transport system has been altered, diminishing the delta's capacity to retain nutrients and pollutants. The new regime allows much of the nutrient-containing silt to pass directly through the main canals into the Black Sea.

Map 3: Floodplain restoration areas in the Danube delta. (map credit: WWF Institute for Floodplains Ecology)



Several projects, initiated by WWF and the Danube Delta Institute in 1990, aim at rehabilitating wetland areas to restructure the biodiversity and to increase the nutrient filtering capacity of the delta. Since 1993, the results are being closely monitored and the successful pilot projects provide valuable information to be used in other attempts to reconstruct the ecological functions of wetlands both in the delta and upstream in the Danube basin. There are presently other restoration projects under way upstream of the delta at the Lower Danube Lakes, the Lower Prut and the Braila island (see map 3).

The sea shipping route through the delta has a depth of 7.3 m. The influences and impact on the delta ecosystem by waterways for maritime waterway transport on the one hand, and by the numerous canals used by small boats on the other hand are completely different. The *Chilia branch* (120 km) at the border with Ukraine carries the largest discharge and suspended bed load but, apart from the harbour facilities and the mean water regulation works, this river branch is not heavily modified. For navigation canals across the Ukrainian delta: see A 3.11. Concerning waterway transport, water pollution and the wash of waves have a negative influence on the ecosystems. The *Tulcea-Sulina branch* (81 km long) was completely canalised (1857-1902) with all former meanders and side channels being cut off, thus reducing its length from 85 to 62 km. The 80 m wide navigation route has to be permanently dredged (even further up to Braila at rkm 170). The southern *Sfantu Gheorghe branch* (109 km) is not used by sea ships but also affected by meander cut-offs since the 1960s (loss of app. 50 km) and by the ship waves destroying the unprotected banks.

2.1.2. Impounded Sections

2.1.2.1. Introduction/Background

The development of waterway transport routes entails, especially in the upper and middle reaches of rivers characterised by small and varying discharges as well as dangerous rapids, the construction of dams and impounded river sections. According to the World Commission on Dams (WCD), there is an approximate total of 800,000 dams (as per 1987) world-wide, over 45,000 of which are classified as large dams (height of dam more than 15 metres above the natural river bed). About 1,700 large dams are currently under construction world-wide. Dams serve functions for irrigation, energy production, water supply for domestic and industrial use, flood protection, waterway transport, and recreation; often these functions are combined (World Commission on Dams 1997 & 2000).

Along the entire Danube, only the Gabcikovo and Iron Gate dams are larger than 15 metres but already the first 1,000 kms of the Danube, i.e. the entire upper Danube, have been developed into a nearly uninterrupted chain of 59 dams with hydroelectric plants. In Bavaria there are 49 dams (the last at Jochenstein is jointly operated with Austria) but only one short free-flowing section (30 km Vohburg - Weltenburg, just upstream the end of the RMD canal at Kelheim) and one large free-flowing section between Straubing and Vilshofen (about 70 km) left. In Austria, there are 9 dams and only 2 non-impounded sections: in the Wachau region (35 km) and east of Vienna (47 km) (Jungwirth et al. 1994; WSD 1998).

Downstream the hydrodam system of Gabcikovo in Slovakia, the more than 1,800 km long free flowing section of the middle and lower Danube is interrupted only by the impounded sections of the two power plants at the Iron Gate (rkm 863-1,215) (UNDP/GEF 1999b).

Impounded sections are favourable for waterway transport since they facilitate a year-round control of water velocity, depths and width. The transport capacity of canalised dam sections is determined, nearly exclusively, by the technical performance of their sluices. The disadvantage of a chain of dams is the loss of travel time during each lock passage and during the maintenance periods of the locks (e.g. in average 30 days per year during the period 1980-1989; see WWF 1992).

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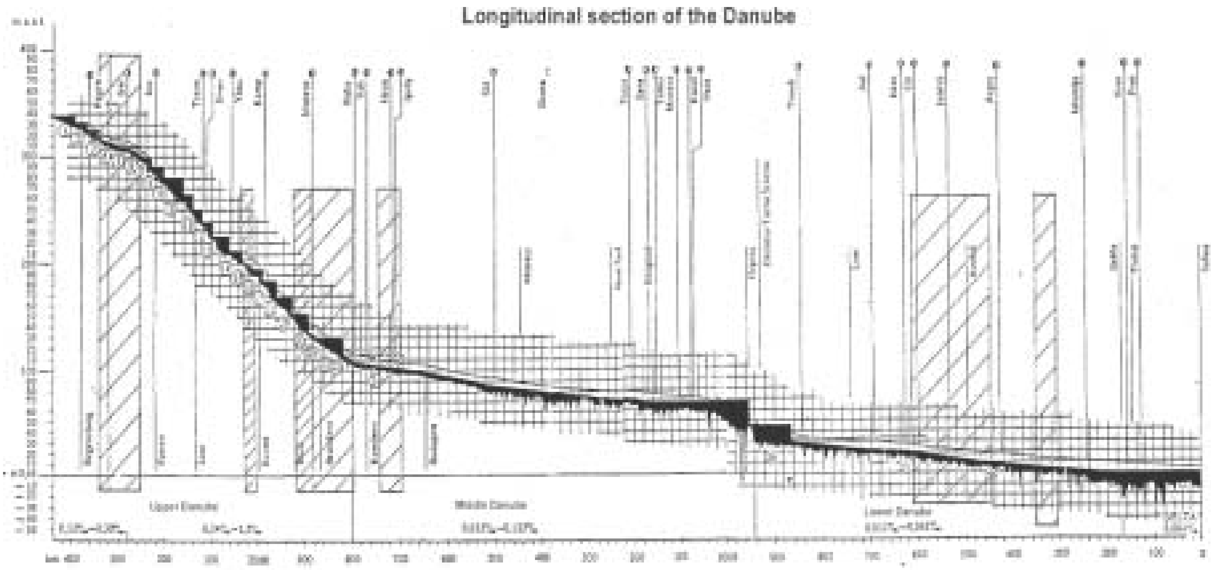
Fig. 6: Impounded river sections (black steps) along the Danube. (from: IDC 1987)



2.1.2.2. General Effects

The ecological changes and effects caused by river dams have been studied and documented in detail on all major river systems of the world, in particular in the recently completed comprehensive report "Dams and Development" of the World Commission on Dams (2000).

The change of a free-flowing water into a chain of impoundments results in fundamental changes of the morphological and hydrological conditions, such as larger water depth and surface, reduced velocity, turbulence and bed load transport, larger lentic areas, increased sedimentation and deposition of fine sediments on the river bed and reduced turbidity. These changes affect the physical, chemical and biochemical processes as well as the saprobiological conditions and the living communities. This was shown by Tittizer (1997) for the Bavarian Danube impoundments which affected 53.6% of the makrozoobenthos species: 20.3% of pelo-, psammo- and limnophilous species benefited from the intervention, while 33.3% of species (litho- and rheophilous river specialists) were heavily affected. The other 46.4% are non-affected, ubiquitous species.

Each river dam leads to a disruption of the natural flow continuum, i.e. the natural hydrological and morphological system. Dams, with their levee system, also interrupt the longitudinal and lateral continuity of the riverine ecosystem. The secondary biotopes developing after dam construction constitute merely residual biotopes of the original river landscape. Each dam and cross-weir causes a lasting change in the natural transport process of solid matter. The major consequences include: in the upstream, impounded section, an enhanced sedimentation and an absence of water level fluctuations (disconnection of the floodplain); in the downstream free-flowing section, a deepening of the river bed with a corresponding lowering of the surface and groundwater levels, resulting in an increased drainage and drying-out of the aquatic habitats of the adjacent floodplain. (Dister 1991, Cousteau et al. 1993)

Where-ever a river is dammed up, its runoff cross-section increases. Its water table gradient is reduced, and in the dammed-up section a successive reduction of the flow speeds and of the sweeping force occurs. The flow of bed load comes to a standstill, and a sedimentation of the suspended particles transported by the river follows, resulting in a sorting of the material into sand, coarse clay and finally fine sludge in correspondence with the decreasing flow speeds. Since 1984, these hydrological changes have been the subject of regular studies at the impounded sections of the Austrian power plants on the Danube (Nachtnebel et al. 1989 to 2001). A lot of research has been conducted also in the sedimentation processes in the dam area of the power plant Iron Gate I. (Varga et al. 1995/96)

On the basis of samples from river beds taken over many years in all the dammed areas on the Austrian Danube it could be shown that the extent and thickness of sludge accumulations correlates, to a great extent, with the head of the respective dam (Prazan 1990). In case of floods or the flushing of the storage lake, large amounts of these fine sediments are shifted and spilled downstream. The sludge accumulations in the impounded sections of the Danube contain considerable amounts of organic substance (up to 2% carbon in the dry mass) and, in contrast to the gravel beds of natural rivers, are inhabited mainly by masses of worms living in tubes (Herzig 1989)

Over time, this sedimentation process hampers waterway transport and makes regular excavation or flushing necessary which itself pose new environmental problems (excavated material needs to be deposited somewhere; flushed fine sediments bring a sudden, thick cover on wetlands and farmlands).
The deep areas near the dam correspond to still water habitats. However, in most cases, they are too cold for the reproduction of still-water-loving fish species on the upper Danube, and the survival of these species is very limited despite the best food supply. (Schiemer et al. 1994)

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Photo 6: Impounded river with artificial dike and drainage canal (left). (photo credit: B. Lötsch)

The construction of dams usually goes hand in hand with a pronounced linearisation and monotonisation of the river bank structures. The rip-rap becomes the almost exclusive type of habitat in the river bank zone, while the former shallow water zone with rubble banks are largely lost and islands disappear in the impounded area. Tributary streams and their natural habitats (in particular formerly richly structured river mouths) are also lastingly changed by the backwater of dams. Side-branches and the surrounding riverine landscape are separated from the main stream.
This leads to an overall loss of biotope diversity, to an impoverishment of the bodies of water typical for the wetlands, and to a monotonisation of the habitat. The survival of species typical for the floodplain is threatened because active and passive species migration between the river and the floodplain is practically stopped.

To prevent loss of water, dam basins in alluvia (sand, gravel, rubble) have to be isolated from the aquifer. This results in an almost complete separation of the stream from any accompanying groundwater streams and in a strongly rePceding infiltration. In this way, the typical, mutual exchange of surface and groundwater is suppressed. In the isolated sections this can lead to problems with the supply of drinking water for settlements which depend on river bank filtrate. The overall surface water capacity for self-purification processes is reduced. The pollution burden from surface waters and the mineral content of the groundwater increase (e.g. nitrates and phosphates from agriculture). Low-oxygen conditions lower the transfer of organic compounds within the biological soil production. A good example exists in the upper Danube: According to recent monitoring results of the Bavarian Agency for Water Management, the water quality of the Danube worsened after the impounding of the Straubing and Geisling dams from class II (moderately polluted) in 1995 to class II/III (critically polluted) in 1999. See also chapter 3.1. and 3.5.

As far as the ecological consequences are concerned, impounded sections in gorge sections must be rated in a different way than impounded sections in braided lowland sections. Impoundments along narrow valleys affect, above all, the river banks and the habitats of the stream itself. Rheophil organisms (in particular river fish) find sufficient habitats only at the upper end of the impoundment. For their survival, new river bank structures have to be created (Zauner 2001). In rocky narrow valleys, low amounts of sediment accumulate. Isolation measures are needed only near the weirs.

In the far softer material of the lowlands, watercourses are particularly unstable. Impounded sections are developed into technologically safe and stable canals which are well isolated against the sediment body that consist of water-permeable clay, sand, and gravel. The higher the gradient of a river, the coarser the grain size of the bed load accumulating in the basins of the alluvial flood plains. The coarsely grained sediment body of the steep braided sections of the upper Danube allow a very dynamic exchange of water between the floodplain and the river, which is cut off by the isolated impoundments.

The natural interactions between the biotic and abiotic factors on a stream are lastingly impaired by the isolation of the impoundment. Habitats typical for the floodplain, whose biocenoses depend on the constant change between dry and wet periods, disappear. Species typical for the wetlands become rare or extinct.

2.1.2.3. Specific Condition and Impacts Along the Danube

2.1.2.3.1. Upper Danube

Apart from a deterioration of the water quality (see previous page), the most recent impoundments of the Bavarian Danube led to a proliferation of chironomides which disturb local people. Legal prescriptions for the dam builders to provide compensating measures proved to have very limited success e.g. for biodiversity of floodplain species

For a long time, the influence of tributary rivers flow ing into the main river under investigation has been underestimated (Sedell et al. 1989). In the catchment area of the upper Danube, hydroelectric plants and dams have been built on nearly all useable streams. The consequences are an increased retention of sediments and a lasting reduced transport of suspended solids in the tributary rivers of the Danube w ith the consequence of bed incision in small areas, the loss of continuity for migratory movements of river fish, the loss of habitats (spaw ning grounds), and irreversible changes in brooks and minor streams (Siebeck 1999).

The nearly continuous chain of dams on the upper Danube itself (Bavaria, Austria) w ith 59 dams resulted in a complete change of the original state of the river and of the natural river-morphological conditions (see map "First 1,000 km of the Danube" below). The biocenoses of the running w ater have undergone a lasting change, the spectrum of species has changed. Rheophil fish species have become rare or completely extinct (Jungw irth 1994).

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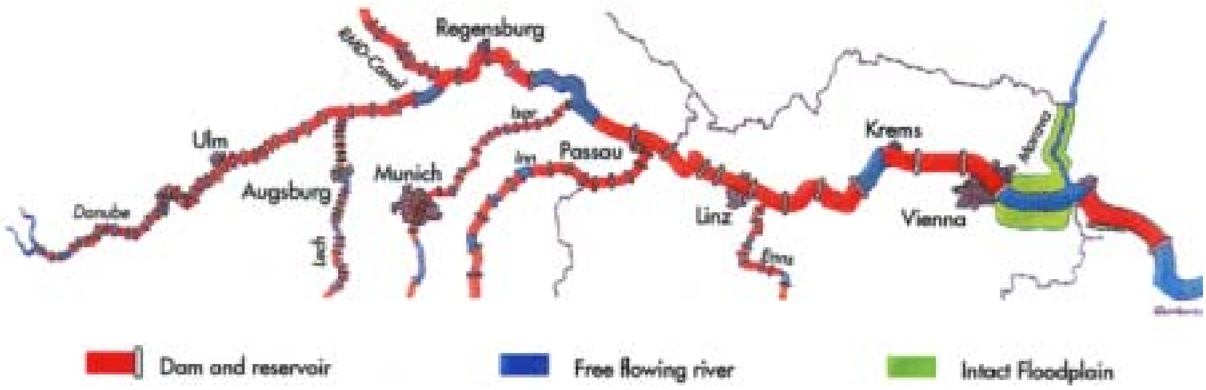
Map 4: The chain of hydro dams along the first 1,000 km of the Danube river. (map credit: WWF-Austria)



Considerable w ater table gradients and pronounced fluctuations in the w ater level, once characteristic for the original Danube, have been preserved only at the upstream end of impoundments w here also the nature of the stream bottom (irregular relief, coarse substrate, shallow gravel deposits along the river banks) still corresponds most to the conditions of the free-flow ing segment (Zauner 1991). In this area, river rubble is still lastingly deposited.

The mouths of small tributaries (e. g. Große Mühl, Kleine Mühl) at the impoundment of the Aschach dam are also impounded and silt up, so that their original function as spaw ning grounds for rheophil fish in the Danube has been lost. More-over, depositions of sludge are found in many river mouth areas (e.g. at theYbbs and Erlauf brooks at the Melk dam, the Tulln brook at the Greifenstein dam). Some tributary streams have been re-routed into new ly created parallel channels and led into the tailw ater of the pow er plants (Kamp, Traisen brooks) (Schiemer 1994).
When building river pow er plants in alluvial basins, oxbow s have been locked or filled in (e.g. dams of Melk; Greifenstein and Altenw örth). When building the pow er plants of Altenw örth and Greifenstein, the biggest self-contained floodplain forest complex of the Austrian Danube w as separated from the natural river regime. The floodplains next to Altenw örth are not

flooded any longer: Next to the dam reservoir of Greifenstein, the floodplains are artificially irrigated by a 42 km long artificial watercourse ("Gießgang"). Intensive monitoring (e.g. Nachtnebel 2000) has shown that the loss of the natural variety of hydrology and species could not be prevented. In particular, the crucial exchange of water between the stream and the floodplain is stopped by isolating the impoundments; this is particularly severe for the impounded sections of Melk, Abwinden-Asten, Altenwörth, Greifenstein and Freudenau.

The Gabcikovo hydrodam system represents a special case on the upper Danube because the Danube is being diverted into a reservoir-like, isolated side-canal leading to the power plant located outside of the river bed and active floodplain. This is also where all waterway transport is re-directed to. Fine sediments from the suspended particles of the Danube are deposited in the reservoir. The temperature of the Danube water is changed. Large areas of the extended floodplain forests have been cleared for the huge engineer scheme. The remaining forests and side-arm system of each 4,000 ha on the Slovak and the Hungarian side have been separated from the main Danube regime. The river is there now completely separated (only receiving 10-20% of overall Danube discharge) while the two side-arm systems are being supplied with an amount of residual water from the canal (Slovak side) respectively from the "old" Danube (Hungarian side), both being insufficient for maintaining their original ecological functions and their natural species stocks. The wetland is therefore subject to a progressive drying-out and succession process that are effective in the long term (WWF 1994, WWF 1997, Cousteau et al 1993). The return of the tailrace canal into the Danube causes major river bed erosion problems which are also affecting the navigability of this section (see also chapter A. 3.5.).

2.1.2.3.2. Middle and Lower Danube

The middle Danube reach stretches from the mouth of the Rába/Mosoni Danube arm into the Danube (i.e. a few km downstream from Gabcikovo) up to the Iron Gate. The only impounded section is at the Iron Gate.

The Iron Gate gorge was the first Danube section where during Roman times (100 A.D.) a tow path was built. Intensive navigability works started in 1834 but the dangerous shipping passage through the cataracts remained until the power plants on the Iron Gate (no. I completed in 1972, no. II in 1984) on the border between Yugoslavia and Romania were opened: At that time, this ecologically valuable cataract section having a difference of 28 metres over approximately 100 kms, was impounded for energy production and made easily navigable (Konold & Schütz 1996). The spectrum of ecological effects of the Iron Gate dams ranges from the complete loss of natural habitats in the cataract section to the decrease of the variety of species of the upstream river sections [dying out of the large migratory fish: Danube sturgeon (*Acipenser gueldenstaedtii*), Beluga (*Huso huso)*, fringebarbel sturgeon (*Acipenser nudiventris*)] to the long-term drying out of the downstream wetlands as well as to the degradation of the Danube delta, due to sediment retention of the dams.

Pronounced sediment accumulations occur behind the dams. Between 1972 and 1994, about 325 mio. tons of sediment were deposited (Varga et al. 1995/96), taking up 10 % already of the entire volume of the reservoir, and resulting in much reduced transport of suspended solids and soil sediments downstream of the Iron Gate. In the backwater area of the Iron Gate, stretching over 270 km up to the mouth of the Tisa river, the effects of the increased inner and outer colmation (clogging) have led to problems with the supply of drinking water in the communities located along the impounded area (Varga 1986). This problem includes the impounding of the mouth of the Sava, having a detrimental effect on the drinking water wells of the city of Belgrade which are supplied with riverbed filtrate.

The reduced transport of solids by the Danube leads to intensive erosion effects on the still unregulated river banks of the lower Danube and on the islands in the stream. Whereas new islands were formed before the construction of the power plant (up to 1966), a number of

islands were completely eroded since that time (e.g. Tcibtriza-Island, km 713 – 714). Other islands must be protected against the progressing erosion. On the Bulgarian island of Belene, erosion is between 0.6 and 7 metres p.a., thus reducing the size of that island from 3,940 ha in 1966 to 3,858 ha in 1980 (Phare-Report 1997). In the long-term perspective, the much reduced transport of solid particles represents even a major threat for the Danube delta and its unique habitats.
Progressive bed erosion leads to a lowering of the water levels of the river. This has severe effects on the extended groundwater system of the lower Danube and on the shallow waters and wetlands adjacent to the river. The survival of their ecosystems and habitats is endangered in the long term (Phare-Report 2000).

Also waterway transport is hampered by the shifting of the bed caused by erosion. Regular translocations of the navigation channel occur and fords are formed. To keep the navigation channel free it is increasingly necessary to carry out dredging, which, however, in turn further accelerates the erosion process. For new regulation projects see chapter A 3.9.

2.1.3. Ongoing Maintenance Measures

2.1.3.1. Dredging

Dredging is one of the main maintenance activities for providing a safe river transport route. Since the beginning of the Main Regulation of the Danube nearly 150 years ago, extensive underwater dredging has been conducted to build, conserve and improve the waterway. Along the regulated sections of the upper and central Danube there are stretches with scour holes and fords. The irregular depths and widths of the navigable channel, which regularly occur in fords, require regular maintenance dredging. Along the unregulated stretches of the central and lower Danube, frequent translocations of the navigation channel occur, which are also cleared by means of regular dredging.

In the delta of the Danube, the overall length of artificial water courses created by dredging amounts to 1,753 km while the total length of the natural water network is 1,743 km (Gastescu et al. 1983). Among the new channels created for transport purposes, the Caraorman Channel and the Mila 23 Channel must be mentioned in particular. They have changed the natural runoff of the water in the delta and cause, apart from other negative effects, an increase of sedimentation.

Due to the size of the river, the required underwater dredging necessitates large special equipment. The use of efficient floating dredgers, transport ships and elevating equipment has led to the commercial exploitation of the mineral bed substrate of the Danube. Especially after World War II, the Danube has become a cheap source of raw material for the construction industry.

The construction of dams as well as regulation measures have led to lasting changes of the natural sedimentation conditions of the Danube. Places formerly characterised by an excess of bed load now show a bed load deficit. Nevertheless the old form of bed load management is continued along the entire Danube, and material is removed for building purposes, in addition to the dredging, as a conservation measure for waterway transport. The removal of material by dredging has been discontinued on the flow sections of the upper Danube, but this dredging for commercial reasons is still carried out in the dammed-up river sections (oral information of Austrian Waterways Authority WSD from May 2001). Commercial dredging leads to an aggravation of the deepening of the riverbed in particular along the central and lower Danube in the area of Bratislava, downstream of Budapest, and on the lower Danube in Bulgaria and Romania (Phare-Report 2000). Studies on the Austrian Danube have shown that downstream of Vienna, in the area of Hainburg, 60 % of the deepening of the riverbed is caused by conservation dredging activities for waterway transport (Bernhart 1990).

During the construction of the Gabcikovo dam system, dam promoters argued that the serious river bed erosion and the related deterioration of water levels (drinking water supply of Bratislava!) and floodplain forests between Bratislava and Gabcikovo was caused by bed load retention in upstream river dams and by dredging of the waterway transport route, and that this could only be stopped by impounding the river. In reality the overriding cause was found to be excessive dredging (50 mio. m³ between 1976 and 1989) for urban and industrial development as well as for the construction of the Gabcikovo scheme (WWF 1994).
River bed deepening is the major development problem for preserving the free-flowing sections of the Danube and their aquatic habitats. Their ecological function can be safeguarded in the long term only by means of a sustainable stabilisation of the riverbed.

Since 1987, along the Austrian Danube, gravel bed load removed during maintenance dredging has again been deposited in the river. The practice of depositing dredged material in the groyne fields outside the bed of the controlled low water bed, however, is no contribution for bed stabilisation.
In impounded river sections, dredging of sedimented silt is needed to maintain the navigation route. The dredged sludge is loaded with toxic compounds and has to be deposited at special deposits.

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Photo 7: Dredging of the Danube navigation channel is needed in both free-flowing and impounded river sections. (photo credit: M. Breiling)

2.1.3.2. Artificial Supply of Bed Load

On the upper Rhine in Germany, the problem of river bed erosion below the last hydrodam at Iffezheim is being countered by artificial supply of bed load, which is constantly balancing the deficit caused by the upstream bed load retention. This method of gravel feeding, developed by Dr. Felkel (Bundesanstalt für Wasserbau, Karlsruhe), is practised on the Upper Rhine ever since 1978 and successfully simulates the natural bed load transport. It prevents further

incision of the river bed and safeguards the navigability of the river. The material initially used for this process came from nearby gravel pits of the Rhine floodplain. Its grain-size distribution equals that of the natural Rhine bed load. Today, however, this is partly substituted by material mined in quarries. The gravel is transported on hopper barges to the sites where new bed erosion has been monitored. The growing use of gravel mined at quarries minimises the ecological impact of gravel pit mining in the alluvial floodplains of the Rhine river.
Since 1996, artificial grain feeding is also used to stabilise the Elbe river bed (oral information by Dr. Schmidt, Bundesanstalt für Wasserbau, Karlsruhe).

By an order of the Austrian federal government issued in 1996, artificial supply of bed load has to be applied to preserve the bed levels of the Danube east of Vienna, as it is practised on the Upper Rhine. The operator of the Danube power plant in Vienna-Freudenau has to maintain the first 11 kms of the river bed level downstream of the plant. The river bed has to be fed with a minimum of 160,000 m³ of gravel per year. Any progress of river bed incision is to be countered by additional grain feeding.

Water engineers have developed new methods of grain feeding aiming at a dynamic bed stabilisation for big rivers. Grain-size distribution affects the rate of bed load transport and the extent of self-pavement of river beds at medium and low flow rates. Grain feeding a river with material - big enough for the self-pavement at medium and low flow rates, and small enough for easy transport and even distribution at high flow rates - should therefore successfully counter progressive bed erosion. This theory is examined in a project following this line of thought aiming to test and operate dynamic bed stabilisation on the Danube east of Vienna (see also chapter A 3.3.).

2.2. Regular Ship Traffic

Regular ship traffic have effects of physical and mechanical as well as of chemical and material nature. In addition there is a potential risk due to accidents where possibly large amounts of harmful polluting substances may come into the water and subsequently into the food chain and drinking water.

2.2.1. Effects From Regular Ship Traffic

2.2.1.1. Physical and Mechanical Effects

2.2.1.1.1. Re-suspension of Sediments / Turbidity

The re-suspension of sediments generated by ship propeller rotations and ship waves has already been the subject of a variety of studies. Intensive traffic can lead to increased turbidity in shallow waters (whirling-up of fine sediments). On the Mississippi, for example, increases in concentrations of suspended particles of between 2.5 and 21.7% have been measured (Smart et al. 1985). Also in the Danube delta, an increase in the content of suspended particles in the water due to waterway transport has been noted (Constantin 1992). In northern Germany, the content of suspended load in artificial shipping canals was compared to the content in navigable rivers. In canals it is clearly higher (47 - 62 mg/l) than in rivers (23 - 49 mg/l). The reference value specified by the European Union for the use of surface waters by fisheries (of 25 mg/l) was exceeded in all canals and in most of the navigable rivers.

The re-suspension of sediments impairs different aquatic organisms in different ways. Fine sediments damage the respiratory organs of the larvae of water insects. The increased turbidity reduces the light intensity, which, in turn, decreases the photosynthesis of plankton and benthic algae and of vascular plant species. This effect has been scientifically proven in Scottish canals (Murphy & Eaton 1983). This lowered production rate at the lower levels of the food chain is reflected also in higher ones. In navigable British canals it has been found that increased turbidity leads to a change of fish communities (Murphy et al. 1995).

The jet of propellers may also result in a relocation of sand and gravel which leads to a fundamental change of the living conditions for benthic organisms (see e.g. Ziegler 1993). The deposition of fine sediments on gravel banks brings about severe changes in the living conditions of specific aquatic organisms. In particular, spawning and living grounds of litophilous species (e.g. fish, insects) are lost, which became very rare in Central Europe due to the abundant loss and destruction of such dynamic habitats during the wide-spread river damming and regulation (Obrdlik 1995).

2.2.1.1.2. Damage by Ship Waves and Ship Propellers

The waves produced by waterway traffic, on the one hand, have direct mechanical effects on organisms living along river banks and, on the other hand, change the hydraulic conditions in the river bank area. The size of wake and surge depends on the size of the ship, its load, speed and direction of traffic, with fully loaded ships going downstream causing higher waves than empty ships going upstream (Obrdlik 1995).

The waves can uproot many plant species, such as the macrophytes with soft leaves growing in the littoral zone. In the Elbe river, damage to non-rooting species such as hornwort (*Ceratophyllum demersum*) and frogbit (*Hydrocharis candida*) were found (Rydlo 1987). In British canals (Murphy & Eaton 1983) and in the Danube delta these observations were confirmed.

Young fish are directly affected by the waves since their swimming capacity is partly low (Zauner & Schiemer 1994). Also the fry can be damaged by the ship waves by which they are thrown on the dry banks (Fric 1872). Here they may fall prey to beetles and ants. Further the density of zoobenthos is reduced by ship waves. High traffic intensity leads to lowered zoobenthos diversity (Obrdlik 1995).

Photo 8: Propeller whirls and waves produced by ship traffic can alter both the morphological character of the river bed and banks as well as the living conditions in the free water and the littoral zone. (photo credit: B. Lötsch)

Though direct damage of aquatic organisms by the rotation of propellers is comparatively rare, it can happen e.g. for submerse macrophytes and smaller fishes. This is particularly the case for smaller ships (e.g. recreational boats) moving in shallow waters (Obrdlik 1995).

As a consequence of the erosion damages from waterway traffic along natural banks, waterway authorities re-built the banks of most rivers with rip-rap, fixed stones, asphalt or concrete. These are alien habitats which do not offer the essential living conditions (food, shelter, shadow, surface to stick) for many typical riverine species.

2.2.1.1.3. Transport of Water Organisms

Water plants and animals are able to survive in the ballast water of ships over long periods of time, or stick on keels and anchor chains, thus bridging long distances. In this process, species may be introduced in areas where they could not be encountered before (e.g. other river basin), and where they sometimes spread explosively (Obrdlik 1995). In the ballast water of ships, several European species have already been brought to the Great Lakes in North America. Due to shipping, some alien species have been introduced also into the Danube delta. Similar effects are presently being examined for the Rhine and Danube river ecosystems which became artificially inter-connected in 1992 after the opening of the Rhine-Main-Danube canal. Especially for macrozoobenthos, such artificial exchange of organisms was already reported by German scientists.

2.2.1.2 Chemical and Material Effects

2.2.1.2.1. Mineral Oil

Mineral oil is brought into navigable waters, among other forms, as so-called bilge oil. In the bilge, viz. the ship's keel area, a mixture of water, lubricants, engine oil, etc. accumulates. The controlled disposal of the bilge oil in the Danube is an issue still to be solved in many countries which do not have the respective legal prescriptions and enforcement as exists e.g. on the Rhine (see chapter A 2.2.1.2.4.).

On a Czech freighter, the annual loss are estimated at 0.75 l of diesel, 3.6 l of hydraulic oils and 5 kg of lubricants, most of them being non-biodegradable (Obrdlik 1995). Also the direct introduction of wash waters from tank cleaning works into the rivers can repeatedly be found despite existing regulations. Due to the dilution of these partly highly toxic substances in the waters it is possible to identify the polluter in only a few cases (Vogt & Lowis 1996).

In cases where oil comes into bodies of water, it first spreads on the surface as a thin, shiny film which influences gas exchange and thus also oxygen supply. Its volatile parts (petrol, light oil) evaporate into the atmosphere. Within several days or weeks, emulsions, sludge and lumps may form which sink down from the surface. The biological decomposition of these substances takes many years (Obrdlik 1995).

Oil is a mixture of a variety of hydrocarbons, which may have different effects on aquatic organisms. The acute toxicity of oil products for aquatic organisms lies between 0.5 and 200 mg/l (Svoboda et al. 1993). Due to their permeable skins, amphibians react particularly sensitively. Birds may be impaired because oil sticks on their plumage. In the blood circulation of birds, fish, and other organisms, hydrocarbons cause severe damage. Oil has a toxic effect on fish already at relatively low concentrations. Also the photosynthesis of plants works only to a reduced extent already at low concentrations of oil. Polycyclic aromatic hydrocarbons moreover have a carcinogenic potential (Mason 1996).

On the Rhine it could be observed how oil sludges deposit in groyne fields and mainly inflict damage on substrate-dependent organisms there (Vogt & Lowis 1996). For cost reasons, however, the shorelines are usually not cleaned by mechanical means. In contrast to that, the chemical cleaning with tenside mixes must be classified as considerably dangerous due to the additional introduction of chemicals there into the biocenosis. Studies in Great Britain (Mason 1996) have shown that such oil-tenside-mixes were sometimes more toxic than pure oil or pure tensides.

2.2.1.2.2. Tensides

Tensides are applied for cleaning ships and in this way frequently end up untreated in the waters. Many of the tensides used today are not easily degradable and are partly toxic to aquatic organisms. Tensides reduce the surface tension of the water. In particular organisms living on the interface between water and air are damaged (Gunkel 1994).

2.2.1.2.3. Ship Paints

Aquatic biocenoses may be impacted by anti-corrosive ship paints, especially those with metal-organic compounds. These heavy metals settle in river sediments but can be re-suspended by waterway traffic, as shown on the Elbe river between Magdeburg and Dresden. They are taken up in the food chain where they exert chronic effects on water organisms (Obrdlik 1995).

Another undesired effect is that, over time, aquatic organisms inhabit every firm surface in flowing waters. This is started by bacteria and single-celled organisms, and followed by higher organisms (shellfish, algae, etc.). Unless counter-measures are taken, ship hulls are also affected by this growth. Such a growth (= fouling) increases the ship's drag and thus also its energy consumption during waterway transport. To slow down this process, different kinds of anti-fouling paints are applied.

Biocide-free underwater paints that have no growth-inhibiting effect but produce easily cleanable surfaces may, to a large extent, be classified as unproblematic from an ecological viewpoint. Other paints, however, must be regarded as very problematic. They contain biocides which, over time, are dissolved out of the paint matrix and released into the surrounding water. These biocides, intended to damage the growth organisms on the hull, may accumulate in sediments and in the food chain. However, the behaviour of these substances in aquatic milieu is still little known. Biocides used today include, above all, copper compounds and organic biocides (triazines, methyl urea, dithiocarbamate, etc.) and, for more than 30 years but today more rarely, tributyl tin (TBT).

TBT is widely used as anti-fouling paint for ship hulls navigating in the marine environment. However, as such sea ships also move upstream into river estuaries and to shipyards and ports in the lower reaches (on the Danube this is possible up to Braila at rkm 170), TBT as one of the most toxic compounds ever introduced into natural waters by mankind may also have an impact on the Danube. Once introduced, TBT accumulates to suspended matter and sediments as well as in the tissue of various organisms (e.g. in fish liver) where it was found to act as an endocrine disrupter (altering the nervous system and reproduction of organisms, including infertility) and is therefore rated as highly toxic; its input into aquatic ecosystems should be minimised or stopped as soon as possible (Arbeitsgemeinschaft für die Reinhaltung der Elbe 1999). TBT was already found in sea birds, sea mammals and canned fish where it may thus also harm the human hormone system. After a big oyster death in the early 1980s, France partially banned TBT paints. Based on new research data, the International Maritime Organisation (IMO) eventually adopted in October 2001 a convention banning world-wide the application of organotin anti-fouling paints upon ship hulls by 2003 and its presence by 2008. WWF, seeking a strong commitment from industry and government before 2003, founded in 2001 a TBT Free Buyers Group whose members will have their entire fleet voluntarily free of TBT by 1 January 2003. These ships will be alternatively protected by organotin-free coatings, like copper self-polishing, silicone and microfibre coatings, which are being tested since 1997 (WWF 2001). Already 15% of German ship owners use such alternative paints.

It should be noted that, within the EU, the legal situation regarding the permissibility of the various underwater paints differs widely among the Member States.

2.2.1.2.4. Waste from Navigating Ships

A EU-Phare study (no. OSS 99-5052.00 "Ship Waste on the Danube"), produced in 2000 within the "*Environmental Programme for the Danube River Basin*", assessed the present status and future needs for the collection and proper treatment of ship-borne oily waters and wastes from ships navigating on the Danube River, including a comparison with the advanced waste management system on the River Rhine. Various traditions and set-ups for management of ship-generated waste in the two river systems cause environmental problems.

The ship waste considered in detail in this study is divided into three waste types:

- oily and greasy liquid waste including oily bilge water,
- hazardous waste and
- solid waste (garbage, household waste).

It was found that, until today, no quantitative data exist on the volumes of such waste along the Danube.

Ship waste collection/treatment system on the Rhine

The Rhine ship waste system is part of the existing organisational and institutional set-up, and built on - well-established/well-functioning - individual and independent national systems, co-ordinated through internationally agreed principles of the Rhine Commission:

➔ No permit for on-board waste treatment but only for waste collection and appropriate storage for later delivery to a reception facility.
➔ A mobile set-up for collection/treatment with a system of special waste collection boats, also able to partly do wastewater treatment.
➔ A sanitary service network.
➔ No direct payment for delivery of oily bilge water and grease waste - waste delivery is free of charge.
➔ All costs for oily bilge water collection and greasy waste covered from public sources.
➔ Right of free sanitary service for all vessels (transit/non-transit) .
➔ Ports are obliged to set-up a system for ship waste collection.

The Association for Bilge Oil Disposal on the Rhine in Germany collects about 8 to 10 millions of litres of bilge oil per year. This corresponds to one fifth of the oil volume that leaked from the oil tanker Exxon Valdes in 1989. Despite all the legal provisions, bilge oil is still sometimes illegally pumped directly into the Rhine (Vogt & Lowis 1996).

The Rhine system is based on the 1996 *Strasbourg Waste Convention*. The planned future Rhine system will implement the Polluters Pays Principle (through an international cost equalisation arrangement and a sanitary fee linked to the fuel price and vessel fuel purchasing).

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Photo 9: Mobil bilge oil collection from a pushed convoy on the river Rhine. (photo credit: BEG-Bilgenentölungsgesellschaft mbH, Duisburg)

Ship waste collection/treatment system on the Danube

The existing institutional and organisational set-up for ship waste management on the Danube is very inhomogeneous due to the big differences between the individual countries (in economic power, in national policies, regulations and their enforcement, in the structures of the river transport sector etc.).

Sanitary services are unevenly distributed along the Danube river and exist as private/semi-publicly owned stationary port services (i.e. floating barges or pontoons mainly destined for collection of oily water from tank-cleaning operations, but also for bilge water). The Danube transport sector with many existing/former state-owned shipping companies provides overall services mainly for its own fleets. Services as bilge water collection can also be provided for other vessels but, due to commercial prices, are rarely used by vessels from other shipping companies. In none of the countries, except Germany, river vessels in transit can be served free of charge for their disposal of bilge water/greasy waste.

Other constraints exist in the operational set-up on the Danube which is generally not mobile and not very flexible (limited number of floating facilities). Vessels with a need for waste/bilge water delivery have to go to a specific reception facility, which can cause undue delay.

The recommendations from the Danube Commission define the regulatory and general technical framework for Danube ship waste management but, contrary to the Rhine system, do lack an agreement on the financing of services and on basic principles for motivating the vessels to use them. No general information system advise the boatsmen about their obligations for waste management and the possibilities for delivery of ship-generated waste. In many Danube countries, the national policy for ship-waste management is still not fully in line with the recommendations of the Danube Commission.

Key differences in the set-up of the Rhine and Danube river systems are:

- The low number of registered vessels on the river (partly caused by the war effects in former Yugoslavia) results in much smaller volumes of oily bilge water and other ship-generated waste than on the Rhine. Old vessels on the Danube still are allowed to use individual oil/water separators.
- In the Danube countries a comprehensive national policy for ship waste management still remains to be fully developed, implemented and enforced. This should also serve vessels in transit.
- The lack of mobile and flexible collection/treatment facilities on the Danube river demotivate boatsmen actually intending to use such a system.
- The principles of the *existing* waste management on the Rhine can be fully applied on the Danube.

Compared with the present environmental problems of the Danube River, the environmental impact arising from pollution of ship-generated waste can be considered as small, except for accidental spills. However, as the Danube waterway is an international transport corridor, the international rules and regulations for good environmental practice governing such water bodies have to be introduced and implemented along the Danube. Therefore, in all Danube countries national "Danube River Waste Management Plans for the Management of Ship-borne Oily Water and other Waste" and respective action plans for their implementation have to be urgently established.

Photo 10: Separate collection system for ship waste at the Abwinden-Asten dam on the Austrian Danube. (photo credit: R. Gabriel)

The mentioned Phare study presents a cost-estimation for a Danube ship waste facility on a regionally co-ordinated basis, using a mandatory annual environmental fee for Danube vessels. Based on estimated investments of EUR 2.26 - 3.785 million for a system for the entire Danube (depending on rebuilt or new vessels for waste collection/treatment) and annual operational costs of EUR 1.75 million EUR (capital costs and depreciation not included), the estimated costs per collected m^3 of oily water are estimated at EUR 90-100 (including 75% grant, 20% soft loan and 5% own financing). This would correspond to an

Annual environmental fee of

➔ EUR 170-180 for large motor vessels/cargo vessels,
➔ EUR 100-130 for smaller motor vessels/floating unit's and
➔ EUR 45-50 for motor yachts/pleasure boats.

2.2.1.2.5. Energy Consumption / Emissions with Relevance for the Climate

In order to assess the ecological effects of inland waterway traffic it is absolutely necessary to analyse the energy consumed as well as those emissions which have a long-term effect on the climate. In particular it is of interest to compare waterway transport with other modes of transport.

The Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT) has published the following table on its web-site:

Vehicle	Energy use per 1,000 tkm	Final energy [Wh/tkm]	CO_2-emission [kg/1,000 tkm]
Road	24.5 kg diesel	287	77.2
Railway	Depending on type of electricity production	93	27.8*
Ship	8.0 kg diesel	93	25.2

*... Assumption: 40% of the electricity is from caloric production

According to this estimation, energy use and carbon dioxide emissions of ship and rail transport are practically equal, only the road transport consumes markedly more resources (about three times more energy and CO_2 emissions).

According to information provided by the Hungarian Transport Ministry, a specific mass can be transported with the same amount of energy over 370 km by ship on inland waterways, over 300 km by train, and over 100 km on the road. In other words: Trains are assumed to use up more than 20 % and lorry transport 3.7 times more energy than ships.

The VCÖ (Austrian Traffic Club) specifies the following emissions for the transport of goods (in grams per ton km):

Vehicle	CO_2	Hydrocarbons	Nitrogen oxides NOx	Particles
Lorry	188.80	0.296	2.044	0.096
Railway	13.21	0.011	0.075	0.006
Ship	24.47	0.023	0.268	0.017
Airplane	1,253.11	0.373	4.357	0.001

Thus, for emissions of carbon dioxide, hydrocarbons and nitrogen oxides, trains achieve the best results in this comparison. CO_2 and hydrocarbon emissions in ship traffic are estimated to be about double as high as those on railways, emissions in road and air traffic are many times higher. According to this estimate, emissions of nitrogen oxides and particles in waterway transport exceed those of rail-bound transport by about three times.

In a study carried out by the IFEU (Heidelberg Institute for Research on Energy and the Environment), the consumption of resources by railway and ship was calculated in a concrete case study. The subject of the study was the transport of fuel oil from Hamburg to Berlin. The results are documented in the following table:

Vehicle	**Nitrogen oxides** [g/ton of goods and transport]	**Sulphur dioxide** [g/ton of goods and transport]	**Carbon dioxide** [g/ton of goods and transport]	**Consumption of primary energy** [litres of petrol equivalent/ton of goods and transport]
Railway	14.6	5.5	6.8	3.8
Ship	276.6	9.4	16.2	6.8

In this case study, emissions of sulphur dioxide and carbon dioxide in shipping are about double as high as in railway transport, the relation of energy consumption lies in about the same dimensions. According to the estimate, emission of nitrogen oxides by ships is even about 19 times higher than in railway traffic.

Even though the results of the studies quoted above differ in their details, they all have in common that the emission of pollutants as well as the energy consumption in inland shipping can be considered less harmful for the environment than the transport of goods on roads. In comparison with rail-bound traffic, however, inland shipping offers, by no means, any clear advantage.

2.2.2. Environmental Impact of Ship Accidents

In addition to the environmental impacts from regular ship traffic, there is the important risk of burdens caused by accidents. Compared to rail transport, waterway transport has a higher accident risk which can be particularly critical with the downstream transport of spilled hazardous substances (oil, chemicals). The likelihood of accidents in inland shipping depends mainly on the following factors:

- traffic density
- nautical conditions: water depth, width of the navigable channel, visibility, signalling, flow speed, etc.
- travelling speed
- training and reliability of the crew
- the technical state of the ship
- the availability and use of effective and reliable navigation systems.

The ecological effects of accidents in shipping vary from case to case. An accident where loaded goods and fuel are lost must be rated much more severe than a collision without any loss of goods. In case of such a loss of load, the ecological impacts again largely depend on the type of transported goods. A frequently transported good is oil respectively oil products and most of the ship accidents happening today involve oil pollution; potential impacts due to oil pollution are described in chapter A.2.2.1.2.1. It is not possible to make any generally valid statement on the impact of the loss of products from chemical industry, which are frequently transported by ship as well, since these effects vary extremely depending on the specific substance. There are many indications in the technical literature on the dangers posed by sunken ships (i.e. wrecks). In 1991, for instance, a ship of the Russian fleet capsized in the main branch of the Danube delta. The scrap is still there and represents a burden for the nature area of the Danube delta (see Constantin 1992).

In spite of all the safety measures, accidents happen again and again. On the 70 km section of the Danube between Straubing and Vilshofen in Bavaria, 62 accidents were counted in the year 2000. On the Waal between Lobith and Zaltbommel (Netherlands), a section with a length of about 73 km and with very good nautical conditions, but an extremely high traffic density, 637 accidents happened between 1987 and 1994, in which 962 vessels were involved.
However, it can be stressed that the number and size of such ship accidents lessened over the last decade which is largely due to the application of European legal prescriptions for the transport of hazardous goods (e.g. permitting only double-walled ship hulls) (Vogt & Lowis 1996) and due to better nautical equipment.

In 2000, the number of accidents in North-Rhine-Westfalia went down to 144, compared to 319 in 1990. 90 of the accidents were caused by wrong nautical behaviour which is considered typical for east-European ship crews. In 2000, 64 accidents were recorded on the Rhine, 59 in Northwest-German canals and 21 in ports. Nautical experts and the German ministry for transport stress causes like deficits in nautical qualification, knowledge of navigable river sections, communication during encounters and technical standards (Bonapart 2001).

Also in the Austrian section of the Danube accidents are reported repeatedly. A particularly severe accident happened at the new hydro-dam Vienna-Freudenau on 22 October 1996 with the cargo vessel Dumbier. Eight seamen were killed and one survived badly injured. The Slovak shipping firm and the British insurance company of the Dumbier sued the Republic of Austria for damages, the dispute has not been settled yet.

In the Wachau, another major tanker accident occurred on the Whitsunday weekend of 1998. A German cargo vessel stroke a rock, and 25,000 litres of fuel oil leaked into the Danube. In the night from 15th to 16th April 2001, another oil tanker accident happend near Aggsbach in the Wachau. A ship crashed into a pier, this resulted in a crack in the tank. According to the shipping firm, some hundreds of litres of fuel oil leaked into the Danube. And that was a blessing in disguise since the leak was not under water. In the latter case, a considerably higher proportion of the total of 1.7 mio. litres of oil could have been introduced into the Danube.
A major accident happened in late winter 1994 at the locks of the Gabcikovo dam (Slovakia): On 14 February, a Ukrainian ship sank due to the early closure of the upper lock gate (see photo below). More than 10,000 l of spilled oil had to be recovered, one person died. It took more than two months to salvage the wreck but, on 20 March, the second lock chamber bursted, probably because it was not ready for operation after previous long-lasting repair works. Danube waterway traffic was closed for five weeks (see also chapter A.3.5.).

The problem of accident risks with ships is underlined by recent discussions in Italy. For the future it is planned there to admit only those ships for oil transports on sea which have a double-walled hull. While major accidents are not frequent events, their damage potential is very high. Such an increase of safety is not only justified for seagoing vessels but also for inland waterway transport, in particular on large rivers like the Danube or the Rhine. Different to road and rail transport, river accidents always risk to spread pollution far downstream to sensitive river habitats, drinking water abstraction zones or the Black Sea. The Tisza-Danube pollution incidents in winter 2000 at tailing ponds of the Romanian mining industry can serve as an example of what can happen after a major spill of oil or chemicals due to a large ship accident.
For the future prevention of ship accidents, there is a clear need for transport politics to foresee a restriction of the transport of hazardous goods on ships at certain river sections, periods and/or for certain substances.

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Photo 11: On 14 February 1994, a Ukrainian ship drowned due to the early closure of the upper lock gate at the Gabcikovo dam. Danube waterway traffic was closed for five weeks. (photo credit: WWF)

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Fig. 7: Between November 2000 and January 2001, a total of 19 accidents were recorded on the Main-Danube waterway, including 15 in cargo shipping. The water police has to regularly stop skippers who are drunken or unacquainted with the navigation conditions (cartoon credit: aqua press international no. 6/2001). The latest accident happened on 8 January 2002 on the Rhine near Dormagen when a drunken container skipper hit a tank ship: 12,000 litres of petrol leaked.

3. Case Studies of Present Conflict Areas

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As it was mentioned before, waterway transport already significantly contributed to the degradation and destruction of the Danube riverine ecosystem. In spite of the large-scale engineering works already completed, there is a continued pressure on various river stretches which still "lack" major human intervention and control. Most experts, local communities and environment authorities and NGOs engaged in the conservation and restoration of these ecologically valuable river areas *support waterway transport as an environment-compatible transport means, provided that it will be continued or upgraded without reducing the ecological character and conditions of the respective river stretch.* The main point of dispute with the lobby group demanding better waterway transport is therefore the creation of new, questionable waterway transport routes as well as on existing routes the degree of their year-round navigability, apart from the investment and maintenance costs.

According to this lobby, the Danube river transport corridor could only be upgraded if all “bottlenecks” (in lateral and depth dimension) are being addressed, i.e.

- the destroyed Danube bridges and possible other unsafe passage in FR Yugoslavia (*remark*: it is assumed that this problem will exist only until spring 2002)
- the shallow and narrow Danube sections in Germany, Austria, Hungary, and
- the shallow sections along the Lower Danube between the Iron Gate II and Braila.

But there are two important questions:

- *How each of these bottlenecks is to be technically improved?*
- *Why all the navigable river sections need to offer the same navigability and what is the ecological price of each waterway improvement?*

The following case studies are to draw the attention to those projects presently under discussion where a strong dispute and opposition over major ecological impairments already exists or will be inevitable in case of realisation. These river areas are therefore presented as the most important *Ecological Conflict Areas in the Danube Basin Affected by Waterway Transport Development* (see also attached map 1); this also indicates that the list is not necessarily complete.

3.1. Straubing – Vilshofen (D)

The section of the Danube between Straubing and Vilshofen is the last free-flowing section of the Danube in Germany with a length of nearely 70 km but has a navigational depth of only 2 m (draught: 1.70 m) for LNRL. For the past 20 years, development plans aiming at its canalisation and impoundment have led to heated discussions between environmentalists and local communities against advocates of the hydrodam and waterway construction lobby. The plan is to close the last non-impounded river gap by up to three dams for year-round perfect waterway transport and possibly for power production. The project has been the subject of a heated dispute for many years. 100,000 signatures were collected in riparian communities against these technocratic plans, i.a. re-calling a lastingly "bad" navigability of river sections up- and downstream (see table 17 in chapter B.3.1. and table 19 in ch. B 3.2.). The provincial government of Bavaria and the construction company Rhein-Main-Donau AG are also under pressure from the German federal government which does not want to support an impoundment solution.

In view of the severe impairment of German river landscapes by dams and canals for hydroelectric power production, flood protection and inland shipping, this Danube section in Lower Bavaria is of critical importance for nature conservation. In this area, all criteria for declaring it a European nature conservation site in accordance with the European legislation (Birds Directive, Fauna-Flora-Habitat Directive) are met; also the conditions for declaring it an internationally important wetland according to the RAMSAR Convention.

Numerous studies have provided documentation that this 70 km long stretch, with the floodplain forests at the mouth of the Isar tributary in its center, may rightfully be called the Noahs ark of Bavaria (800 ha protected area): Along the adjacent ten km long river section near Osterhofen alone, 62 plant communities (of which 22 are on the Red List) have been mapped. An area which corresponds to less than half a % of Bavaria hosts more than 400 vertebrate species, 60 % of the bird species classified as being threatened by extinction in the Free State of Bavaria (e.g. curlew *Numenius arquata*, black-tailed godwit *Limosa limosa*, corncrake *Crex crex*), as well as 85 % of endangered fish species, such as zingel (*Zingel zingel)*, Danube ruffe (*Gymnocephalus baloni)* and streber (*Zingel streber*) – all three being endemic for the Danube. More-over the largest population of blue-throats in entire Central Europe can be found there, as well as 53 fish species (57% rheophil; 30 fishes are on the Red List of Bavaria, 12 are on the EU-FFH list). The variety of species in that upper Danube section can be compared with the national park Danube Floodplains east of Vienna, and the construction of the canal would destroy its future. Present average groundwater variations of the riverine ecosystem are at 3 m which would be much levelled by an impoundment.

On 31 March 2001, the German Federal Minister for Environmental Affairs suggested the Government of Bavaria to nominate the Lower Bavarian Danube between Straubing and Vilshofen as a Natura 2000 area, because it meets all EU directive criteria for nomination. In fall 2001 the final steps were taken to specify the borders of the area. Any EU support will be linked to a full respect of these EU conservation laws (comment 2001 of EU commissioner Wallström). Model decisions of the European Court of Justice confirm that all nature sites presently qualified for the Natura 2000 list have to be nominated and effectively protected by EU member states, and cannot be set aside for or deteriorated by other development.

It is publicly stated that the ship transport lobby needs the Danube being developed along its full length for an loading draught of 2.5 m over the whole year but it is also known that during the low water period actually only very few ships would really require it (freight becomes lighter, many ships are not fully loaded or have less draught etc.): See part B.

According to the most comprehensive development variant (D2) it is planned to build here three dams near Pleinting (close to Vilshofen), near Aicha and near Waltendorf; and to cut off the Danube bend of Mülham with a lock canal. Variant D1 provides for a dam regulation for the whole stretch, with two dams near Waltendorf and Osterhofen as well as for a lateral canal with a length of about 10 km up to Pleinting. Variant C includes only one dam in the center of the Danube stretch but it would destroy and affect the most valuable biotopes, including the mouth of the Isar; critical river engineers also predict that this can only be an interim solution due to its up- and downstream effects.

Alternative proposals suggest an ecologically acceptable, "soft" development of the Danube by non-impounding river bed works. This became known as Variant A, while the so-called Variant B aims at a radical technical upgrading of the river bed without a dam.

Over the last four years, these alternatives were detailed, modelled and compared by the German federal institution for river engineering. Result in spring 2001 was that, *for the entire year* (i.e. for LNRL = 94% of the ice-fre period), a minimum loaded draught of 2.50 m (i.e. a channel depth of 2.80 m) can only be achieved by building two to three dams; a draught of 2.15 m (i.e. a depth of 2.45 m) can be achieved with one dam, while without any dams, i.e. with groynes and dredging (Variant A), only a draught of 1.90 m (depth of 2.20 m) was found as feasible.

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Photo 12: Groynes at the largest free-flowing section of the Upper Danube in Bavaria/Germany: If properly upgraded they can provide better waterway transport without needs to impounding the river (see also chapters A 3.1. - 3.3.). (photo credit: Bund Naturschutz Bayern)

These studies were criticised for having narrow conditions and for neglecting certain aspects that favour Variant A. The following arguments support a solution without any new impoundment:

- A channel depth of 2.80 m is not necessary. Even on the Rhine, where twenty times as many goods are transported, the guaranteed depth on the free-flowing section from Iffezheim to Cologne is merely 2.10 m across the year. In addition, future river transport requires more space below bridges than lower water depths (see section B of this study).
- A new political standpoint was adopted by the European transport ministers (including from Germany, Austria) on 6 September 2001 with the Rotterdam Declaration which aims at "Accelerating Pan-European co-operation towards a free and strong inland waterway transport" by carrying out i.a. Action 3: "*To improve the navigational conditions and infrastructure on the main Pan-European waterways (waterways that meet at least the requirements of class IV of the 1992 ECMT-UN/ECE classification) with the ultimate objective that these waterways may in due course be used for at least 60% of the navigation period by vessels having a draught of 2.5 metres and, in the case of vessels carrying containers in the hold, by vessels transporting 3 layers of containers*." Existing comprehensive data show that such navigational needs can be fully met at the Bavarian Danube by simple waterway improvement without any impounding dam (Variant A). For container transport, however, a number of low bridges over the RMD canal and the Bavarian Danube allow only a transport of two layers.

- The water depths and channel width in Variant A can be expanded beyond the limits calculated in the government study, so that the difference in navigability would be only a few days per year. See chapter B.2.2.7.1.
- In case of the dam stage solution, the sealing up on the banks would much cut off groundwater exchange with the river. This would deteriorate the groundwater quality and affect the drinking water supply. In addition, major biotopes and agricultural land in the hinterland that depend on the groundwater (fluctuation) would be lost or deteriorated.
- The resulting costs for water quality restitution would be considerably higher than the construction costs themselves; so far, communes have invested about DEM 370 mio. to improve the quality of the water from "critically polluted" to the desired degree of "moderately polluted". Damming the river up would reverse this improvement, as it happened with the water quality changes after the Danube impoundment downstream of Regensburg (Geisling and Straubing dams): Recent monitoring results of the Bavarian Agency for Water Management indicated such deterioration between 1995 to 1999.

3.2. The Wachau (A)

The Wachau is one of Europe's oldest settlement areas and, since the year 2000, a world cultural heritage site included in UNESCO list as well as a EU Natura 2000 area. The scenic mountain valley is one of the biggest tourist attractions in Austria (Danube canyon, castles, small wine villages, boat cruises). It is the last canyon section of the upper Danube where no dam has been erected yet.

Photo 13: The Wachau is one of the most beautiful Danube sections; the free-flowing river is part of the protected character of the landscape. (photo credit: B. Lötsch)

In 1952, the Österreichische Donaukraftwerke AG (Austrian Danube Power Plant Co.) presented the first plan by stages for the development of the Austrian part of the Danube into a "power waterway". They planned to build a hydroelectric plant between Dürnstein and Weißenkirchen at rkm 2.012.
Between 1971 and 1983 the project with four different variants was subject to heated public discussions and was then abandoned. Since 1984 the Austrian Waterways Authority (WSD) has developed the navigation channel in the Wachau region with traditional methods of hydraulic engineering, aiming at a minimum depth of 25 dm for the low water table.

In 1998 the WSD presented the project "Wachau 2000", which specifies the development of the Danube with a navigable channel depth of 30 dm. This project provides for a stabilisation of the riverbed by adding gravel with grain sizes of 4-7 cm (Hirtzberger 1999).

However, the amount of gravel taken out for expanding the channel aggravated the problem of bed erosion. Today, only 21-22 dm are technically feasible for the WSD while 25 dm would require very much dredging (oral information of WSD from 2001). Thus, the Wachau is in a similar water depth constraint like Straubing-Vilshofen and its free-flowing character is still not fully secured in the longer term.

3.3. The Danube East of Vienna (A)

East of Vienna there is the last large Austrian floodplain area where no power plant has been erected yet. The right side of the Danube banks are limited by a steep terrace. Along the left banks, between Vienna and the March/Morava tributary, the floodplain spreads out several km but was diked in the second half of the 19^{th} century to secure flood protection and allow for intensive agriculture .
The remaining floodplain has a width of up to 2 km from the Danube. The Danube here flows in an approximately 350 m wide regulated bed, which is secured by rip-rap and contains a runoff of up to about 5,000 m³/sec, corresponding to a one-year flood. For waterway transport, low water regulation was conducted in early 1900. The navigable channel, a stretch with scour holes and fords, is developed with a minimum depth of 2.5 metres over a width of 80 - 100 metres. An effect of former engineering works is continuous river bed erosion at a rate of 2 cm / year which has led to a reduced water supply of the valuable floodplain habitats (see also figure 4 on page 36).

According to the former plans of the Austrian Federal Government and the international Danube Commission, the upper Danube should be developed into a non-interrupted power waterway. This plan provided for channel depths of 27 dm upstream of Vienna and of 35 decimetres downstream of Vienna. Between Vienna and Bratislava it was planned to erect two power plants, one at Hainburg and another one a few km downstream near Wolfsthal.
The construction of the Hainburg dam failed as a result of the massive opposition of the Austrian population in December 1984. The building site was occupied and, after heated conflicts with the police and large-scale demonstrations in Vienna, the government ordered the stop of construction works. In early 1985 the building permit for the power plant of Hainburg was suspended by the Austrian Administrative Court upon appeal of WWF. In 1985 the Austrian Federal Government formed an Ecology Commission, which was to develop approaches towards the future protection and sustainable development of this river section. The Commission, later-on re-established twice again, spoke out against the dam construction and recommended the establishment of a national park to protect the wetlands east of Vienna.

Due to ongoing public pressure (e.g. WWF campaigns "Bail Out Nature" 1989-90 with the purchase of 411 ha of riparian land and "Yes to the Floodplain" 1995-96), the Austrian Federal Government eventually followed the Commission's recommendations and, after ten years of planning, contractually set up the national park "Danube Floodplains" on 27 October 1996 (legal basis guaranteed by federal legislation in 1997). The national park Danube Floodplains has a size of 9,500 ha and was recognised by IUCN under category II. The floodplains are also a Ramsar site, a Natura 2000 area and, partly, a biosphere reserve.

Still, during the planning of the national park, an overall concept for the development of this river section from the view point of hydrological engineering was elaborated. It provided for a systematic re-networking of the wetland waters that had been separated by the Main Regulation of the Danube in the 19th century, the rehabilitation of river regulation works, and measures related to a sustainable bed stabilisation.

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Photo 14: Swallow island is the largest remnant of the once braided river bed at the Danube east of Vienna. (photo credit: B. Lötsch)

In 1985, the re-organisation of the waterway authority resulted in a new legal mandate for ecology-oriented hydrological engineering. This re-connection of the side-arm system with the river was first applied in 1996-98 at the Danube reserve of Regelsbrunn (joint restoration project with WWF) and since 1999 at several sites of the northern banks in form of 2 EU-Life projects (jointly with the NP authority).

However, in March 1999, the Overall River Engineering Project for the development of the Danube east of Vienna was submitted to the Waterway Management Authority (WSD), providing for an increasing of the navigable channel to a minimum depth of 32 dm for low water. Its publication provoked heated discussions about its traffic engineering usefulness and ecological compatibility with the national park.

The Scientific Advisory Councils of the national park and of WWF (as land owner along the navigation channel) demanded new planning on the basis of targets recommended by the Danube Commission, i.e. a minimum depth of 25 dm at low water. According to an oral statement of the Waterway Management Authority from May 2001, plans are being made now also for a variant with a minimum depth of 27 dm (see also section B).

Along this stretch, the problem of bed erosion is only partially solved. Within the permit to construct the Vienna-Freudenau hydropower plant (opened in 1997), the plant operator was obliged to provide for conservation measures in the downstream 11 km long free-flowing section of the Danube (= national park section). In addition, the bed load deficit caused by the plant construction has to be made up for by regular supply of gravel of at least 160,000 m³/year. In contradiction to this, the WSD obtained in 1999 the permission to dump bed load from ford dredging *outside* the navigable channel.

The whole river engineering project of the WSD for the final development of the Danube east of Vienna provides for a further narrowing of the navigation channel by extending groyne installations by 30 m (Ogris 1999) as well as by constructing additional groynes. The bed of the Danube is to be secured by the so-called "granulometric bed stabilisation", the building of bottom sills and submerged sills, and partly by the filling of scour holes).

The ecological disadvantages of this low water regulation at a minimum of 32 dm include:

- **Groynes**
  The narrowing of the flow cross-section of the navigable channel leads to an acceleration of the flow speeds of 5 and 10 % (Ogris 1999). This is also connected with disadvantages for waterway transport since upstream transport always requires increased fuel consumption. Furthermore, the narrowing of the channel entails an increased risk of accidents.
  The acceleration of the flow speed brings about an increased bed erosion and a progressive colmation (clogging) in the enlarged groyne fields. In the stream itself, the ecological gradients are lastingly changed.

- **Bed stabilisation**
  The "granulometric" (grain-size) bed stabilisation involves the introduction of a blanket of gravel covering the entire surface of the channel remaining after the installation of the groynes. This blanket of gravel with a grain size of 40-70 mm must be realised with a medium layer thickness of 25 cm over all parts of the river bed exposed to the current. This is meant to accelerate the natural formation process of the top bed layer. However, this has the result that inner silting processes, which occur in free flow sections, act over a longer period of time and has negative effects on the water exchange between the groundwater and the free flowing water of the Danube.
  This "granulometric bed stabilisation method" has not yet been tested in nature at a larger scale. It is therefore not yet sure whether the theoretical projection of a sustainable bed stabilisation will occur in practice. There is the risk that, if the "granulometric bed stabilisation" fails, harder river engineering techniques must be applied to achieve higher channel depths (new dams or massive bed pitching). The large-scale formation of a top layer – as desired, over longer periods, in terms of a sustainable stabilisation of the Danube riverbed – is likely to lead to a more intensive "sealing" of the bed sediments and reduces the lateral and vertical connectivity to the body of groundwater.

- **Bottom sills, submerged sills**
  The river engineering project of the WSD (Austrian Waterway Management Authority) provides for the installation of bottom sills, submerged sills, and partly also the filling of scours. In this way, technical structures would be created on the bed which change the natural depth structures. Morphological bodies naturally transporting sediment material (riffles, dunes, banks) are reduced by such measures. These natural bed structures, of all places, are major habitats for many rheophilous fish species.

Concluding it can be stated that the technical planning of the further development of the Danube east of Vienna is ahead of the assessment of its ecological effects and its economic effects. No cost-benefit analysis has yet been carried out for the whole river engineering project; neither the economic efficiency nor the profitability / financial benefits have been studied so far. More-over, the ecological effects of this "maximum variant" on the national park were never assessed. Only after a scientifically based discussion of all variants, including the status quo, should a decision be taken for the Danube section east of Vienna.

3.4. Danube-Oder-Elbe Canal with the Port at Devinska Nova Ves

Subsequent to the opening of the Rhine-Main-Danube Canal in October 1992, old ideas for international waterway transport routes received a revival, namely

- Danube-Oder-Elbe Canal as a shipping link from the Black Sea to the North Sea and to the Baltic Sea;
- Danube-Sava-Adria Canal (Croatia) as a link to the Mediterranean Sea (see A 3.8.).

3.4.1. Danube-Oder-Elbe Canal (CZ, SK, A, P, D)

The DOE Canal is lobbied for by a relatively small group of powerful corporate bodies, public institutions and companies in Czech Republic and Austria, united in the international "*Association Danube-Oder-Elbe*" in Prague. Their argument is to offer a new transport route for the growing heavy traffic between South-eastern and Central-northern Europe by which goods could be removed from trucks and railway onto ships. This would connect some industry zones in Silesia and eastern Czech Republic with new European markets. Additional plans suggest that along the new waterway there will be a development of new settlements, industry zones, ports and recreation areas which all would increase its beneficial use. Such options are expected to stimulate local public bodies to join the association and other donors to ease the difficult financing. In opposition to these ideas, there exists - since decades - a most serious critique of the overall feasibility, economic need and of its enormous environmental impact (see WWF 1999).
Until today, the realisation of the canal is very uncertain (Schrems 2001), and there are unclear routes and implementation steps. Basically the canal would take the following route (see also map on page 62):

- **Danube-Morava Branch (A-SK-CZ)**: 170 km from Vienna north-east over the lower Morava floodplains and river up to Prerov (Czech Republic), by means of ca. 10 impounding dams, a canal bridge *over* the river and, in one variant, through a ship tunnel.

Then, the canal would divide into two branches:

- **Oder Branch (CZ-P-D):**
  - 1st section over 100 km from Prerov to Ostrava (upper Oder river), by means of 8 impounding dams and, possibly, one canal *tunnel*. Highest altitude: 275 m asl.
  - 2nd section over 46 km from Ostrava to the Gliwice canal (Poland) by means of 6 dams.
  - 3rd section from Poland to Szczecin (Baltic Sea): As the Oder is only navigable to a small extent, this needs a river regulation over 520 km (Wroclav to mouth of the Warthe) including the (re-)building of 15-20 dams.

- **Elbe Branch (CZ-D):**
  - 1st section over 150 km from Prerov to Pardubice (upper Elbe river). This would be a technically most difficult crossing of the Bohemian heights by means of a canal bridge over the Morava, by 2-3 *ship lifts* of each ca. 100 m (unique in Europe!) and by 4 dams (each 20-25 m high). Highest point: 395 m asl.
  - 2nd section over 676 km from Pardubice to Hamburg (Germany) by means of 2 new Elbe dams in Czechia (46 km) and more than 20 dams on the German stretch of 630 km. The German government already abandoned such plans years ago after conducting a cost-benefit analysis.

The total length of the canal and rivers to be re-built is thus ca. 1,600 km. The canal is planned for a depth of 4 m (2.80 m draught) and a width of 55 m (ship class Vb), therefore making it useless for large pushed barges, i.e. goods will have to be re-loaded (inter-modal transport).

Map 5: Map of the planned Danube-Oder-Elbe Canal: Its realisation would affect over 400,000 ha in 61 protected areas in Austria, Slovakia, Czech Republic, Poland and Germany. (map credit: U. Schwarz)

The canal will directly have to compete with high-capacity train routes (20% more than the canal capacity) which mostly already exist, and which need much less construction and maintenance costs. Canal construction is estimated to last some 10-20 years, i.e. a time span during which the central European transport needs could completely change again. It is not surprising that until today there is not any serious economic cost-benefit analysis made for the canal. For this aspect, for instance, the German government demands now a cost-benefit ratio of *minimum 1:4* to support such infrastructure schemes.

Ecological Impacts

Both the Danube, Morava, Oder and Elbe rivers still own some of the best riverine landscapes in Europe, different to e.g. the upper Danube or the Rhine. The realisation of the canal, however, would inevitably impact their preservation. It is expected that 61 protected areas (including national parks, Ramsar sites, nature reserves), covering 400,000 ha, would be impaired by the DOE canal in their size, character and special diversity - the largest intervention into natural landscapes ever planned in Europe. Further, a non-natural exchange of species will be triggered by linking the three European river basins with unknown effects on local biodiversity (WWF 1999, Zinke Environment Consulting 1999).

In addition comes the needed diversion of the already limited local water resources for operating the canal, in particular for the section Vienna-Hodonin (lower Morava) and for the highest sections of the Oder and Elbe during low water periods. The canal route would also dissect/block existing flood retention areas (which already proved to be too small to cope with floods) and reduce the self-purification capacities of natural waters. This would deteriorate river sections which are either already subject to river pollution and flood disasters (e.g. upper Odra, middle Morava), or where exist the last intact floodplains in Europe with unique biodiversity and important nutrient uptake capacities (e.g. lower Morava and Odra, middle Elbe) (WWF 1999, Daphne 2000). Finally, the proposed transport of - in fact hazardous - goods (chemicals, fertiliser, petrochemicals) (Schrems 2001) entails a new accident and pollution risk for a region known for its fragile water balance.

All these environmental impacts correspond to economic losses that have to be part of a cost-benefit analysis which then would hardly be positive.

3.4.2. Port Devinska Nova Ves (SK)

In July 2000, a baseline study was registered at the Slovak Ministry for Environment in Bratislava to build a ro-ro ramp at Devinska Nova Ves, i.e. 5 km upstream the mouth of the Morava river into the Danube. After the Austrian authorities asked in autumn to become involved, an international environment impact assessment procedure was started in Slovakia in May 2001.

The project was initiated by the Czech Ports (Ceske pristavy) wanting to build this ramp for their own needs and for the loading of cars from near-by Volkswagen plant onto cargo ships (size: 104.5 m, width: 9.5 m, draught: 1.35 m; needed waterway depth: 1.5 m) aiming at a capacity of 160-320 cars / day resp. 40,000 per year. Costs are expected at EUR 1.2 million, to be co-financed via EU-Phare.

However, it was found that neither does Volkswagen yet need such an installation nor that the existing railway capacities (Bratislava - Brno, Bratislava - Vienna) would already be fully used.

A ro-ro ramp is an inclined concrete platform or adjustable steel structure for horizontal ship-to-shore reloading of road vehicles, usually connected with a storage (parking) area (EUDET 1999).
While the Czech study does not expect major environmental impact, the local environment authorities and NGOs foresee major problems. As the Morava is not as long navigable as stated (250 days/year), a technical regulation (permanent dredging) of the river would be needed to make the project economic. As the Morava in that section is still largely untouched, its soft banks, islands and side-arms would have to be technically protected.

Such intervention contradict with all nature conservation prescriptions: The riparian sections of this border river are protected landscapes in both countries, on Austrian side they also are Natura 2000 and Ramsar sites. During GEF biodiversity, EU-Phare and EU-Life projects, some EUR 6 mio. were spent for wetland management and restoration from 1993-2001. Commercial shipping on the Morava is neither compatible with the ecological goals agreed in the region and the respective development concepts recently prepared.

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Photo 15: View from Devin castle at the mouth of the Morava upstream to the planned port site. (photo credit: DAPHNE-Institute for Applied Ecology)

Impacts expected by various experts (e.g. Zuna-Kratky 2000, Baumgartner 2000, Daphne 2000) are:

- Increase of noise and pollution emissions through construction works (access road, parking and storage areas), port operation (truck transport, loading, ship traffic) and potential accidents;
- Dissection and destruction of the biocorridor with its special features (mud banks, backwaters, gallery forests), all being obstacles or disturbances for waterway transport;
- Alteration of the hydrological regime of floodplain biotopes up to rkm 20, resulting in an indirect impact for the adjacent national park Danube floodplains and the internationally important white stork colony at the nature reserve Marchegg/A;

- At least 30 bird species (out of 196 registered species) protected under the EU-Bird directive or Lower Austrian law would be affected by the port; these mostly very sensitive birds use the river confluence area as feeding, breeding and resting places (winter);
- Other species affected by e.g. blocked migration, ship-induced waves and increased turbidity include the beaver, the river otter, benthos communities and various fish which use this river area for spawning and growing.

This port would therefore directly and indirectly alter the still high ecological quality of the Morava mouth. The realisation of this port project would be the starting point for a full navigability of the Morava and the expansion of industrial sites in the floodplains located between the industrial centres of Bratislava and Vienna. This port can also be seen as a precedence for realising the DOE canal.

3.5. Gabcikovo (SK/H)

With its 25 km by-pass canal and its capacity to produce peak power, the Gabcikovo hydrodam system represents in its design, construction and implementation a special case on the entire Danube river. A 50 km long, artificial and largely sealed-up canal, including a storage reservoir (45 km²) and a large power plant with locks was erected between 1978 and 1992 *beside* the "old" Danube river bed.

The Danube diversion dam at Cunovo (rkm 1,852) impounds and deviates 80-90% of the river water to the Gabcikovo power plant, with a head of 24 m and an installed capacity of 720 MW (2,100-2,300 GWh annual electricity production). This is operated in a small peak operation (officially in running mode); for a full peak operation, a second huge storage reservoir created by the Nagymaros power plant (located 130 km downstream) was planned but has not been built, after the Hungarian government abandoned its construction in 1989 and the entire joint project with Slovakia in 1992.

The main objectives of the engineering scheme were to improve flood protection and navigability, and to produce electricity. The site is located at the so-called former "Danube inland delta", a huge sediment fan created when the alpine river entered into the Hungarian plain. Numerous small and large arms sprouted in this extended wetland even after the braided Danube bed was regulated at the end of the 19th century. Also the mean-bed regulation and the massive dredging activities between Bratislava and Gabcikovo of the 1960s and 70s incised the river bed but did not alter much the ecologically most valuable relicts of this multi-branched system.

For the realisation of the Gabcikovo system, it was necessary to eliminate 3,900 ha of agricultural area and 5,400 ha of floodplain forests. The remaining 8,000 ha of richly structured riverside wetlands and woodlands (approx. 50% of which are located on either side of the Slovak-Hungarian border) were completely cut off from the river when putting Gabcikovo into operation in October 1992. Since then they are recharged from the canal (Slovak side) and the "old" Danube (Hungarian side) with a volume of 30-100 m³/sec (even subject to a prescribed seasonal artificial "flooding") of residual water. This, however, is insufficient for maintaining their original ecological functions and depends on annual negotiations with local interest groups (energy production, forestry, fisheries, recreation, public health, local communities, nature conservation etc.).

Although optically well-watered, the lack of former hydro-dynamics (regular inundation and dry periods) created a new progressive degeneration of the floodplain ecosystem (designated as Protected Landscape Area, Ramsar site and potential Natura 2000 site): The waters of the Slovak side-arms are "stabilised" by a system of 7 crossing dike-roads (cascade) at mean water level, which led to a drying out of higher sites, to an over-irrigation of the lower ones, and, on the whole, to non-natural fluvial biocenoses and successions in the medium and long term (e.g. loss and isolation of most valuable spawning habitats for the Danube fish species, decline of specialist species typical for the wetlands, immigration of alien, invasive and ubiquitous species).

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Map 6: Situation of the Gabcikovo dam system since November 1992, leaving only 15% of the river water in the original river bed. The once internationally important floodplains north and south of the river bed are now dammed off the Danube and artificially irrigated. Waterway transport (except for some recreational boating) is redirected through the power plant canal. (WWF 1997)

As most of the Danube water is taken away for power production, only about 15% remain in the "old" riverbed which was already eroded after former waterway regulation works. The resulting new 2-3 m difference to the floodplain water level required to cut off all former connections to prevent the – now irrigated – wetlands from draining completely.

Today, Danube waterway transport is carried out year-round through the by-pass canal which, on the stretch to the power plant, is raised up to 20 m above the surrounding landscape – ending at two big sluices (275 m x 34 m). In the latter, two severe accidents occurred in February/March 1994 (an accident in the right chamber required that the left chamber – in long need of repair – had to be put into operation, which caused the lower gate to burst within a few days). This led to a five-week halt for all Danube waterway traffic and two years of repair work. Also in the following years, the Gabcikovo sluices proved to be a sensitive point, which may be explained by the poor quality of their construction and the delayed commissioning of the canal.

The Gabcikovo-Cunovo Reservoir forms an artificial silting basin extending up to Bratislava where fine sediments from the bed load of the Danube are also deposited. To reduce this undesired process, artificial islands were built below Cunovo after opening the scheme but they did not really bring about the intended effects. Whereas the canal is completely sealed off towards the land located directly below and towards the groundwater body, the reservoir was deliberately designed slightly permeable in order to raise the groundwater table of the surrounding land. According to official information, this system is successful and under constant comprehensive monitoring; but the publication containing the measuring data is under strict control, since the first measuring data from late 1992 indicated some chemical pollution and thus damaged the image of the Gabcikovo system (WWF 1994).

The next undesired effect is at the return of the bypass canal into the Danube (rkm 1,811), which firstly creates an impounding effect in the "old" river bed with rapid silting up of fine sediments, secondly created erosion scours (more than 2 m deep) in the Danube bed downstream because the full volume of water, deprived from all usually transported sand and gravel, hits the unprotected river bed. Thirdly, the material eroded there is then again deposited in the next section (rkm 1,805-1,795) which poses a serious new problem for waterway transport (Kern & Zinke 2000). The locations of extensive erosion and sediment deposits are also still changing over time. The bed erosion can even reach back up to the Gabcikovo dam which could then result in a problem for ship access to the locks (fixed bottom level).

Not only did the start of operation of Gabcikovo with the diversion of the Danube from its river bed (border line!) cause an international conflict, but there is an ongoing major dispute on how much water should remain for the "old" Danube with the wetland system and how much for energy production. As the tense Gabcikovo conflict between Hungary and Slovakia could not really be solved by the International Court of Justice in September 1997 either (resulting in - unsuccessful - bilateral negotiations at governmental level up until today), practical suggestions for ecologically sound solutions nearly always (EC Mission Date Report from 2 November 1993; WWF Reports 1994 and 1997; Kern & Zinke 2000) have pleaded for maintaining waterway transport in the Gabcikovo canal (only requiring 2.5% of the runoff of the medium water of 2,000 m³/sec). If such a solution is found, this area could become the first stretch of the navigable Danube where ships bypass the main river bed and floodplain which would allow unhindered self-restoration processes.

3.6. Navigation Route Upstream of Budapest (H/SK)

Gabcikovo allows waterway transport all through the year – provided that its sluices work. Problems caused by Gabcikovo start below the return of the bypass canal into the river bed of the Danube (rkm 1,811), because – after short-term desired scouring of river sediments – considerable erosion processes (rkm 1,811-1,805) were triggered, resulting in new sedimentation downstream (see chapter A 3.5. above). This stretch between the inland delta near Bratislava and the Danube bend north of Budapest has a number of shallow and narrow sections in the navigation channel (e.g. near the Helemba Islands). This resulted in various river bed development plans (ranging from the full impoundment by the Nagymaros dam to a "soft" groyne/dredging project). The Hungarian government plans to develop - by dredging and stone works - the Danube section upstream of Budapest for the European waterway class VI.b, i.e. a draught depth of 2.50 m (Ruppert 2001).

As a special problem it has to also be assessed in this stretch, in how far the "moderate peak operation, being practised in Gabcikovo for many years, is already responsible for intensifying these negative effects. In other words: After excessive dredging near Bratislava had already made the dam of Gabcikovo "necessary", a continuous deterioration of the conditions for waterway transport could provide new arguments for an impoundment "need" in the area of Helemba-Nagymaros.

The construction of a dam at Nagymaros was already started in 1987-1989, in which context the river bed and the navigable channel had to be slightly shifted. After the construction halt in April 1989 (end of communist era) and some years of deliberations, the building site was completely re-cultivated in the mid-90s. After that, a part of this section of the Danube was declared a national park area (Danube-Ipoly NP) (Cousteau et al. 1993, WWF 1994, WWF 1997, Kern & Zinke 2000).

3.7. Danube Between Paks (H) and Belgrade (FRY)

As it was explained in chapter A 2.1.1.2.2. this Danube section (especially in Hungary) is subject to river bed erosion due to bed regulation works for the navigation channel which is deteriorating the valuable floodplain habitats. Efforts to halt this erosion and drying out process e.g. by diverting more water and retaining it in the side-arm system should be very much supported. This area is renowned for its rich fisheries which can only thrive by restoring the migration routes and spawning areas in the floodplain. Respective proposals were already worked out over the last years by the nature conservation authorities of the Danube-Drava national park (Hungary) and the Kopacki Rit nature park (Croatia). At the Hungarian Gemenc forest, initial restoration activities were already carried out. The total area benefiting from such measures could be up to 800 km² between Baja (H) and Osijek (HR) which includes the largest floodplain forest in Europe and one of the most extended wetlands of the Danube basin after the delta.

The second subject is the lack of channel maintenance during the Yugoslavian war and post-war period which allowed natural self-restoration processes along the Serbo-Croatian (Baranja-Vojvodina) Danube banks. It is important that the future resumption of river bed maintenance works will be well tuned with nature conservation interests because, different to the rip-rap banks in Hungary, the Danube south of Hungary has still some untouched bank sections.

Photos 16 & 17: The Danube at the Kopački Rit, showing the still largely intact banks and floodplain ecosystem. (photo credits: U. Schwarz and T. Mikuska)

There is a great danger that present political negotiations over the future border line between Croatia and FR Yugoslavia could result in a new ecological degradation. While the existing border line follows the old meandering Danube bed, "modern" border lines are often fixed at the middle of the main regulated river bed. At the moment there are about 7,000 ha of Croatian land on the left river side and 500 ha of Yugoslav land on the right side of the Danube. Recently, new plans of the water management authorities became known which suggest to "adjust" (i.e. shorten and canalise) the present Danube bed to improve waterway transport and possibly also to ease the exchange of lands. However, such a measure would deteriorate some of the most valuable banks along the middle Danube and the protected areas (especially the Ramsar site Kopacki Rit). From an opposite perspective, this Danube river and floodplain stretch should get the chance to become an area of reconciliation between people living across the border and the river where nature helps to heal the war wounds. Therefore, urgent pressure is needed on both governments to give priority to its natural heritage and not to waste money from limited funds.

A similar careful approach is particularly important for the *lower Drava* where new sand and gravel exploitation as well as river bed regulation works should not be permitted. Another intervention in the form of a new hydro-power dam upstream of Osijek would have impacts up to the river mouth (compare Schneider-Jacoby 1998). The documents of the Danube-Sava-Adria canal (see chapter 3.8.) envisage even three dams and a port at rkm 196 (Schneider-Jacoby 1994). At the same time, the Dravske Sume (Drava Forest) is an Important Bird Area (IBA) whose protection has been proposed by Croatia for the Strategic Action Plan of the Danube River Basin and by the county of Osijek/Baranja (Euronatur 1999). The Hungarian section of the lower Drava is part of the Danube-Drava national park and a potential Natura 2000 site. The Hungaro-Croatian floodplains are also the subject of international wetland restoration proposals submitted to the GEF/World Bank in 1999.

3.8. Danube-Sava-Adria Canal (HR)

Apart from the Danube-Oder-Elbe Canal (see chapter 3.4.), the Danube-Sava-Adria Canal project is the second "futuristic" waterway transport link which has been regularly presented to the international public and donor community.

The main lobbyist is the Croatian government (Ministry for Maritime Affairs, Transport and Communications) which promotes its realisation since 1991 but has now re-affirmed its *strategic goal to connect the Danube region with the Adriatic Sea* (Bednjicki & Grubisic 2001). This is complemented by the objective to increase river traffic from the present 2% to 15% of transport over the next 10 years.

This strategy is to be implemented by a complex new transport link, the *Danube-Sava-Adria Canal which* is composed of

1. A waterway transport route subdivided into:
   - ➔ The *Danube waterway* up to Vukovar
   - ➔ The *Danube-Sava Canal* (Vukovar - Samac): starting at Danube rkm 1,334.7; length 61.5 km with 2 locks up to Sava rkm 310.75, designed for waterway class Vb (width: trapezoid profile 34 - 58 m; depth: 4 m; for ships up to 1.850 tons) and to be realised by 2020 at costs of ca. EUR 200 mio.
   - ➔ The *Sava and Kupa rivers* up to Zagreb resp. Karlovac; length: 340 km, 3 navigation locks; class IV.
2. A double-track *railway line Zagreb - Karlovac - Rijeka* harbour (class Va); lenght: 160 km
3. A *railway line* through Bosnia & Hercegovina *to the harbour of Ploce* (class Vc)

The Croatian Parliament has already ratified the AGN Contract on European inland waterways (corridor VII Danube) which includes

- ➔ The *Sava waterway* up to Sisak (mouth of Kupa river), including the ports of Slavonski Brod and Sisak: class IV to be realised by 2005 at costs of ca. EUR 15 mio., class Vb by 2010 at costs of ca. EUR 20 mio.
- ➔ The *navigable lower Drava* up to the port of Osijek (rkm 12; class IV)
- ➔ The future *Danube-Sava canal,* including the new international port of Vukovar.

The *Croatian priority programme* (canal Vukovar - Samac, ports, waterway maintenance and safety system, canals on Sava and Drava rivers) entails total investments of about EUR 1 billion by 2010. This was already discussed at the donor conference in December 1998 in Zagreb where Bavarian representatives promoted its support (the Rhine-Main-Danube company is the main foreign consultant).

Potential transport capacity will be 7 mio. tons / year within 30 years, with 50% being transit transport. The Canal would be built at 80 m asl. (i.e. above the Danube, below the Sava river levels) in three sections:

- 10 km through the Vuka river with excavations up to 10 m
- km 10-18 through hilly land with excavations up to 22 m
- km 18-60 through existing small river valleys of Bosut, Bid and Konjsko with average excavations of 8 m.

Critique of the Canal Project

There are multiple critiques of this project stating that, similar to the Danube-Oder-Elbe canal, the DSA project would both heavily impair major wetlands along the Sava river and has hardly any economic and environmental benefits. The overall project was yet not subject of a serious cost-benefit analysis nor of an Environment Impact Assessment. Its overall structure was recently changed from a canal linking the Danube with the Adriatic Sea at Rijeka into a combined canal-railway system (both under the same name!).

Only for the first section Vukovar (Danube) - Samac (Sava) more detailed studies and information do yet exist. They present a multi-purpose scheme which is supposed to serve

- Shipping
- Irrigation and
- Drainage.

So, the Danube-Sava Canal will actually by used to intensify agriculture, with the planned drainage of 173,000 ha and the irrigation of 62,000 ha of land. But irrigation with Sava water will become a supply problem during the dry summer periods with extreme low water rates.

The canal will affect the hydrology of the oak floodplain forests in the Bosut area which are still partly inundated and, as a mosaic of small protected sites of large oak forests, extend across the border with FR Yugoslavia (Important Bird Area). The first dam on the Sava will further impound a stretch of 200 km, including impacts on the famous wetland Lonjsko Polje (nature park) and on the self-purification capacity of the river.

Fig. 8: Satellite image of the still intact Sava river at the mouth of the Una river. The DSA canal would dissect the meanders. (image credit: WWF Institute for Floodplains Ecology)

The Croatian nature and environment protection authority has not yet given a construction permit, i.a. due to the potential impact on 100,000 ha of oak forests along the Sava river.

An attractive alternative for the DSA Canal should be a railway connection from Vukovar to Rijeka and to Ploce (through Bosnia & Hercegovina). In 2001, the European Investment Bank granted respective credits for the extension of the railway system between the Adriatic Sea, Bosnia, Croatia and Hungary (Euronatur 2001). In this case the inter-connection of the different transport systems would be at Vukovar. The recent decision not to built a canal across the Karst to Rijeka (Bednjicki & Grubisic 2001) is an important change in the overall project design which reflects a new assessment of all components. As the Danube-Sava-Adria canal is still a part of the Croatian Programme for Physical Planning, this still has to be adapted to the new facts.

3.9. Danube Islands Between Bulgaria and Romania

The many Danube islands along the Bulgarian-Romanian border are part of one of the last long near-natural Danube sections. However, they also create navigation problems. Development plans until 1990 aimed at constructing three hydrodams which would also improve waterway transport. Due to a lack of funds, alternative plans focus on river constriction and dredging measures.

A Phare (1999) "*Study to Improve Navigation on the Danube in Bulgaria and Romania*" made respective proposals to improve the problematic waterway transport route downstream the Iron Gate, in particular for the waterway transport bottlenecks of the border section between the Vit river and Silistra: rkm 610-375) and along the Romanian section from Calarasi to Giurgeni (rkm 375-239). The objective of the proposal is an improvement of the navigable channel up to 2.50m (involving an overall lifting of the mean river water level by 10 cm) by means of groynes, parallel training walls and bottom sills at side-channel openings. It is evident that these lateral obstacles and barriers will reduce the hydrological connectivity with the side-arms, reduce the morphological dynamics of the island - side-arm system and increase river bed incision, i.e. they will later make more technical "improvements" (more groynes, bank protection) necessary and much deteriorate the natural conditions (exchange of waters, migration of organisms, dynamic morphological processes outside of the main channel).

The priority sites identified in the Phare study are (LAD = least available depth for vessels):

On *Bulgarian* side:

- Belene island (rkm 576-560): presently LAD of 18 dm, channel width 40-60 m
- Vardim island (rkm 546-538)
- Batin island (rkm 530-522)
- Michka island (rkm 463-457)
- Popina (rkm 407-400)

and on *Romanian* side:

- Caragheorghe sand bar (rkm 345-343): LAD 14.5 dm; insufficient depth for in average 90 days/year; vessels have to then make a detour of 100 km.

Maintenance dredging in this Danube section is estimated at an average of 4 million m^3/year.

For the section Calarasi to Giurgeni, the Romanian government started to build a guiding wall and two bottom sills at the Bala mouth in 1995 as well as to do dredging between the

Bala arm and Giurgeni. The construction could not be finished due to lack of funds (Phare 1999).
Another action is maintenance dredging in the upper river section between Iron Gate II and the Vit river (rkm 863-610). The main impact will be a further lowering of the water tables in this section which is already impacted by river bed incision. Further, this will locally increase the turbidity of waters, and the disposal of dredged material will be a special problem, both being sensitive to the river and wetland ecology. The Phare report stresses that an Environment Impact Assessment (EIA) is still required.
The total investment costs were estimated at some EUR 140 million and the annual maintenance costs at EUR 5-8 mio. (Phare 1999).

Such engineering measures have to be compatible with present nature conservation and wetland restoration efforts (see also chapter A.1.3.). This border stretch holds intact river banks and a chain of some 100 islands (75 on Bulgarian side) of varying size (few ha to 2,000 ha, altogether 11,000 ha) which all still have active morphological development and high ecological quality. Even though many of them are damaged by intensive forestry (poplar plantations), these islands still are areas with rich biodiversity and such with a high ecological potential for restoration. Ecological restoration projects are under way or under preparation on Belene, Vardim and some other Danube islands. These islands were therefore included into the biggest wetland programme of the entire Danube basin, *the "Lower Danube Green Corridor"*, established upon the initiative of the government of Romania and with the active support of WWF. In June 2000, the ministers of environment of Bulgaria, Romania, Moldova and Ukraine signed a declaration for the establishment of the Lower Danube Green Corridor, consisting of nearly 1 million ha of existing (773,000 ha) and future protected sites (160,000 ha), and areas planned for wetland restoration (225,000 ha, partly already protected). The countries are committed to develop an action plan for the establishment of the *Green Corridor* including measures on monitoring, information exchange, pollution reduction and wetland conservation and restoration (WWF 2000).

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Fig. 9: Examples of Danube islands along the Bulgarian-Romanian river stretch being subject of new river regulation plans. (figure credit: WWF-DCPO)

It has to be pointed out that more sustainable waterway transport management systems without major river regulation works are successfully being used at large east-European sandy rivers like the lower Volga and Lena rivers (Schoor 2001).

3.10. Danube Port of Moldova

Based on feasibility studies from 1992, the government of the newly, independent Republic of Moldova decided in 1994 to build an oil-import port. The terminal is to be located at the very short Moldovan river stretch (only 546 m long) at the confluence of the Prut river with the Danube (rkm 134) between the nearby borders with Romania and Ukraine, 3 km from the village of Giurgiulesti. In December 1996 this government project received support from the European Bank for Reconstruction and Development (EBRD) (US$ 19 mio. financing) and from several Greek investors (represented by the company "Tehnovax"). These parties share-hold a joint Terminal company (41% MD Government, 20% EBRD and 39% Tehnovax). Total construction costs are reported at US$ 38 mio. Works started in November 1997 but stopped in 1999 (Moldova Azi 2001).

The Giurgiulesti terminal has a planned size of 23 ha and a 173 m long wharf with docking facilities for tankers with a capacity of up to 10,000 tons (140 m long) which are running through the Sulina branch of the delta. The terminal is to have a transferring capacity of 2.1 million tons of fuel a year, including diesel (600,000 t), crude oil and petrol (Hermes 1999). The oil will be procured from Azerbaidjan (Baku), Russia (Samara) and other countries.

The EBRD required a full environmental assessment (EA) in conformity with national, international and Bank requirements, resulting in recommendations for ensuring environmentally sound construction and operation. In August 1993, 573 local people attended a first public meeting to learn about the port project. Two public scoping meetings were held before the EA process in September 1994 in Giurgiulesti and Kishinev. A follow-up public hearing was held on 9 December 1994 in Moldova to review the draft EA and to incorporate public concerns. Invited stakeholders from Ukraine and Romania did not attend any of these meetings (F.R.Harris 1995; EBRD 2001)

After 60% of the terminal was constructed the whole project was stopped in 1999. The main reason was apparently the failure of the Moldavian government to commit $ 2 mio. for the external terminal infrastructure and to secure enough fuel imports to make the port profitable. Due to major oil import contraband, the legal imports of oil products to Moldova were at only 0.4 mio. tons in the year 2000. But if the planned port capacity of 2 mio. tons will not be met, the government will have to pay $ 9.75 for each missing ton of petroleum products.

In spring 2001, the Greek investor initiated a law suit at the Arbitration Court in London. This could cost the MD government $ 40 mio. In August 2001, the EBRD also publicly considered the project as inefficient and unprofitable, and therefore demanded their credits ($ 25.5 mio.) to be repaid (Moldova Azi 2001).

On 3 August the 3 parties agreed to finish the dispute by 15 December 2001, probably with the help of a mediator. In September 2001, the Moldovan government decided to complete the port project and to look for a foreign investor willing to take over their commitment. Respective talks with interested parties from Greece, Russia and Canada indicated in autumn 2001 that the Moscow City Government showed interest in finishing the oil terminal and to construct next to it a port for handling dry cargo (Infotag 2001).

Environmental Impacts and Risks

The Environment Impact Assessment was drafted (together with an "Economic/financial analysis and pre-tender design review") in November 1995 by the Dutch consultant company Frederic R. Harris for the EBRD and the Moldovan Ministry for Ecology, Construction and Territorial Development (financed from the 1993 EU/Tacis Action Programme for Moldova). The EIA was finalised by the Moldovan Department of Environment Protection (former name of the Ministry) and local experts. The F.R.Harris EIA report (1995) revealed a major lack of information about local fauna and flora (the Zoological Institute of the Moldovan Academy of Sciences proposed a series of inventory studies taking a number of months) but concluded that "the terminal will not affect natural fauna and flora" and "not directly impact valuable landscapes or nature protection areas as far as known".

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Photos 18 & 19: The site of the Giurgiulesti terminal before and during construction. (photo credits: Ruslan Melian, Institute Acvaproject/MD)

For terminal construction 20 ha of arable lands was lost; on the side adjacent to the village, a 200 m buffer zone will be planted with trees and bushes. 137.400 m³ of fertile top soil were removed and used for re-cultivation of agricultural lands on adjacent territories.

The terminal is planned to operate in an ecologically highly sensitive and vulnerable region, i.e. at the mouth of the Prut river, one of the most important Danube tributaries, and only some 60 km away from the Danube delta and some 130 km from the Black Sea.

Most port facilities will be located at a 25 m high terrace along the left banks of the Danube. But the mooring and pump house is placed on a 200 m wide strip of natural river bank and sand bars with sparse floodplain forest vegetation which over a length of 400 m were destroyed (lifting of the moorage ground by 7.1 m and deepened of the moorage bay by 7.4 m). So, these excavation works destroyed very valuable fish spawning habitats (e.g. soodak, perch, Crucian carp and bream), and resting sites for migrating birds. Until recently mass migration was observed for species like soodak, crucian carp, Danube-herring, pike, sea-roach and sturgeon Black sea salmon. Most Danube fish species faced dramatic losses in the last decades due to radical biotope changes (F.R. Harris 1995). For fish and birds the port-induced ship traffic will increase noise, water pollution and water turbidity. But there is apparently no further investigation concerning how the terminal construction and operation affects these phenomena both in the port area and further away (e.g. at the Lower Prut), and how this could be limited.

A large forested island is located in the middle of the Danube opposite the mouth of the Prut and the port. Bank material eroded from the left banks (partly induced by ship waves) is enlarging this island at a rate of 1 m per year which thus is slowly narrowing the navigation route in this only 300 m wide channel (some 20 m deep). The channel south of this island is 600 m wide but only 6 m deep. The Romanian area is called "Cotul Piscii" (Cat's Bend), around which the Danube turns in a double bend from a northbound to an eastbound direction. This diked-in 10,000 ha of former floodplain ("Crapina") is one of the core areas under the "Green Corridor" international river restoration concept. One aim is here to reduce the flood problems at this hydraulic bottleneck of the Danube which also affects the port in Moldova.

There is another floodplain forest of 73 ha (willows, poplars and oaks) near the village of Giurgiulesti (3,000 inhabitants) at the mouth of the Prut. Local wildlife includes river otter, mink, black stork and great white egret.

It is important to stress that there are three other important ports close to Giurgiulesti: Upstream at Braila (rkm 170, as the last port for sea ships: up to here the guaranteed navigable depth is 7.30 m) and Galati (rkm 150), and downstream at Reni/ Ukraine at rkm 127) with another functioning oil terminal (F.R.Harris 1999: "old, low technical standards, high pollution rates and environmental risks"). Together with all other ship traffic going up and down the Danube, this river section will probably not only be subject of the heaviest traffic density in south-eastern Europe (experiencing already some 3,000 to over 7,000 ships per year) but also get a pronounced share of hazardous goods transport: A total of about 350 runs of loaded petrol tankers are expected per year at Giurgiulesti (12 hours per ship handling and unloading). During the Yugoslavian embargo the intensity of waterway transport at Giurgiulesti was at only 12 runs per day but normal intensity is 24-36 runs per day. Considering the allegedly limited navigation skills of many crews, this constitutes a substantial risk for major ship accidents and subsequent oil spills.

Such expansion of oil industries, transporting/reloading activities and river transport only a few km upstream the Danube Delta would enormously increase the environmental threats the most important wetland in Europe. Over time this will inevitably lead to a major pollution incident for the Danube and Black Sea environment; therefore this oil port is not compatible with nature protection and sustainable development objectives.

The Giurgiulesti EIA report states that in case of an accident, the international environment regulations will be met by protecting surface water from potential oil spills with barrage booms ("to be installed around each visiting tanker prior to unloading") and treatment of washing waters (small WWTPs). The oil tanks are designed to prevent oil overflow and pollution of surrounding areas. The re-loading of oil-products from tankers into reservoirs is to be done by oil-pipes, the oil transport through Moldova, however, is planned to go with a fleet of 160 tank trucks over the improved existing road (200 truck movements per 24 hours), later a new road is to be constructed to Vulcanesti.

The port area is located in force 9 zone of the Moldovan seismic activity map. An emergency catchment area is projected south of the tank farm to prevent any major spill into the river.

The EIA further indicates an increased (risk of) water pollution by oil products. 7,300 m³ of wastewater will be discharged every year into the Danube after biological treatment (up to the admissible standards of 0.05 mg/l). The capacity of the treatment installation will be at 240 m³ per day but is limited to treating waste water with a low concentration of pollutants.

According to the calculation, the annual amount of treated water is indicated as:

- 50,000 m³ from oily water treatment
- 7,300 m³ of treated sewerage water
- 22 kg of organic substances (sewage sludge).

Un- and reloading activities will also result in air emissions of harmful substances. The calculated amount of 125,500 tons results in yearly payments of just US$ 1,800.

The EIA also states that ships are the main sources of oil pollution by dumping most of the oil used on board. By 1994, Romania had no ships / barges able to collect oil and organic wastes from tankers. To avoid illegal discharges, the Ministry of Transport of Romania designed a project to supply all river ports with barges collecting wastes from passing ships/tankers. For environmental impact of oil pollution see chapter A 2.2.1.2.1.

In fact, the EIA acknowledges that navigation, mooring and tanker movements can result in oil discharge, depending on the navigation conditions, the traffic intensity, the crew proficiency etc. However, to avoid this risk, buoys and leading lights along the Danube will be used. It is also "intended" to use modern tankers of displacement of 5,000 to 15,000 tons with 10-12 cisterns on board.

The Frederic R. Harris company states that in case of accidents, the amount of oil leakage discharge normally varies from 1,500 to 4,500 tons, and that 90% of the oil discharges is at 7 tons on average. The next community and irrigation intake is at Isacha in Ukraine which a spill would reach after 2-4 hours. Further, the EA encourages "further progress on co-ordination, monitoring, notification and emergency response by Moldova, Romania and Ukraine within the Danube Commission to address potential major incidents and accidents arising from increased navigational traffic on the Danube" (EBRD 2001).

The EIA mentions another high risk at the pumping station and buffer platform situated in a water protection zone. Therefore, oil products must not remain on the buffer / regulating platform any longer than needed for pumping. To prevent further spreading of any leakage, floating barriers are to close the moorage bay after the mooring of each tanker and during unloading. As a "safe distance", the EIA asks for 42 m between the existing railways (line Romania-Ukraine) and the oil terminal constructions, and for also a minimum of 42 m between a moored tanker in the port and passing ships on the Danube.

The EIA also stresses complicated navigation conditions to and from the terminal moorage: Due to the depth of the navigation channel, the fast Danube flow (turbulent currents and eroding banks) and navigation of other ships, berthing has to be carried out in an upstream direction. Unloaded tankers should turn 5-6 km upstream the terminal. In addition, the lower Danube has some 35 days/year with floating ice which usually create navigation obstacles at this river bend. Since the Danube has there a highly unstable braided course, so the fortification of the port river banks will not prevent the overall erosion process (F.R.Harris 1995).

In conclusion, it is evident that this port project brings about additional river pollution with toxic substances and triggers an enormous risk of major oil pollution for the Lower Danube, the delta and the Black Sea. The actual needs and benefits for Moldova are already questioned, and today the EBRD is - for economic reasons - against its realisation.

With the discussed reduced needs of the oil terminal capacity (e.g. Moldova's thermal power stations are being re-equipped for gas), alternative business ideas suggest the construction of a cargo or passenger ship mooring, former plans also included a container terminal. However, any such changes would require a new EIA. This will have to more thoroughly address the high accident and pollution risk of an oil terminal which is simply not compatible with the internationally agreed environmental protection needs of this vulnerable region. If any port should be discussed for future operation, then a passenger terminal, different to the oil port, could really bring about some lasting jobs for local people, i.e. in the tourism sector (traditional folklore, handcrafts, food products etc.). Moldova has potential as a river tourism destination between the Iron Gate and the delta.

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Photo 20: Petrol tanker on the river Rhine. (photo credit: Duisburg Hafen AG)

3.11. Ukrainian Danube Delta Canal

New construction works are reported from the mouth of the Kilija arm near the Black Sea coast: Some 3 km downstream of the city of Vilkovo, a 3 km long new waterway transport route is being built at the Bystry (Novo Stambulsko) delta branch right across the youngest and most valuable part of the Danube Delta being protected since 1998 as the Ukrainian "Danube Biosphere Reserve" (official status accepted by UNESCO).

The limited information available and local field observation of WWF experts from October 2001 indicate preparatory dredging works were already started aiming to deepen the branch from 2-2.5 m to a navigable depth of 5.85 m. Some 1.5 mio. m³ of sand and mud have to be removed. It is also planned to expand the shipping canal into the Black Sea to limit sedimentation. Total project costs are estimated at US$ 138 mio. The canal is promoted by the Ministry for Transport as a response to unemployment and other socio-economic problems in Ukrainian delta ports. The project is implemented by the firm "Delta-lotsman".

Fig. 10: Aerial view of the Ukrainian delta indicating the existing (solid line) and the planned new navigation route (dashed line) across the most dynamic part of the Danube delta. (Figure credit: U. Schwarz/WWF Institute for Floodplains Ecology)

However, the real economic purpose and benefit of the new waterway transport route is yet unknown. Vilkovo at the Kilija arm is already linked by a large navigable canal with the port of Ust-Dunajsk at the northern end of the Ukrainian delta. Taking the navigation route via the Bystry branch corresponds to a major detour; there is no port at either end of this branch.

This new canal dissects the core zone of the Ukrainian delta which is still a very dynamic ecosystem with extended reed beds, small lakes and gallery softwood forests. Further the extension of the canal into the Black Sea will result in coastal erosion processes, as can be observed at the mouth of the Sulina branch of the Romanian delta.

Various members of the Ukrainian Academy of Sciences (UNAS) heavily criticised the project as a breach of protection obligations in the UNESCO reserve (prohibiting economic activities in the core zone). They predict huge maintenance costs due to the high silt load of the Danube. As a response to a UNAS protest letter, the Ukrainian Prime Minister ordered on 5 November 2001 an investigation into how to solve the problem.

4. CONCLUSIONS

This analysis has shown that any comprehensive assessment of current inland waterway transport cannot be considered as an ecologically sound mode of transport. The public must be much more aware of the long and serious list of waterway transport-related interventions and impacts, which have already deteriorated the ecological state of most stretches of the Danube. In addition, it should be made clear that these new waterway transport projects constitute the largest threat for the few remaining natural areas in this part of Europe.

Nevertheless, waterway transport has been and can still be performed in an ecologically acceptable way along the Danube, and - in terms of energy consumption and CO_2 emissions - river transport is much more ecological than road and air transport. Waterway transport can therefore be compared to railway transport as relatively better transport mode, as long as the (re-) construction of the waterway and its regular operation are economically, socially and environmentally sound. Such comprehensive pre-assessments are particularly important because waterway transport is usually operating in the core zones of sensitive freshwater ecosystems which rank in Europe as well as on a global scale, among the most threatened ecosystems (see WWF Living Planet Index).

The past technical development of navigable rivers and the construction of various canals have resulted both in immediate destruction as well as increasing deterioration of natural resources. Usually, projects resulting in continued improvements of navigation routes have not sufficiently assessed and taken into account indirect economic losses in biodiversity, flood retention, soil productivity, water quality and recreational values.

Modern cost-benefit analyses very much question new waterway transport projects because correct calculations should include both planning, construction, maintenance, social and ecological costs. For example, the German government demands a cost-benefit ratio of, at least, 1:4 in order to support a waterway transport project.

The old idea to adapt a dynamic river to the technical needs of a certain type of ship and goods is not compatible with the present interest of our societies to maintain and restore intact riverine landscapes with their typical ecosystems and economic services (e.g. timber and fish production, water purification, tourism, aesthetic benefits). The past demands of "full navigability" during low water periods can only be met at an extremely high ecological price. In times of market liberalisation and over-capacities in the transport sector, and of new obligations from the EU Water Framework and Habitats Directives, European transport ministers voted in their *Rotterdam Declaration* (6 September 2001) for the environmental sustainability, safety and efficiency of inland waterway transport. They want to foster the growth of inland waterway transport by improving many institutional co-operation problems (non-harmonised legal, fiscal, social and economic conditions, technical regulations, professional requirements and administrative procedures; low safety and transport efficiency, lack of logistic centres and information service, lack of intermodal transports and of a competitive transport market etc.). These are overdue tasks for making European waterway transport more competitive for today's market needs. Investing in these soft solutions will be much more cost-efficient than the continued hard engineering of rivers.

This analysis has also shown that the past technical development of the Danube for better navigability as well as for more energy production has already degraded too many sections, including virtually the entire upper reach. The new large development plans for the upper, middle and lower Danube reaches as well as for some tributaries (Morava, Sava) are therefore against the interests of the people in the Danube region, and they are in strong conflict with national, international and EU nature protection regulations. They would continue to alter basic river-morphological, hydrological and ecological inter-relationships (i.e. further dissect the lateral and longitudinal river continuum). This makes their future implementation unrealistic and unacceptable from both the environmental, social, political and economic perspectives.

River transport will have a better future when it better uses existing river transport capacities and when it accepts and adapts to certain natural limits of navigability: Rather than further re-engineering our rivers according to certain types of ships, waterway transport now has the opportunity to make better use of rivers by upgrading transport intelligence. This will bring Europe an important step forward towards sustainable development.

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Photo 21: "Boat still life" (photo credit: Anton Vorauer/WWF DCPO)

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Part B: WATERWAY TRANSPORT NEEDS

Part B: WATERWAY TRANSPORT NEEDS

Executive Summary

The objective of the *technical part of the study* was

- to explore the political, economical and technical conditions needed for ecologically compatible waterway transport,
- to document the latest knowledge on this matter and
- to indicate further necessary investigations.

The Danube is considered as part of the whole transport system, embedded in the European inland waterway network along its entire route. Special focus is put on the Danube section east of Vienna up to the Austrian border.

The major issue for conflict between waterway transport and nature conservation regards the development of waterways allowing a greater draught of vessels. The construction of barrages or river engineering measures are among the possible means to achieve this aim.

The situation of European Inland Waterway Transport

European inland waterway transport as a whole is stagnating, losing market shares and facing hard competition, mainly with rail, as regards the carriage of long-distance bulk goods. This development has structural reasons. Bulk goods that have traditionally been carried by ship are characterised by low growth dynamics. The consumption of solid fuels, petroleum products or fertilisers stagnates. The dynamic growth of highly processed parcelled goods with smaller freight sizes and higher requirements as for flexibility and punctual delivery are of benefit to the truck.

On the Danube these problems become even more critical than in the Rhine area, given that only a few industrial sites are situated along the waterway and that for goods carried by ship inter-modal transports are thus rather the rule than an exception. The result is a considerable competitive disadvantage as against truck and rail, offering substantially better covering of space. Moreover, on the Danube in Eastern European countries, the structural change of economy, liberalisation of the transport market and the political crisis in the Balkan area have caused a dramatic fall of transported goods to less than one third of the volume carried in 1980.

Perspectives of Inland Waterway Transport

In this context the question arises on the future perspectives of European inland waterway transport in general and on the future of transport on the Danube in particular. One may generally proceed on the assumption that, to secure its own survival and for eco-political reasons as well, inland waterway transport has to gain goods from the dynamically growing parcelled goods market, i.e. groups of goods that have not traditionally been carried by ship (chemicals, semi-finished and finished goods). This is why container shipping, roll-on / roll-off transport and the use of flexible multi-purpose vessels has to be extended. Technical adaptation and increase of capacity of port terminals, as well as coherent logistic chains are also prerequisite. As for infrastructure, the overhead clearance under bridges is of great importance whereas a maximisation of the navigation channel depth is no priority task.

The example of the Rhine has shown that it is actually possible that waterway transport gains more and more goods that are traditionally not typical for ship: While between 1991 and 1999 the volume of heavy bulk goods decreased by 14 mio. tons (7.3 %), this fall could however be almost compensated, thanks to both an 8.7 mio. tons (+ 44.4 %) increase in chemical products and in semi-finished and finished goods, and a 4.2 mio. tons (+ 20.8 %) increase in agricultural products, foodstuff and animal feed. For the Danube all forecasts show that a mere change of the trade relations after the collapse of the planning economy in Eastern Europe and given the future integration of Eastern Europe in the European Union, a considerable increase in transported goods is to be expected, most of all on the

Hungarian, Slovakian, Austrian and Bavarian Danube (+ 20 % up to 100%). In addition, this trend is being strengthened by the opening of the Rhine-Main-Danube canal in 1992.
The question that arises now is which measures are required to carry these eco-politically desirable additional goods. Eco-politically desirable transports are mainly those which are transferred from the truck to the ship, i.e. exactly those goods that have not traditionally been carried by ship, which are, however, of special importance to the future of European inland waterway transport. In this respect one has to consider the fact that over the last twenty years the ecological requirements of the Danube as a natural entity have become a significant criterion for the evaluation of the ecological compatibility of waterway transport.

Alternative Global Concepts for the Development of the Danube Waterway

At present, two fundamental concepts for a further development of the Danube Waterway are under discussion:

(1) Proceeding from the 1959 Belgrade Danube Convention and the subsequent resolutions passed by the Danube Commission, a final development, mainly based on the construction of a continuous hydropower plant chain, has been drawn up for the Danube waterway. On this occasion the Danube has been split up into an upper section (upstream of Vienna) with a waterway transport channel depth of 27 dm below LNRL (low waterway transport and regulation level), and a lower section (downstream of Vienna) with a channel depth of 35 dm below LNRL. As the implementation of a continuous chain of hydropower plants was revealed to be non-feasible for political reasons (Wachau, Hainburg, Nagymaros), now as much as possible of the initially proposed channel depths are to be obtained by means of river engineering measures.

(2) Alternative to this a concept has been elaborated which rejects the initially planned maximum development and the splitting of the Danube into two training sections. As a continuous hydropower plant chain is no longer to be constructed, the Danube should now be transformed by means of moderate river engineering measures into a waterway with guaranteed and harmonised waterway transport channel depths. The channel depths should comply with the major, for a long time non-changeable river sections of the whole Rhine-Main-Danube waterway. These changes should be achieved only through interventions that are compatible with floodplain ecology.

This is the background for the discussion regarding the development measures on certain river sections.

Development Standards of the Rhine-Main-Danube Waterway

The decisive river sections of the Rhine-Main-Danube waterway (sections that in the long term will not be developed) as for their waterway transport channel depth are situated on the Rhine, in the Wachau and between Palkovicovo and Budapest (see table 3).

Even if we assume favourable discharge conditions for the Rhine, a harmonisation of the Danube development to about 25 dm waterway transport channel depth below LNRL turns out to be a realistic long-term perspective for the whole RMD waterway. This is why the development of the section east of Vienna to a channel depth of 32 dm has to be looked at and questioned as a strategy in the spirit of the old concept of hydropower dam construction.

Table 3: Bottlenecks in major river sections along the RMD waterway as for their navigation channel depth.

River section of Rhine and Danube (managing state)	Length in km	ECWL[2)] resp. LNRL[(3)] in dm	Minimum availability in days / year		Maximum development (ECWL resp. LNRL)
			25 dm navigable depth	25 dm draught	
Rhine Koblenz – St. Goar (D)	35	21	315	265	21
Rhine St. Goar – Budenheim (D)	49	19	300	250	21
Rhine Budenheim–Mouth of the Main (D)	9	21	315	265	21
Danube Straubing – Vilshofen (D)	68	20.0	153	40	25
Danube Wachau (A)	26	25	343	300	25
Danube Vienna – Bratislava (A)	50	25	343	300	32
Danube Palkovicovo – Budapest (H)	165	21	252	1)	25
Danube Belene (BG)	15	18.5	280	1)	25
Danube Caragheorghe – Fermecatul (RO)	23	14.5	275	1)	25

1) no data available
2) ECWL (Equivalent Control Water Level): minimum depth of the navigable route obtained for 94% of the ice-free period
3) LNRL (low waterway transport and regulation level): corresponds to the water level obtained for 94 % of the ice-free period on the basis of an observation period of 40 years.

Sources: EC, Directorate 1A / B5: Study to improve waterway transport on the Danube in Bulgaria and Romania, 1999
ÖIR: Beiträge zur Planung des Nationalparks Donauauen, Vienna, 1995
Wösendorfer H.: Vienna, 1992, 2001 (oral information)
Kleemeier H.: Beiträge zum Arbeitskreis „Die Wasserstraße Donau“. In: ÖIR: Europäische Binnenschifffahrt – Perspektiven im erweiterten Europa, Vienna, 1998.

Political and Legal Framework Conditions

The analysis of the existing international agreements also shows that the Austrian Danube responds to all minimum norms recommended and agreed upon. This applies to the 1996 "European Agreement on Main Inland Waterways of International Importance", which assigned a minimum draught of 25 dm for 240 days / year, as well as to the agreements for Trans-European Networks. It also applies for the 1988 "Recommendations on the determination of standard dimensions for the waterway transport channel as well as on river engineering and other development of the Danube." In the latter, the Danube Commission recommends a minimum depth of the waterway transportal route of 25 dm below LNRL for the free-flowing stretch east of Vienna.

In a memorandum on waterway transport dated 1992, the development of the Danube section east of Vienna to a channel depth of 32 dm to avoid a "structural bottleneck" on the Austrian Danube was planned by the Federal Government. However, given the fact that no further hydropower plants will be constructed on the Hungarian Danube, these arguments can no longer be raised.

Opposite to the navigable depth, the overhead clearances under bridges constitute numerous bottlenecks that are relevant to container shipping. This applies to four bridges on the Main river and on the Bavarian Danube that do not reach the required minimum height of 5.25 m for two-layer container transports; the same is true for the RMD waterway which does not secure the required overhead clearance for three container layers.

The Need for Measures

The eco-politically important transfer of goods from the truck to the inland waterway vessel primarily regards parcelled goods that have fundamentally different requirements for transport management than do the bulk goods traditionally carried by ship. The transport occurs by means of container or roll-on / roll-off vessels. *The main bottlenecks are not the draughts of the vessels but the overhead clearances of bridges.* The Austrian Danube already provides good conditions for the traditional transport of bulk goods. Bulk goods with a specific weight of less than 0.8 t/m³ (solid fuels, cereals and foodstuff / animal feed, forestry products, benzine / benzol and chemical products) may be carried on all important types of vessels in operation on the Austrian Danube on about 300 days / year, at a capacity utilisation of 100 %. At the moment, existing vessels are even being reconstructed for this purpose and to increase their cargo capacity. As they can be stored, more heavy goods (ores, metal products, minerals, building materials, fertilisers, heavy oils) may be transported in periods with favourable water levels, thus limiting productivity losses.

Inland waterway transport is presently in a stage of technological change and renewal which considerably increase the prospects for an ecologically compatible river transport. In the 1960's the objective was the development of waterways for larger vessels with deeper draughts carrying few bulk goods (especially on the Danube). Today, new ship-building technologies as well as new information and communication systems offer the possibility of increasing both productivity and interest of inland waterway transport without extending massive interventions in the riverine landscape. A re-orientation to other groups of goods also changes the requirements for inland waterway transport, i.e. more flexible, regular and frequent offers. This in turn demands closed logistics chains, where the emphasis is put on types of vessels showing the following characteristics: multipurpose use, high specialisation, integration in an information and communication network of the waterway, fleet and logistics management; draught is less important in this context.

The improvement of waterway transport systems, faster updates as well as better and more precise forecasts of water levels have about the same effect as an increase in the channel depth of about 10 % (in the area east of Vienna from 25 dm to 27 dm).

The Danube East of Vienna

Proceeding from the assumption that the Wachau, a Natura 2000 area and established UNESCO World Heritage Site, is to be considered as an decisive section with regard to the depth of the waterway transportal channel on the Austrian Danube, one may determine the losses in capacity if the section between Vienna and Bratislava is not developed to a channel depth of more than 25 dm. Only about 10 – 15 % of the traffic volume could benefit from an increasing in the channel depth east of Vienna – or alternatively would be disadvantaged if the development did not occur.

For these transports a total loaded draught may be guaranteed on 200 – 270 days / year (55 – 75 % of the year). As the whole loaded draught is, however, not used for every transport (lighter goods, smaller vessels with a smaller draught, partly loaded vessels at smaller carriage), only a maximum of 5 % of the transport volume would be negatively affected if the maximum development of 32 dm navigable water depth did not occur, compared to the present 25 dm. This would mainly affect the transport of heavy bulk goods, most of which, however, being characterised by their storability. Thus, they may be transported at favourable water levels and with an optimum utilisation of vessel capacities. *One may thus proceed on the assumption that the development of the Austrian Danube section east of Vienna would neither lead to remarkable increases in waterway transports, nor would a non-development lead to a loss of transported goods.*

The decision regarding the development of the waterway transport channel in this section has therefore primarily to be taken according to financial and ecological criteria (stabilisation of the river bed, raising of the water level, extend of the shallow water areas in the riparian zones etc.), provided that the conditions for waterway transport will not worsen compared with today. But the possible widening of the waterway transportal channel from 100 m to 120 m coming along with the stabilisation of the river bed will, by all means, be an improvement for waterway transport.

Conclusions

It is recommended that the Rhine-Main-Danube waterway be considered as a whole and that development standards be harmonised in line with those decisive river stretches which will be over long time stable. This corresponds to a target development standard of 25 dm navigable depth at LNRL (Low Navigation and Regulation Level: a depth that is available for 94% of the ice-free period). This standard allows to manage even ecologically sensitive sections without additional impounding dams, provided that small restrictions are accepted. On the Bavarian Danube, for instance, this would require a reduction of the navigable width at 70 m in some sections. A navigable depth of 25 dm can also be provided by means of technical river engineering measures along the Hungarian (Palkovicovo - Budapest), the Bulgarian (Belene) and the Romanian (Caragheorghe - Fermecatul) Danube.

For the Austrian Danube the present development standard of 25 dm waterway transport channel depth may then be considered as adequate. This strategy would constitute a turning away from the “maximum development paradigm”, orienting on a continuous impoundment chain, and would allow an ecologically compatible design of the waterway.

The measures for improving waterway transport should rather concentrate on better-elaborated waterway transport, information and communication systems. The establishment of an intelligent waterway, fleet and logistics management is prerequisite for the competition for goods that are presently largely carried by truck – "competition" that is both ecologically welcome and evoked by the shipping lobby. An intensified competition with rail for bulk goods by means of expensive and ecologically hardly compatible waterway development measures is appropriate neither from an eco-political, nor from a national economics point of view.

The “Comprehensive River Engineering Project” for the development of the Danube east of Vienna is thus to be evaluated primarily from an ecological and financial point of view: However, an extensive comparison of the ecological and financial consequences for different development variants (25 dm, 27 dm, 32 dm waterway transportal depth) is not available at the moment.

An agreement on a moderate development standard of the RMD waterway - orienting on those decisive river stretches which will remain as they are over long time and, at the same time, the optimised use of new information, communication and logistics technologies - offers the chance to link secured and predictable navigation water conditions for waterway transport with an ecologically compatible development of the riverine landscape. This could resolve the conflict between waterway transport being attractive for traffic and environment politics, and the protection goals for river and floodplain ecology.

1. Development Trends in European Inland Waterway Transport

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1.1. Development Up to Now

Transport capacity in the EU as a whole has considerably increased over the last decade. Inland waterway transport has also benefited from this fact, though to a lesser extent.

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Table 4: EU freight transport – transport capacity in billion tkm.

Transport category	1993		1997		Difference	
	tkm	%	tkm	%	tkm	%
Truck	955	74	1 221	74	+ 266	+ 28
Rail	158	12	236	14	+ 78	+ 49
Inland waterway vessel	101	8	118	7	+ 17	+ 17
Pipeline	76	6	85	5	+ 9	+ 12
Total	1 290	100	1 660	100	+ 370	+ 29

Source: Federal Ministry of Transport, Building and Housing, Verkehr in Zahlen 2000, Hamburg, 2000.

In the long term, however, the market share of inland waterway transport is continuously decreasing:

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Table 5: Market share of inland waterway transport in German domestic transport in % (except short distance road service).

	1960	1970	1980	1990	1997[1)]
Truck	22	24	38	48	62
Rail	43	40	31	25	19
Inland waterway vessel	32	27	24	22	16
Pipeline	3	9	7	5	3
Total	100	100	100	100	100

[1)] including the former FRG
Source: Federal Ministry of Transport, Building and Housing, Verkehr in Zahlen 2000, Hamburg, 2000.

Inland waterway transport suffered a particular fall on the Danube in Eastern European countries.

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Table 6: Development of inland waterway transport on the Danube in Eastern Europe in 1.000 t.

	1980	1990	1998
Slovakia	3.750	5.510	4.985
Hungary	11.098	13.223	3.706
Yugoslavia	15.768	10.628	4.519
Bulgaria	9.292	3.537	905
Romania	18.772	10.264	4.592
Ukraine	19.507	19.847	6.090
Total	78.187	63.009	24.797

Source:UN, Annual Bulletin of Transport Statistics for Europe and North America 2000, New York and Geneva, 2000.

This drop is due to various reasons:

- Economic changes after the collapse of the centrally planned economies together with a decrease in economic performance, a fall in the heavy industry and a reorientation of economic exchange relations within Eastern Europe, and between Eastern and Western Europe.
- The end of the state-controlled transportation market with modal split transfers to the benefit of the truck.
- The political crises, with the Yugoslavian economic embargo, the toll charges on the Yugoslavian Danube and the obstruction of waterway transport caused by collapsed bridges as a result of NATO bombings.

This is why the present data regarding freight transport on the Danube river give a distorted picture and are not representative. Despite these circumstances, both the volume of freight traffic and goods waterway transport service have increased over the last years on the Austrian Danube.
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Table 7: Development of ship freight transport on the Austrian Danube.

Year	Transport volume in mio. t	Transport capacity in billion. tkm
1960	6.2	0.9
1970	7.6	2.4
1980	7.6	7.2
1990	8.1	9.0
1995	8.8	8.2
1999	10.0	8.6

Source:Statistik Austria: Statistisches Jahrbuch der Republik Österreich, 2001.

This increase in transport volume has to be attributed to the opening of the RMD-waterway in 1992. The losses caused by the Balkan crisis have been more than overcompensated for by traffic growth in the Rhine region. About 3.4 mio. tons have been transported on the RMD canal either from or to Germany, the Netherlands, Belgium, France and Switzerland (Statistik Austria, 2000). This shows that a normalisation of the situation in Eastern Europe would bring about considerable potential for waterway transport on the Danube. Irrespective of this, waterway transport is much less important to Austria's transport economy than to the German one: merely 4 % of the transport volume (not counting short distance traffic and airfreight) are transported by inland waterway vessels (ÖSTAT, 1994), compared to ca. 16 % for Germany.

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Table 8: Transport volume in Austria by form of transport in 1994[1)] (not counting short distance freight service on roads and airfreight).

	Mio. tons	%
Road	64.37	34.1
Rail	62.81	33.3
Vessel	7.71	4.1
Pipeline	53.79	28.5
Total	188.67	100.0

1) after 1994, given a change in the data collection method, the total transport volume may only be shown in part (without the voyages and volume of foreign vessels) and inclusive of short-distance freight service on roads

Source:ÖSTAT, Güterverkehrsstatistik 1994, Vienna, 1995.

The structure of the transported goods is dominated by bulk goods:

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Table 9: Groups of goods carried by inland waterway transport on the Austrian Danube in 1.000 t.

NSTR- [1] groups of goods	1984		1989		1994		1999	
	abs	%	abs	%	abs	%	abs	%
Agricultural products	338.5	4.2	664.9	7.2	324.5	4.2	836.2	8.3
foodstuff and animal feed	79.8	1.0	191.8	2.1	751.6	9.8	1412.5	14.1
Solid mineral fuels	1640.3	20.3	1767.3	19.3	297.7	3.9	295.9	3.0
Oil products	1336.7	16.5	1351.8	14.8	1257.2	16.3	2037.5	20.4
Ores and metal waste	2118.7	26.2	2391.9	26.2	2724.4	35.4	2773.2	27.8
Metal products	1588.4	19.6	1329.9	14.5	866.2	11.2	997.0	10.0
Building mineralsand material	228.1	2.8	560.4	6.1	464.9	6.0	734.0	7.3
Fertilisers	343.7	4.2	622.5	6.8	830.3	10.8	804.8	8.1
Chemical products	242.5	3.0	118.4	1.3	73.2	0.9	76.8	0.8
Semi-finished and finished goods	177.1	2.2	146.6	1.6	116.0	1.5	202.2	2.0
Total	8093.9	100	9145.4	100	7705.9	100	9986.6	100

1) Standardised list of goods for transport statistics

Source:ÖSTAT: Güterverkehrsstatistik 1984 – 1999, Vienna.

Inland waterway transport mainly realised its traffic function in long-distance transport. The average transport distance on the Danube was 875 km in 1999 (ÖSTAT, 2000). This is why rail is the main competitor in the transport market. However, the majority of these goods that traditionally have been carried by rail or vessel are in branches of trade that are not growing:

- The use of solid fuels is stagnating or is decreasing.
- The transport of liquid products has partly been transferred to pipelines over the last decades.
- The use of fertilisers is decreasing.

Compared to the Rhine, competition with rail is much stiffer on the Danube river, given that industrial sites are not, with a few exceptions, situated along the waterway and direct transport is the exception rather than the rule. Growth markets for traditional bulk goods could be “agricultural goods” and “foodstuffs”, as, in the case of an EU-enlargement to the East, trade barriers could be further reduced in this branch. A further growth impulse may only be expected if, besides goods traditionally typical for ship transport, products from the groups “chemical products” and “finished and semi-finished products” can be directed to the waterway as well.

In Germany this goal has been reached during the last ten years through an expansion of container waterway transport:

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Table 10: Development of the volume of goods on the Rhine in mio. tons.

NSTR-groups of goods	1991		1999	
	abs	%	abs	%
Agricultural and forestry products	7.9	3.4	9.8	4.3
foodstuff and animal feed	12.3	5.3	14.6	6.4
Solid mineral fuels	26.8	11.7	30.8	13.4
Oil products	42.0	18.3	38.3	16.7
Ores and metal waste	41.8	18.2	35.2	15.3
Metal products	13.1	5.7	12.0	5.2
Building minerals and materials	60.2	26.2	52.5	22.9
Fertilisers	6.3	2.7	7.7	3.4
Chemical products	15.5	6.7	18.2	7.9
Semi-finished and finished products	4.1	1.8	10.1	4.4
Total	230.0	100	229.1	100

Source: Federal Ministry of transport, building and housing, Verkehr in Zahlen 2000, Hamburg, 2000.

Whilst the share of heavy bulk goods has decreased by about 14 mio. tons (7.3 %), the share of agricultural and forestry products as well as of foodstuffs has increased by 4.2 mio. tons (20.8 %). Chemical products, semi-finished and finished products have even increased by 8.7 mio. tons (44.4 %). These products thus represent 12.3%, while on the Danube, they only represent 2.8 %, and thus range below the share obtained in 1984.

The beginning of structural change on the Rhine river is closely related to the expansion of container waterway transport, roll-on / roll-off transport and to the use of flexible multipurpose vessels. These branches of higher processed parcelled goods may compete with long-distance truck transport and the advantages of waterway transport, i.e. its environmental impact, take full effect.

1.2. Future Perspectives

Numerous forecasts regarding inland waterway transport on the Danube river are available. They range from forecasts that start from a status quo of infrastructure on the one hand to those considering changes of navigable water depth, port capacity or other infrastructural changes on the other (see table 11).

The forecasts for Danube waterway transport, with the exception of the EUDET study, predict a considerable increase in transport even without further waterway development measures.

The EUDET study also compares the forecast based on the status quo with scenarios of expanding the infrastructure. These forecasts are based on the assumption of improved harbour infrastructure, above all in Eastern Europe, and of a further developed waterway Kelheim and Budapest. The EUDET study makes the assumption that:

- Between Kelheim and Linz the Danube will be developed to a water depth of 2.5 m. According to German Waterways and Shipping authorities at least two impoundments have to be constructed on the Bavarian Danube for this purpose.
- Between Linz and Budapest the Danube will be developed to a draught of 2.7 m. This corresponds to a navigable water depth of 3.2 m and would imply dramatic development measures in the Wachau area, east of Vienna, and on the Hungarian river section.

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Table 11: Goods transport forecasts for the Austrian Danube with an unaltered infrastructure in mio. tons.

Forecaster		Year of Forecast	
	1999	2010	2015
ROSINAK / SNIZEK 1991	10.0	17.1	1)
ÖIR 1995	10.0	18.3	23.5
HERRY / SNIZEK 1998	10.0	17.6	21.8
EUDET 1999	10.0	12.8	1)

1) no forecast carried out

Sources: *Rosinak, W., Snizek, S.: Güterverkehr in der Ostregion – Conditions und Handlungsbedarf, Vienna, 1991.*
ÖIR: Beiträge zur Planung des Nationalparks Donauauen-Schifffahrt, Vienna, 1995.
Herry, M., Snizek, S.: Schienengüterverkehrsprognose für 2015, i.A. d. ÖBB, Vienna, 1998.
EBD, Impetus Consultants, ÖIR: Evaluation of the Danube Waterway as a Key European Transport Resource (EUDET), Duisburg, Athens, Vienna, 1999.
Statistik Österreich: Güterverkehrsstatistik 1999, Vienna, 2000.

Given the legal and political conditions (see chapter B.2), these development measures have to be considered as unrealistic until 2010. Moreover, in the Wachau area, non-solvable conflicts regarding the conservation regulations of Natura 2000 and UNESCO-World Heritage are to be expected. The effect of the forecasted development measures may however only be reached in the case of a total development on the planned scale. This is justified by the great transport distances of inland waterway transport (an average of 800-1000 km on the Danube).

The EUDET study presents the following forecast results:

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Table 12: Forecast of freight transport volume on the Austrian Danube in mio. tons.

Forecast variants	1999	2010
Status quo	10.0	12.8
Variant waterway development	10.0	17.9
Variant port development	10.0	16.0
Variant waterway and port development	10.0	21.4

Source: EBD, Impetus Consultants, ÖIR: Evaluation of the Danube Waterway as a Key European Transport Resource (EUDET), Duisburg, Athens, Vienna, 1999.
Statistik Österreich: Güterverkehrsstatistik 1999, Vienna, 2000.

The determination of the effect that the waterway development would have on the future transport volume is derived from a generalised cost function, which assumes a basic demand for maximum possible loaded draught. This, however, ignores the fact that future growth markets are those of light bulk goods (agricultural products, foodstuffs) and parcels (semi-finished and finished goods, container transport), and that for these goods the navigable water depth is of little importance. We assume that these forecasts underestimate the potential for inland waterway transport on the Danube for the case that no further development measures will be taken, and that they overestimate the effect of higher draughts.

1.3. Conclusions

European inland waterway transport as a whole is stagnating and losing market shares. However, despite the crises and problems in the Balkan area, the volume of Danube waterway transport has increased. This must be attributed to the opening of the Rhine-Main-Danube canal. A lasting improvement of the situation in Eastern Europe will thus lead to considerable increases in the transport volume on the Danube even if the waterway is not subject to further development measures. The stagnation of the transport volume for bulk goods that have traditionally been carried by vessel (solid fuels, oil products or fertilisers) may be compensated by goods of the parcel market (chemical products, semi-finished and finished goods). Rhine waterway transport is a good example of this. To reach this aim, however, above all the container transport (which still plays a secondary role on the Danube) has to be developed. But for these 'new' kinds of goods to be transported a deepening of the navigation channel is of little importance.

2. Political and Legal Conditions

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2.1. The Transport Policy of the European Union for Inland Waterways

The transport policy for inland waterways is determined by a number of measures that have been approved by the Council of Ministers on 11th November 1996, on the proposal of the former Transport Commissioner Neil Kinnock:

(1) Step-by-step liberalisation of the inland waterway transport market, abolition of the rota system in Belgium, France and the Netherlands by 1.1.2000 – i.e. the end of a freight assignment at fixed prices according to the first-come-first-serve principle.

(2) Reduction of structural surplus capacities by means of a temporary action of structural adjustment in 1996 – 1998. In this way, surplus dead weight of vessels could have been reduced by 15 % and productivity could have been increased. This action has, however, been delayed for four more years.

(3) Inland waterway transport is supported with subsidies of up to 50 % by the member states, in order to support investments in the infrastructure of transshipment sites or

investments in local or mobile transshipment facilities, that are necessary for the loading or unloading of inland vessels. This provision was valid until 31.12.1999.

(4) Co-ordination of the development of a trans-European inland waterway network within the frame of the Trans-European Transport Network (see also chapter B.2.2.3).

Moreover, during recent years many efforts have been made aimed at the harmonisation of legal conditions for inland waterway transport. Among others:

- Directive on a harmonisation of conditions for the acquisition of the boat master licence;
- Development of a uniform European boat master licence;
- Revision of the 1982 directive on technical regulations for inland waterway vessels;
- Directive for dangerous goods transports on inland waterways.

In 1992 the Commission was given a mandate from the Council of Ministers to negotiate and conclude multilateral agreements with the Central and Eastern European states to establish open and harmonised European inland waterway transport. Adaptation and harmonisation is to be completed in the course of accession negotiations.

The EU-policy on inland waterway transport firstly aims at market liberalisation, market regulations and at the harmonisation of legal framework conditions. In questions regarding the standards of waterway development the EU acts according to international agreements:

- Economic Commission for Europe (ECE): European Agreement on Main Inland Waterways of International Importance (AGN), 1996.
- Danube Commission: Recommendations regarding the establishment of regulations for the navigation channel as well as for the river engineering and other development of the Danube, 1988.

2.2. Political and Legal Conditions for the Development of the Danube Waterway

This section presents the topical political and legal conditions applying to the development, standards of the Danube waterway. Statements regarding the development standards of the Danube are found with varying commitment and different parameters in differing documents. Commitments are made for the depth of the navigation channel, the draught of the vessels, the width of the shipping lane, the channel curve radius, the lock dimensions, the minimum height and width under bridges and cables. The following description is confined to the standards of the Danube waterway which are limiting the use and presently very controversially discussed. These standards apply mainly to the depth of the navigation route, the draught of vessels and the overhead clearance under bridges.

2.2.1. Recommendations of the Danube Commission

In 1988 the Danube Commission passed the “Recommendations regarding the establishment of standards for the navigation channel as well as for the river engineering and other development of the Danube”. They determine the minimum depth of the navigation channel during LNRL (Low Navigation and Regulation Level), or the lowest impounded water level. LNRL is the minimum water level available for 94% of time, based on a period of 40 years of monitored discharges (except for ice periods). The following minimum depths are recommended:

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Table 13: Recommended minimum depths of the Danube waterway below LNRL in dm.

River section	Impounded area		Area with free-flowing conditions	
	Gravel ground	Rocky ground	gravel ground	rocky ground
Kelheim – Regensburg	27	28	-	-
Regensburg – Kachlet	27	28	18,5	19,5
Kachlet – Vienna	27	28	20	21
Vienna – Braila	35	35	25	25

Source: Danube Commission: Empfehlungen bezüglich der Aufstellung von Regelmaßen für die Schifffahrrinne sowie den wasserbaulichen und sonstigen Ausbau der Donau, Budapest, 1988.

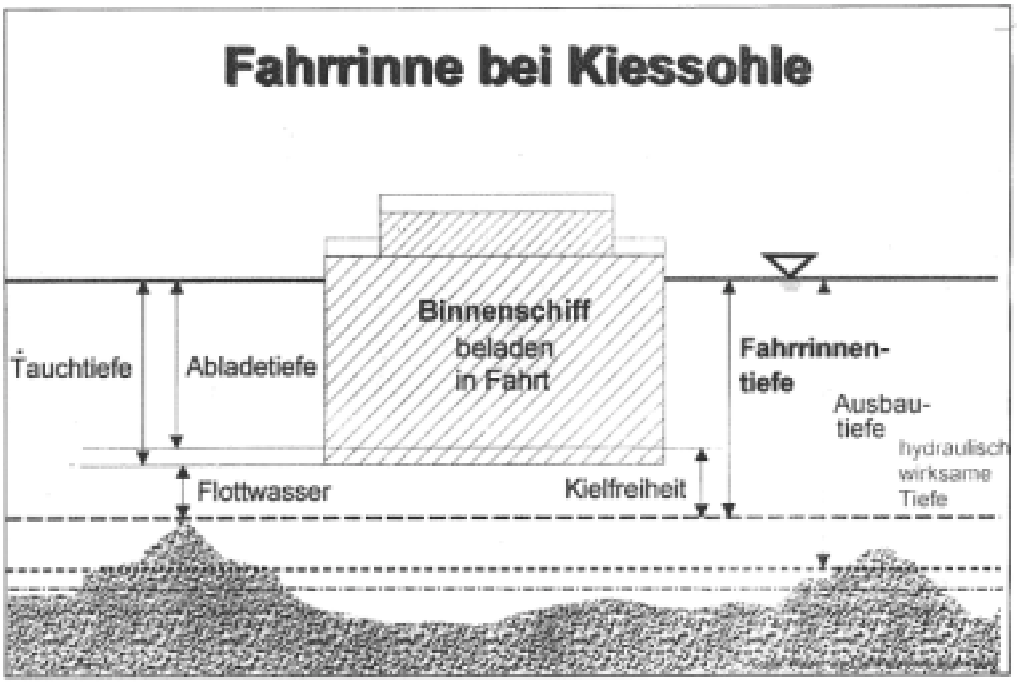
The Danube Commission makes no statement on the draught of vessels. The following assumption is used for the calculation of draught from the depth of the navigation channel:

- The total draught is composed of the loaded draught (immersion of the vessel) and a draught addition for dynamic effects during the navigation of the loaded ship (negative surge, trimming). This draught addition is of about 1 dm.
- The necessary net under keel clearance (water depth between the bottom edge of the navigating vessel and the river bed) is about 4 dm.

The permissible total draught of the vessels is thus calculated by the depth of the navigation channel, minus 4 dm. If a vessel has a loaded draught one has to add 5 dm to obtain the required depth of the navigation channel. This method, used to establish the relation between loaded draught, total draught and depth of the navigation channel is a constant subject of debate. Different values are indicated depending on ground (rocky, gravel) and the service level of the waterway (free-flowing section, free-flowing section with bed protection, impoundment). Furthermore, the relation between loaded draught, total draught and depth of the navigation channel is calculated as follows:

- The possible draught is calculated by the depth of the fairway minus 4 dm (net underkeel clearance).
- The necessary depth of the navigation channel is calculated by the draught (loaded draught) plus 5 dm (draught addition and net underkeel clearance).

Fig. 11: Depth of the navigation channel ("Fahrrinnentiefe") for a gravel riverbed "(Kiessohle"): loaded draught ("Abladetiefe"), negative surge ("Flottwasser"), total draught ("Tauchtiefe") for a loaded inland vessel when navigating ("Binnenschiff beladen in Fahrt").



Source: Waterway and shipping office Regensburg

The calculation method used is that of the Austrian Waterw ays Authority (Wasserstraßendirektion WSD). Except for the sections Regensburg – Kachlet, Palkovicovo – Budapest, and some spots w ith low w ater levels on the Bulgarian and Romanian stretch, the values recommended by the Danube Commission can be adhered to. On the free-flow ing sections of the Austrian Danube, 25 dm even below LNRL may be guaranteed (WÖSENDORFER, 2001).
The follow ing overhead clearances are recommended under bridges:

Table 14: Recommendations for overhead clearances under bridges and existing bottlenecks (m beyond the highest navigable water level = HWL).

Section	Recommendation (m beyond HWL)	Presently lowest overhead clearance (m)
Kelheim – Regensburg	6.4	5.25
Regensburg – Kachlet	7.5	4.42
Kachlet – Vienna	8.0	6.65
Vienna – Devin	10.0	6.70[1)]
Devin – Braila	9.5	6.70[1)]

1) Bratislava, Budapest

Source: EBD, Impetus Consultants, ÖIR: Evaluation of the Danube Waterway as a Key European Transport Resource (EUDET), Final Report 1999

For every section there are some bridges that do not reach the recommended overhead clearance (see also chapter B.3.2.)

2.2.2. European Agreement on Main Inland Waterways of International Importance

In 1996 a “European Agreement on main inland waterways of international importance” (AGN) was concluded within the frame of the ECE. It comprises a “co-ordinated plan” for the development and extension of the European network of inland waterways, which is to be implemented by the contracting parties within the frame of their action programmes. In an appendix, the relevant technical service standards which need to be reached are defined (see table 15). In contrast to the recommendations of the Danube Commission, these data concern the draught of the vessels but not the depth of the navigation channel. The recommended development standards were confirmed in the Declaration of the Pan-European Conference on Inland Waterway Transport in September 2001 in Rotterdam by 19 European ministers of transport, the European Parliament and the European Commission.

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Table 15: Survey of the minimum requirements for technical and operational characteristics of inland waterways of international importance.

Type of development		Development class	Minimum draught in dm		overhead clearance in m
			240 days / year	360 days / year	
free-flowing section	existing waterways	IV	25	12	5.25
	after modernisation	Va	25		5.25
after new construction 1)		Vb		28	5.25

1) New construction is interpreted as a new building of a waterway, i.e. basically as the building of a canal. On the other hand, the modernisation is understood as a reconstruction of already existing European waterways by river-regulating measures or impounding dams.

Source: ECE: European agreement on main inland waterways of international importance, Geneva, 1996.

The development classes IV, Va and Vb mainly differ from one another for the maximum length and width of the vessels, as well as for the draught and cargo freight ranges of the vessels (see classification table no. 16). Vessels are classified according to their outline dimensions. Possible draughts and overhead clearances may vary most of all for free-flowing rivers within the given ranges, but they do not influence their classification.

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Table 16: Classification table of European inland waterways.

CLASSIFICATION OF EUROPEAN INLAND WATERWAYS OF INTERNATIONAL IMPORTANCE */

Type of inland waterways	Classes of navigable waterways	Motor vessels and barges – Type of vessel: General characteristics					Pushed convoys – Type of convoy: General characteristics					Minimum height under bridges 2/	Graphical symbols on maps
		Designation	Maximum length	Maximum beam	Draught 5/	Tonnage		Length	Beam	Draught 5/	Tonnage		
			L(m)	B(m)	d(m)	T(t)		L(m)	B(m)	d(m)	T(t)	H(m)	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
OF INTERNATIONAL IMPORTANCE	IV	Johann Welker	80-85	9.5	2.50	1,000-1,500		85	9.5 5/	2.50-2.80	1,250-1,450	5.25 or 7.00 4/	
	Va	Large Rhine vessels	95-110	11.4	2.50-2.80	1,500-3,000		95-110 1/	11.4	2.50-4.50	1,600-3,000	5.25 or 7.00 or 9.10 4/	
	Vb							172-185 1/	11.4	2.50-4.50	3,200-6,000		
	VIa							95-110 1/	22.8	2.50-4.50	3,200-6,000	7.00 or 9.10 4/	
	VIb	3/	140	15.0	3.90			185-195 1/	22.8	2.50-4.50	6,400-12,000	7.00 or 9.10 4/	
	VIc							270-280 1/ 195-200 1/	22.8 33.0-34.2 1/	2.50-4.50 2.50-4.50	9,600-18,000 9,600-18,000	9.10 4/	
	VII						6/	275-285	33.0-34.2 1/	2.50-4.50	14,500-27,000	9.10 4/	

*/ Classes I - III are not mentioned in this table, being of regional importance.

Exceptions from the given minimum requirements for both the minimum draught and the minimum overhead clearance under bridges are possible for existing waterways. The values regarding the modernisation of existing waterways and the reconstruction of waterways are recommended "target values".

For the waterway reconstruction, no distinct requirements for the depth of the navigation channel depth can be derived. This is because the demanded draught does not refer to the LNRL but to a period of 240 days / year, without giving details on the duration of the measuring period.
The Austrian Danube may in any case be qualified as an existing waterway with free-flowing sections on the Wachau and east of Vienna. The following regulations of the AGN agreement are considered to be relevant with regard to further development requirements:

(ii) Only those waterways that meet the minimum requirements of class IV (minimum vessel dimensions 85 m x 9.5 m), are European waterways. Limitations of the draught (less than 2.5 m) and the minimum overhead clearance under bridges (less than 5.25 m) are possible for existing waterways and in exceptional cases.

(iii) In the case of a modernisation of a class IV waterway (as well as of narrower regional waterways) it is recommended to at least come up to the requirements of class Va.

(viii) On free-flowing river waterways the recommended value of the navigation channel depth has to be guaranteed for at least 240 days / year (or for 60 % of the navigation period). As far as it is feasible and economically wise, the recommended value of the overhead clearances under bridges (5.25, 7.00 or 9.10 m) should be warranted for the highest navigable water level.

Source: ECE, European agreement on main internal waterways of international importance (AGN), Appendix III, Technical and operational characteristics of inland waterways of international importance, Geneva 1996.

The assignment of the Austrian Danube sections to the ECE classification is shown in the following illustration:

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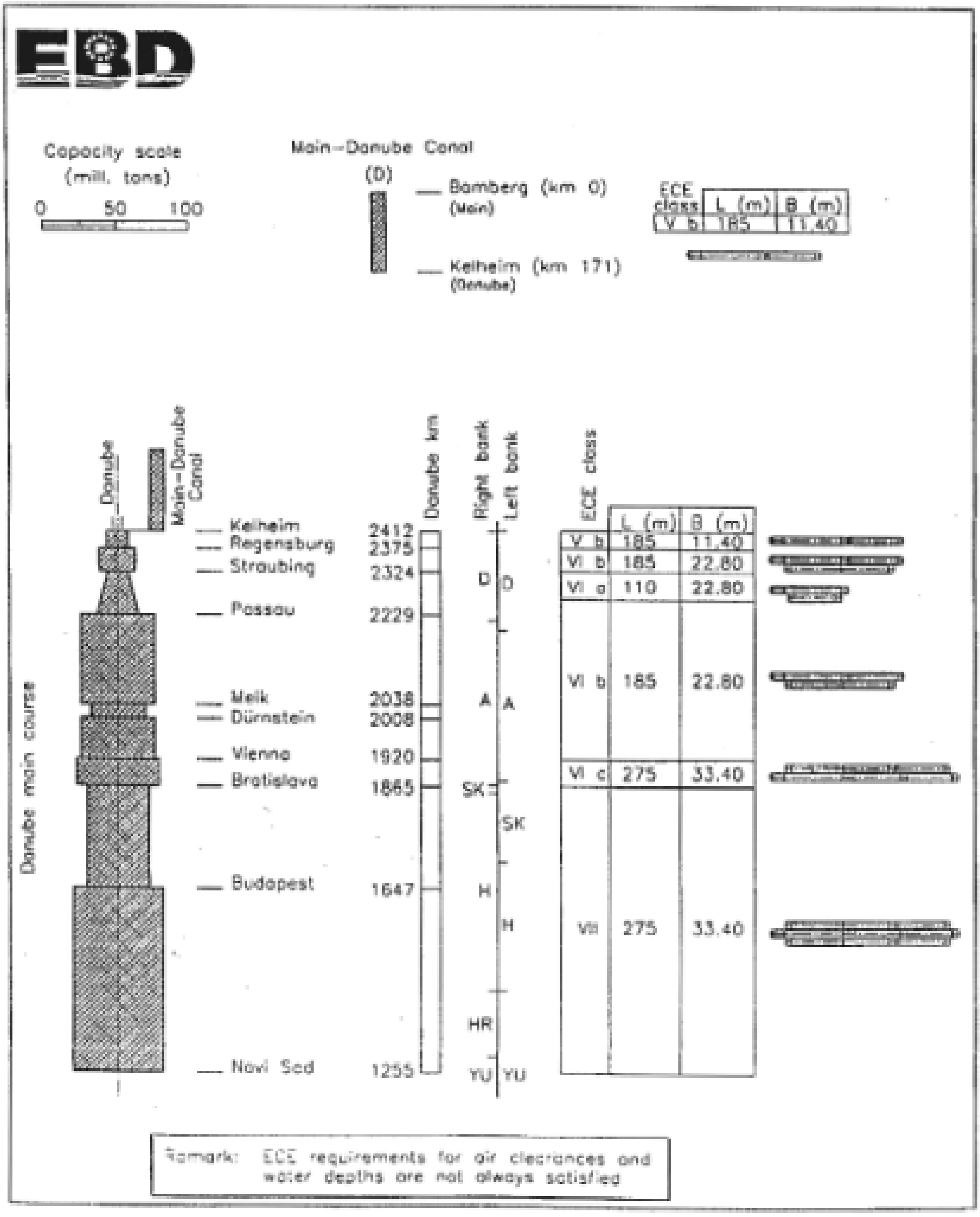
Fig. 12: Capacities and ECE classification of the Danube between Kelheim and Novi Sad.



The Austrian Danube corresponds to the waterway classes VIb (Passau – Vienna) and VIc (Vienna – Bratislava). The required minimum draught and minimum air clearances are met. On the Bavarian Danube, however, the requirements for the minimum draught are only partly met: 25 dm draught are reached on about 40 days (KLEEMEIER, 1999), whereas 12 dm draught may be obtained on 360 days / year. Moreover, two bridge passages do not correspond to the required minimum norm of 5.25 m air clearance (see also chapter 3).

2.2.3. Guidelines for the Development of a Trans-European Transport Network

In 1996, "Directive number 1692/96/EG of the European Parliament and the Council dating July 23rd 1996 on common guidelines for the establishment of a Trans-European Transport Network" (TEN-T) was passed. The purpose of this directive is the establishment of a common framework for the co-ordination of the expansion of transport networks in every member state. Provision of funds, setting of priorities and implementation are still demanded of the individual member states. The transport infrastructure includes road, rail and inland waterway networks, sea and river ports, airports and further node points. Moreover, transport management, locating and navigation systems are also part of the TEN-T. Article 11, paragraph 2 states the following commitments for the expansion of the inland waterway network:

(2) The inland waterways of this network have to respond at least to the technical requirements of class IV, i.e. they have to guarantee the passage of a vessel or a pushed convoy of a length of 80 – 85 m and a width of 9.50 m. If a waterway is expanded or newly constructed and included in this network, the technical specifications have to at least respond to class IV. Later on, the possibility must be provided to meet the requirements of class Va / Vb and to sufficiently allow for the passage of vessels used in combined transport. The waterway class Va allows the passage of a vessel or pushed convoy of a length of 110 m and a width of 11.40 m, as well as the class Vb of a pushed convoy with a length of 172 to 185 m and a width of 11.40 m.

The directive states no further details on the depth of the navigation channel, or on the draught of the vessels. The reference to inland waterway classes is an indirect statement on the draughts, which are regulated by the "European Agreement on main inland waterways of international importance". The Danube is an integral part of the TEN inland waterway network.

2.2.4. Pan-European Transport Corridors

At the European Conferences of Transport Ministers held in Crete in 1994 and in Helsinki in 1997, transport corridors were defined for the Central and Eastern European countries (CEE corridors), supplementing the TEN of the EU states and connecting them to the TEN network. The Danube is one among ten corridors (corridor VII). For each corridor, a so-called "corridor management" has been established. The Danube corridor co-ordination is managed in Vienna. Three working groups have been established to elaborate a common "Memorandum of Understanding" of all the riparian states of the Danube. The three working groups are:

- the "infrastructure" group under Romanian leadership
- the "operational" group under Austrian leadership
- the "fleet" group under Hungarian leadership.

The work of the corridor management rests upon existing international agreements of the Danube Commission and the ECE. Regulations on a further development of the waterway reaching beyond the present agreements do not exist.

2.2.5. Memorandum of the Austrian Federal Government on Inland Waterway Transport

In 1992, on the occasion of the opening of Eastern Europe and the completion of the Main-Danube Canal, the Minister of Public Economy and Transport presented a "Memorandum on Inland Waterway Transport" to the Council of Ministers. This memorandum has been noted approvingly and serves, together with the "Presentation to the Council of Ministers", as an instruction to the responsible authorities to further advance Danube development. It comprises the following initiatives:

- *The Danube has to become a reliable transport route. In Austria an immediate measure is the improvement of the Danube section downstream from Vienna by means of ford dredging to obtain, as soon as possible, a water depth of 2.50 m at LNRL (low navigation and regulation level) which should be secured by efficient waterway management. This measure had already been decided by the Danube Commission in 1962.*
- *In the medium term the development of the Austrian Danube has to be organised in a way to avoid structural bottlenecks in Austria. As regards the conditions of the navigation channel along the whole Rhine-Main-Danube waterway, international consent has to be striven for. As a result of the development measures carried out in neighbouring countries, this route should finally allow a draught of 2.70 m for LNRL.*

Another objective is the establishment of a scheduled container service on the Danube that should be supported by a so-called "Wasserkombi".

Of the plans mentioned the immediate measures guaranteeing a water depth of 2.50 m east of Vienna have already been implemented. The "European Agreement on main inland waterways of international importance" also fostered international consent with regard to the whole Rhine-Main-Danube waterway. Preliminary work has been achieved by several EU-co-financed projects for the sake of an efficient waterway management: establishment of the "Wasserkombi", establishment of a regular container service but which has already been dropped due to a lack of demand. Meanwhile, the "Wasserkombi" has also been given up.

The medium-term objective of avoiding structural bottlenecks for waterway transport in Austria has been reached, thanks to river engineering rehabilitation measures on the Wachau and east of Vienna.

According to the waterway transport memorandum, the planned final development up to a water depth of 2.70 m is only necessary if jointly reached with the neighbouring countries. Neither Bavaria (discussing the development for a maximum depth of the navigation channel of 2.50 m) nor Hungary (river engineering rehabilitation measures between Palkovicovo and Budapest) are striving for a comparable draught at LNRL in the short term. There is thus no urgent need for action.

2.2.6. National Park Law

In the course of the establishment of the Danube Floodplains national park, a contract has been concluded between the Federation and the federal states of Lower Austria and Vienna according to article 15a B-VG. It comprises the following agreements on waterway transport in the national park area:

"The function of the Danube as an international waterway is to be guaranteed for an undisturbed operation of waterway transport. The länder Vienna and Lower Austria will

ensure that adequate measures regarding the following points will not be subject to the respective national park laws: maintenance and operation measures as well as necessary regulation measures, especially regarding the improvement of the shipping route conditions up to a loaded draught of 2.7 m at LNRL."

The agreement determines the maximum admissible developmen standard but this does not mean an obligation to actually implement such development dimensions. However, claims do arise regarding a review of the adequateness of the methods used to obtain a loaded draught of a maximum of 2.7 m. Notwithstanding this regulation, the stipulations of conservation law and the laws of Environmental Impact Studies are still valid.

2.2.7. Further National Commitments of the Riparian States of the Danube

Germany

A spatial master plan for the development of the Bavarian Danube with two impoundments and a waterway transport canal was started in 1992. In 1996, this plan had to be suspended to clarify unsettled questions. On 17th October, 1996, the two contractees, i.e. the Federation and Bavaria, agreed that, considering both the financial situation and transport economic and ecological objectives, the development of the Danube should be realised in two steps:

(1) Securing of a water depth of 20 dm at LNRL, by means of river engineering rehabilitation measures. These works have mainly been completed (Schiffahrt und Strom, no. 170, 5/6/2000).

(2) Examination of variants, aiming at a greater depth of the navigation channel.

For the Bavarian Government this means a development up to a loaded draught of 25 dm (Schifffahrt und Strom, no. 166, 171). However, the recommendations of the Danube Commission do not state anything about the loaded draught but merely refer to the navigation channel depth. Another point to be clarified is the question of whether this requirement refers to the ECE Agreement on main inland waterways where the draught has only to be guaranteed on 240 days / year, or whether it refers to the LNRL, securing a 94 % security as for the depth of the navigation channel.

The studies on the development of the Bavarian Danube have been completed meanwhile, presenting four planning variants. For variants with two respectively three barrages a loaded draught of 2.5 m may be guaranteed. With the construction of one barrage the water level may be increased to 2.4 m. If no barrages are constructed, a minimum waterway channel depth of 2.2 m may be reached (Schifffahrt und Strom 2001). According to calculations by BERNHART (1998, 1999), a depth of the navigation channel of 2.5 m below LNRL '97 together with a channel width of 70 m (at the Isar estuary it is limited to 60 m) may also be obtained with the exclusive use of river regulation measures. A final clarification of the development measures is still pending. See also chapter A.3.1.

Slovakia

After the completion of the Gabcikovo barrage no development projects are presently planned in Slovakia.

Hungary

In 1992, Hungary elaborated a three-step-programme for the improvement of waterway transport conditions between Esztergom and Vác. The bottlenecks between the Gabcikovo power plant and Budapest will be reduced by means of river engineering and dredging measures. In the first phase a water depth of 2.10 m to 2.30 m for a width of 80 m should be obtained on 240 days / year. The objective of the second phase is a navigation channel depth of 2.50 m for a width of 80 m on 240 days / year. Beyond the year 2005 the recommendations of the Danube Commission (2.50 m depth of the navigation channel below LNRL) should be realised (EUDET, 1999). A river engineering development concept including a stabilisation of the river bed does not, however, yet exist and is not even under development. The construction of barrages is no longer planned.

Yugoslavia
The problems existing on the Yugoslavian Danube are not caused by the conditions of the channel but occured as a result of the war (collapse of bridges) and the reactions of the Yugoslavian government to the economic embargo (passage tolls). However, the reconstruction of bridges offers the opportunity to improve the overhead clearance under the bridge of Novi Sad and thus to eliminate a bottleneck for container transport on the lower Danube.

Bulgaria and Romania
In the years 1999/2000 a Phare study “Study to improve navigation on the Danube in Bulgaria and Romania“ was commissioned. The objective of the study was to control the technical and economic use of river engineering measures to improve navigability and shorten the travel time. This development occurred in the frame of the signing of the contract of the “European Agreement on main inland waterways of international importance” by Romania and Bulgaria. The study analyses waterway transport problems on the Bulgarian and Romanian Danube, recommending river engineering measures for securing a navigation channel depth of 25 dm below LNRL and further steps.

2.2.8. Conclusions

The existing political and legal conditions provide extremely differing information on the development of the Danube waterway (depth of the navigation channel, draught, time required to fulfil the norms). Nevertheless, the Austrian Danube responds to all agreed and recommended minimum norms and does not, even in the medium term (in the next 20 years), represent a structural bottleneck.

It is supposed that the general improvement of waterway transport conditions, scheduled in the Belgrade Danube Convention in 1959 and carried on by the Danube Commission with subsequent resolutions for the Danube section downstream Vienna, is now obsolete. They tried to obtain 35 dm below LNRL by the construction of a continuous chain of impoundments, but there is no obligation any longer to achieve this depth of the navigation channel without impoundment. Free-flowing river sections are thus subject to the “Recommendations regarding the establishment of regulations for the navigation channel as well as the river engineering and other development of the Danube”, decided by the Danube Commission in 1988.

The political and legal conditions indicate a change in the future development standards of the Danube waterway. The maximum development, initially based on a chain of power plants of various dimensions on the upper course (27 dm depth of the navigation channel up to Vienna) and the lower course of the river (35 dm depth of the navigation channel downstream Vienna) should be replaced by an - as good as possible - homogeneous development of 25 dm navigation channel depth for the entire waterway. These dimensions are also compatible with the decisive river stretches on the Rhine (see also chapter B.3.1).

3. Development Status of the Rhine-Main-Danube Waterway

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The main limitations of the Rhine-Main-Danube waterway are the possible draught and the overhead clearance of the bridges. Shipping interests are:

(1) predictable, at best homogeneous navigable waters,
(2) the highest possible loaded draught of the vessels,
(3) the highest possible overhead clearances under bridges.

3.1. Navigable Water Depth and Draught of Vessels

At present, the Rhine-Main-Danube waterway is determined by the following decisive river sections as to the depth of the navigation channel.

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Table 17: Bottlenecks of the navigation channel depth along the RMD waterway.

River section	Length in km	EWL [2)] or LNRL [3)] in dm	Minimum availability in days/year	
			25 dm navigable water	25 dm draught
Rhine Koblenz – St. Goar (D)	35	21	315	265
Rhine St. Goar – Budenheim (D)	49	19	300	250
Rhine Budenheim–Mouth of the Main	9	21	315	265
Danube Straubing – Vilshofen (D)	68	20	153	40
Danube Wachau (A)	26	25	343	300
Danube Vienna – Bratislava (A)	50	25	343	300
Danube Palkovicovo – Budapest (H)	165	21	252	1)
Danube Belene (BG)	15	18,5	280	1)
Danube Caragheorghe – Fermecatul (RO)	23	14,5	275	1)

1) no data available

2) EWL: Equivalent water level : minimum depth of the shipping route obtained for 94 % of the ice-free period

3) LNRL: Low Navigation and Regulation Level: corresponds to the water level obtained for 94 % of the ice-free period on the basis of an observation period of 40 years

Sources: EC, Directorate 1A / B5: Study to improve waterway transport on the Danube in Bulgaria and Romania, 1999
ÖIR: Beiträge zur Planung des Nationalparks Donauauen, Wien, 1995
Wösendorfer H.: Vienna, 1992, 2001 (oral information)
Kleemeier H.: Beiträge zum Arbeitskreis „Die Wasserstraße Donau". In: ÖIR: Europäische Binnenschifffahrt – Perspektiven im erweiterten Europa, Wien, 1998.

Relevant for the whole waterway are the navigable water depths on the Rhine and on the Wachau, as on these sections development measures - even in the long term - are not to be expected. On the lower Danube no impoundments are planned but improvements are striven for by means of river engineering measures to reach a maximum navigable water depth of 25 dm.

With respect to homogeneous water depth conditions in combination with the vessel's draught, the following standards are applied:

(1) LNRL: Low Navigation and Regulation Level on the Danube resp. Equivalent Water Level (EWL) on the Rhine: minimum navigable water depth obtained for 94 % of the ice-free period.

(2) Number of days for which a minimum navigation channel depth of 25 dm (recommendation of the Danube Commission related to about 360 days / year) is obtained (corresponds to a draught of about 20 dm).

(3) Number of days for which a minimum draught of 25 dm (ECE agreement AGN related to 240 days / year) is reached (corresponds to a navigation channel depth of about 30 dm).

A differentiated consideration regarding LNRL and minimum navigable water depth and / or minimum draught is required, as varying flow characteristics on upper and lower river courses and varying climatic-geographical influences may imply dramatic differences for the achievable period of various minimum navigable water depths despite the same LNRL / EWL value. This accounts for the fact that the minimum navigable water depth of 25 dm on the Rhine is obtained to the same extent as on the Austrian Danube, even though the Rhine EWL is considerably lower (19 dm) than the LNRL on the Danube (25 dm).

The different flow characteristics are especially dramatic on the upper and lower Danube: Even though on the lower Danube the LNRL (Caragheorghe sand bar - Fermecatul) is 3 dm lower than on the upper Danube (Straubing - Vilshofen), a minimum navigable water depth of 25 dm is reached on 275 days, whereas on the upper Danube this is merely the case on 153 days. This means that on the upper Danube a higher LNRL is necessary than on the lower course in order to obtain mostly homogeneous conditions also for larger draughts.

With respect to the decisive river sections of the Rhine and the lower Danube, the development conditions of the Austrian Danube with a LNRL of 25 dm may be described as absolutely sufficient. Both the recommendations of the Danube Commission (25 dm below LNRL for free-flowing river sections) and those of the ECE agreement for European waterways (25 dm draught on 240 days) are met. On the Danube section between Vienna and Bratislava a draught of 28 dm can be driven on 240 days. The actual bottleneck, also regarding international agreements, is represented by the section between Straubing and Vilshofen on the upper Danube.

3.2. Overhead Clearances Under Bridges

The overhead clearance under bridges represents the decisive parameter for container transport. The overhead clearance is determined with regard to the highest navigable water level. Relevant for container transport is the number of container layers that may be piled up. Table 18 indicates the required overhead clearances depending on the number of layers.

The taking up of ballast (additional load) to increase the draught may provide an additional room of up to 60 cm.

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Table 18: Overhead clearance under bridges for different container layers and current vessel types[1)] in m.

	empty	50 % loaded
2 layers	5.25	4.50
3 layers	7.50	6.80
4 layers	10.25	8.60

1) motor cargo vessel 85 x 9,50 m, large motor cargo vessel 110 x 11,40 m, pushed barge SLII 76,50 x 11,40 m

Source: ÖIR: Beiträge zur Planung des Nationalparks Donauauen – Schifffahrt, Vienna, 1995.

For the Rhine-Main-Danube w aterw ay the follow ing possible container layers result from this:

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Table 19: Critical bridges along the Rhine-Main-Danube waterway.

Section	Decisiv e bridges	Height in m	Possible number of container lay ers	
			empty	50 % cargo
Rhine Rotterdam-RMD		9.10	3	4
Main	road bridge Auheim	4.39	1	1 (2) [1)]
	rail bridge Auheim	4.90	1 (2) [1)]	2
	Löwen bridge Bamberg	5.33	2	2
	Chain bridge Bamberg	5.43	2	2
RMD canal		6.00	2	2
Danube	Kelheim	6.35	2	2
	Kelheim	6.31	2	2
	Bad Abbach	6.32	2	2
	Bad Abbach	6.31	2	2
	Regensburg	6.73	2	3
	Regensburg	6.08	2	2
	Bogen	5.02	1 (2) [1)]	2
	Deggendorf	4.73	1	1 (2) [1)]
	Deggendorf	7.30	2	3
	Kachlet	6.67	2	2
	Passau	6.36	2	2
	Passau	6.03	2	2
	Linz	7.42	2	3
	Linz	6.65	2	2
	Bratislav a	6.70	2	2
	Budapest	6.70	2	2
	Budapest	6.70	2	2

1) with ballast

Source: EBD, Impetus Consultants, ÖIR: Evaluation of the Danube Waterway as a Key European Transport Resource (EUDET), Duisburg, Athens, Vienna, 1999.

On the central section of the RMD-waterway (Main, RMD canal section, Bavarian Danube) container transports are limited to two container layers. On the Austrian and Hungarian Danube up to Budapest container transport is also limited to two layers at the highest navigable water level, a passage with three layers is however already possible at a 2 dm lower water level. During the major part of the year a three-layer transport is thus possible.

3.3. Conclusions

The decisive sections of the Rhine-Main-Danube waterway (sections that will not be subject to large development measures in the long term) according to their navigable water depth are situated on the Rhine and on the Wachau. From the point of view of waterway transport, the main bottlenecks presently occur on the Bavarian, Hungarian and Romanian / Bulgarian Danube. The Austrian Danube does not require any imminent development measures.

The main bottlenecks regarding minimum overhead clearance under bridges are situated in the central section of the RMD waterway: on the Main, the RMD canal and on the Bavarian Danube. In this section container transport is limited to two layers.

4. Need for a Larger Navigable Depth

Waterway transport representatives put forward the following arguments for a larger navigable depth:

- A greater security for transports with a high capacity utilisation improves the competitiveness so much that the other traffic systems rail and road will be relieved.
- This will create greater benefits for eco-politics and national economy.

The goods typically carried by vessel are traditionally long-distance shipments of bulk goods with no short-term schedule. This is particularly true for the Danube, because, contrary to the Rhine and apart from a few exceptions, the industrial sites are not situated along the river. For these kind of goods, waterway transport mainly competes with rail. Cost advantages may be obtained by large units; however these make heavy demands on the development standard of the waterway. From an environmental policy and national economic point of view, the development of the waterway, resulting first-of-all in modal split transfers from rail to vessel, is hardly justifiable.
However, as regards the transfer of goods from the road to the vessel, the question arises whether large units, requiring a much higher water depth, are actually necessary. The need arises to find out which goods and groups of goods are transported by which type of vessel and what are the requirements arising for the development standard of the waterway.

The determination of goods-related draughts for individual types of vessels requires the association of loadable volume, specific weight of the transported goods, dead weight of the vessels and draught. As these data differ from one vessel to another and may only be derived from the vessels' calibration certificates, almost no processed data are available. One usually proceeds on the assumption that the maximum draughts are utilised. In the following chapter, the expected loaded draught for representative types of vessels and transported goods is shown. Difference is made for bulk goods, container for parcelled goods an roll-on / roll-off transports.

4.1. Bulk Goods

The following representative types of vessels have been assessed:

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Table 20: Types of vessels for bulk goods transport.

Type of vessel		length (m)	width (m)	dead weight (t)	volume (m³)	draught (cm)
Motor cargo vessel	Kreuzenstein	95	11.4	2 290	2 186	299
	Hainburg	84.4	9.54	1 180	1 253	247
Pushed barge	SL 12 500	81.89	10.02	1 198	1 235	185
	Europa IIa	76.5	11.4	1 813	1 850	222
	Europa IIb	76.5	11.02	1 757	1 998	227

Source: ÖIR: Beiträge zur Planung des Nationalparks Donauauen-Schifffahrt, Vienna, 1995.

The draught of these types of vessels has been determined for the transport of representative goods.

Table 21: Specific weight of representative bulk goods typically carried by vessel.

Transported goods	Specific weight in t/m³		
	minimum	average	maximum
peas, wheat	-	0.8	-
corn feed	-	0.7	-
sunflower seeds	-	0.4	-
trunk wood	0.4	0.7	0.9
sawn timber, bundled	-	0.7	-
wood chips, wood flour	0.2	0.4	0.5
coal, pieces	-	0.8	-
coke	-	0.6	-
petrol / benzol	-	0.7	-
diesel, fuel oil (light)	-	0.84	-
fuel oil (heavy)	-	0.9	-
Iron ore (coarse) / pyrite	2.2	3.0	4.5
bauxite		1.3	
gravel	1.5	1.8	2.0
slag sand	-	0.9	-
loose cement	-	1.6	-
loose fertiliser	-	1.2	-
PVC powder	-	0.5	-
metal sheets / coils	2	3.2	4.5
aluminium bars	-	0.9	-

Source: ILLIES, K.: Handbuch der Schiffsbetriebstechnik, Teil 1, Braunschweig, 1984.
HELMERS, W. (Hrsg.): Seemannschaft und Schiffstechnik, Teil A: Schiffssicherheit, Ladungswesen, Tankschifffahrt, Berlin / Heidelberg, 1980.

To determine the vessel-specific draughts according to the transported goods, the average values of the specific w eights have been used.

Table 22: Draughts of different vessel types using the loadable volume for selected transport goods and navigability of the Austrian Danube (in cm).

Transported good	Motor cargo vessels		Pushed barge		
	Kreuzenstein	Hainburg	SL 12 500	Europe barge IIa	Europe barge IIb
peas, wheat	258	231	203	235	251
corn feed	237	213	185	203	227
sunflower seeds	174	160	129	137	153
trunk wood	174 – 277	160 – 247	129 – 221	137 – 247	153 – 270
sawn timber, bundled	277	247	221	247	270
wood chips, wood flour	174	160	129	137	153
coal pieces	258	231	203	235	251
coke	216	202	166	188	214
petrol / benzol	250	225	200	218	240
diesel, fuel oil (light)	299	247	230	247	-
fuel oil (heavy)	299	247	230	260	-
iron ore (coarse)/pyrites	299	247	233	270	270
bauxite	299	247	233	270	270
gravel	299	247	233	270	270
slag sand	277	247	221	247	270
loose cement	299	247	233	270	270
loose fertilisers	299	247	233	270	270
PVC powder	195	178	148	160	178
metal sheets / coils	299	247	233	270	270
aluminium bars	277	247	221	247	270

navigable throughout the year — navigable on about 300 days / year

Source: *Mierka Donauhafen Krems GmbH, Tauchtabellen für Schiffstypen und Transportsubstrate, own calculations, 2001*

For bulk goods it was concluded that a hundred % capacity utilisation of the representative fleet operating on the Austrian Danube over the whole year may only be reached for some light bulk goods such as sunflower seeds, light types of trunk wood, wood chips, wood flour, coke and PVC powder.

However, all vessels with a draught of no more than 25 dm can already have a hundred % capacity utilisation on 300 days / year (vessels of the Hainburg type or the barge SL 12 500, frequently used in Eastern Europe).

Even vessels with a higher draught may have a full capacity utilisation on 300 days if they transport lighter bulk goods: cereals, foodstuffs, trunk wood, wood chips, wood flour, coal pieces, coke, benzin / benzol or PVC powder. This means that the existing development standard of the Austrian Danube also offers relatively good conditions for motor cargo vessels and barges with a draught of up to 2.50 m (e.g. Hainburg, J. Welker, SL 12 500). The restrictions for larger vessels (Kreuzenstein, Europe barges IIa and IIb) and heavier goods especially concern storable goods with variable transport schedules, allowing a minimisation of productivity losses caused by low water levels.

4.2. Container

Container transports are the most likely to enter into competition with the road. Proceeding from the overhead clearances under bridges, two container layers may be transported from the Austrian Danube to the west and three container layers to the east. This results for different types of vessels in the following draughts and requirements for the navigation channel:

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Table 23: Draughts and navigable water depths of container ships for a 50 % capacity utilisation[1] in m.

	motor cargo vessel		barge II		large motor cargo vessel			
	2 layers	3 layers	2 layers	3 layers	2 layers		3 layers	
	3 rows	3 rows	3 rows	3 rows	3 rows	4 rows	3 rows	4 rows
draught	1.22	1.50	1.12	1.43	1.27	1.45	1.57	1.85
navigable water depth	1.72	2.00	1.62	1.93	1.77	1.95	2.07	2.35

1) The general assumption is that container transports reach a probable capacity utilisation of 50 % of the highest possible payload capacity of a container. This results from the different loads of the goods the containers are filled with, the different capacity utilisation of each container and the mix with empty containers transported.

Source: ÖIR, Beiträge zur Planung des Nationalparks Donauauen, Schiff-Fahrt; Vienna, 1995

It thus becomes apparent that container transport does not require special waterway development conditions for the depth of the navigation route, neither on the upper Danube (2 layers) nor on the lower Danube (3 layers).

4.3. Roll-on / Roll-off and Heavy Load Transports

Roll-on / roll-off carriage merely plays a secondary role on the Danube. The following vessel types are operating:

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Table 24: Special vessels for Ro-Ro transport

Types of vessels	length (m)	width (m)	maximum dead weight (t)	maximum draught (cm)
Danube – Ro Ro SL 30	76.5	11.4	1 555	240
Danube – Ro Ro double deck	76.5	11.4	33 trailers or 150 cars	210
heavy load Ro Ro SL 40	81.39	9.22	1 611	300
Ro-Ro catamaran	114.0	22.8	49 trailers	165

Source: Oral information of the Bayerische Lloyd
Egger J.: Schiffsbau für Ro/Ro auf Binnenwasserstraßen. In: Schiffahrt und Strom Nr. 120/121, 1988

The maximum dead weight is not reached by heavy load transports, trailer or car transports. In principle, these vessels may operate throughout the year on the Austrian Danube.

4.4. Conclusions

The ecopolitically important transfer of transported goods from the truck to the inland vessel concerns first-of-all parcelled goods with fundamentally different requirements for transport management compared to the traditional bulk carriage of goods typically carried by vessel. The transports occur by container or roll-on / roll-off vessels. The decisive bottlenecks are not the vessel draughts but the overhead clearances under bridges. But the Austrian Danube already offers adequate conditions for traditional bulk goods carriages. Bulk goods with a specific weight of less than 0,8 t/m³ (solid fuels, cereals and foodstuffs, forestry products, benzine / benzol and chemical products) may be carried by all relevant types of vessels operating on the Austrian Danube on about 300 days per year at a hundred % capacity utilisation. Given their storability, the transport of heavy goods (ores, metal products, building minerals and material, fertilisers, crude oil) may to some extent be organised so that they may be carried in periods with favourable water levels. This allows a limitation of productivity losses in waterway transport.

5. Innovation Potential for an Ecologically Compatible Waterway Transport

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As regards energy consumption and emission of air pollution, and compared to the truck, waterway transport represents an ecologically compatible category of traffic. However, waterways are an integrated part of complex, sensitive and in many ways threatened ecosystems. Ecologically compatible waterway transport has to use the whole technological potential that allows an increase of efficiency in business management independent of massive interventions in the river landscape. Possible strategies will be discussed in the following sections.

5.1. Adaptation of the Vessels to the Waterway

Over the last fifty years development was characterised by the adaptation of the waterways to the vessels. The construction of barrages and the regulation measures allowed the use of vessels with both a higher dead weight and larger draughts.

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Table 25: Development of dead weight and engine output / vessel.

Year	Austria		Germany	
	dead weight in t / vessel	engine output in kW / vessel	dead weight in t / vessel	engine output in kW / vessel
1970	949.5	139.0	800.0	174.5
1990	1.207.0	208.5	886.5	327.0
2000	1 374.7	254.2	1)	1)

1) As a result of the re-unification the numbers are not comparable

Sources: Federal Ministry of Transport, Verkehr in Zahlen, Bonn, 1991
Statistik Österreich: Statistisches Jahrbuch der Republik Österreich, Vienna, 2001

It is a fact that, as a result of its impacts on floodplain ecology and landscape, a total development of the waterways with barrages no longer has the support of the general public (for example on the river section of the Rhine near St. Goar, of the Wachau, the National Park Danube Floodplains, the Hungarian Danube upstream Budapest). So, free-flowing river sections remain in between the barrages. Therefore the demands for complete adaptation of waterways to the business management and productivity-oriented demands of shipping, for the largest possible units with the largest possible draughts are to be questioned. The task of the ship-building industry for the future is therefore to create vessels that are adapted to the waterway, and the objective of shipping companies is to procure respective vessels when modernising their fleet.

5.1.1. Shallow-draught Inland Vessels

For this purpose a research and development programme has been started in Germany by the Ministry of Science, Research and Technology with the objective of developing and testing vessel types and vessel propulsion units that are perfectly suitable for extreme shallow water levels. The priority operation field should be inland waterway transport in the new federal states which are frequently subject to low water level conditions.

The following types of vessels are in the development stage:

- Motor cargo vessel VEBIS:
  Dimension: 82.0 x 9.5 x 2.5 m
  Maximum loaded draught: 2.50 m
  Dead weight for 2.0 m loaded draught: 900 t
  Dead weight for 2.5 m loaded draught: 1,250 t

- Special motor cargo vessel for the Elbe river:
  Dimension: 95 x 11.45 x 2.0 m
  Dead weight for 1.70 m loaded draught: 1,035 t
  Dead weight for 2.0 m loaded draught: 1,340 t

The “ELBE vessel” is still in the project stage, the objective is however to use it on the Rhine and in the Western German waterway network. This kind of vessel could be of great importance for those kinds of transports which frequently pass the bottleneck on the Bavarian Danube. On the Austrian Danube and further downstream larger draughts may be used for the major part of the year. Thus, the use of larger vessels with greater draughts that cannot be completely unloaded during a short period of the year is, from a business management point of view, better than the use of new vessels with a smaller capacity for a better use at low water levels.

5.1.2. Adaptation of Existing Vessels

Another possibility is the adaptation of existing vessel types to the maximum admissible dimensions. This kind of “ship enlargement” may considerably increase productivity, especially for “light” bulk goods such as cereals, saw dust, fertilisers etc., without any need for a change of the navigational water depth. This is how DDSG-Cargo rebuilt two motor cargo vessels:

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Table 26: Motor cargo vessel Klosterneuburg.

Motor cargo vessel Klosterneuburg	before	after
length (m)	80	113.50
width (m)	9.54	11.00
dead weight (t)	1,320	2,000

Source: Schiff-Fahrt und Strom, Folge 172 Nov / Dec 2000

This example shows that considerable increases in productivity are possible even for unchanged depths of the waterway.

5.1.3. Renewal of the Fleet

The fleet of the Danube countries needs a modernisation push. The majority of existing vessels is conceived for the traditional transport of bulk goods. There is a lack of large- and medium-sized motor cargo vessels that respond to the technical requirements of the Western European waterway network and may be used as multipurpose vessels. Among them are vessels for the transport of heavy goods, hazardous goods, car transports or containers. The requirements for these transports are characterised by a higher flexibility, rapidity and regularity. The necessary renewal of the fleet offers the chance to use the best available technology (see ch. B.5.1.1.) and to adapt the fleet to the navigable conditions of Danube and Rhine that are to be expected in the long run.

5.2. Navigation Systems and Water Level Forecasts

One of the major problems of inland waterway transport is the forecasting of water levels and, resulting from these, the loaded draught of long-distance upstream transports. Improved forecasts combined with electronic information systems may lead to a higher capacity utilisation of the vessels of up to 10 %. The implementation of a European inland waterway transport information system – "River Information Services (RIS) on European Waterways" – is presently in development (EC, DG TREN, 2001). Besides an improvement of transport safety, it may also be linked with a river bed model with water level calculations and thus offer a more exact estimation of the loaded draughts. Standardised management of information may also contribute to the defusing of existing bottlenecks on locks, by informing captains or fleet managers in time.

To improve estimations of water level development, long-term forecasts are needed, but regular (e.g. every six hours instead of once a day) and more precise (e.g. indication of the variation trend not only in quality but also in quantity) data are required as well. These potentials have not yet been exhausted.

5.3. Conclusions

Inland waterway transport presently is in a phase of technological change and renewal that considerably increases the chances for an ecologically compatible river transport. In the 1960's the objective was the development of waterways for larger vessels with higher loaded draughts carrying few bulk goods (especially on the Danube). Today, new shipbuilding technologies as well as new information and communication systems offer the possibility to increase both productivity and interest in inland waterway transport, without massive interventions in the river landscape. A reorientation to other groups of goods also changes the requirements for inland waterway transport towards flexible, regular and frequent offers. This in return demands closed logistics chains, where the emphasis is put on vessels showing the following characteristics: multipurpose use, specialisation, integration in an information and communication network of the waterway, fleet and logistics management. The draught is less important in this context.

6. The Danube Section East of Vienna up to Bratislava

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For the Danube section east of Vienna up to Bratislava a development to a 32 dm navigable water depth resp. 27 dm loaded draught by means of river engineering measures is presently under discussion. As for all free-flowing river sections of the upper course of the Danube, a secondary intended effect of these measures is the stabilisation the river bed. The average annual bed incision caused by a lacking bed load transport as a result of the impoundments (about 75 %) and dredging (about 25 %) is at 2.5-3.0 cm / year. In the national park area this would also have negative ecological consequences in the medium or long term. The measures required for the stabilisation of the river bed are associated with a re-dimensioning of the navigation channel. Presently a navigable depth of 25 dm below LNRL is obtained for this section. This water depth is secured by regular dredging and conservation works carried out by the waterways authority. From the point of view of waterway transport any improvement is without doubt welcomed. But with respect to the legal conditions that have already been specified and in the context of the whole Rhine-Main-Danube waterway, the existing development standard of 25 dm below LNRL is considered as adequate.

These dimensions may easily be justified given the extent of potential capacity losses with respect to desired loaded draught of 27 dm. The estimation of capacity losses is based on the assumption that the Wachau, with 25 dm below LNRL, is a decisive Danube section where no further development will occur in the long term. All transports operating both on the Wachau and on the section east of Vienna are not negatively affected if this section is not developed to a depth of more than 25 dm below LNRL.

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Table 27: Transport Relations on the Austrian Danube in 1000 tons.

	1990		1995		1999	
	absolute	%	absolute	%	absolute	%
Transit transport	1,339.7	16.5	2,879.5	32.7	2,777.4	27.8
Origin / destination transport west	1,174.0	14.4	1,832.5	20.8	2,455.1	24.6
Origin / destination transport east	5,020.1	61.7	3,556.9	40.5	3,980.3	39.9
Inland transport	606.5	7.4	521.6	5.9	773.7	7.7
Total	8,140.3	100	8,790.5	100	9,986.5	100
Passage east of Vienna, not crossing the Wachau	1,504.0	18.5	1,083.4	12.3	1,114.0	11.2

Source: ÖSTAT, Güterverkehrsstatistik 1990- 1999

There remain about 10 – 15 % of the traffic volume which could thus benefit from a development of the channel depth east of Vienna or, in other words, would be disadvantaged if the development did not occur.

A loaded draught of 27 dm may already be obtained for about 270 days (74 %) per year. If insecurity of predictions for the type of load are generously taken into account with 25%, about 200 days (55 %) remain, for which the entire loaded draught of 27 dm may be used already. This is why a maximum of 5 – 7.5 % of the transport volume would thus be affected by capacity restrictions. As the whole loaded draught is, however, not used for every transport (because of lighter goods and smaller vessels with a smaller draught), one has to proceed on the assumption that no more than 5 % of the transport volume would be negatively affected if the maximum development of 32 dm navigable water depth compared to the present 25 dm, did not occur. This would mainly affect the transport of bulk goods. But most of these goods are characterised by their storability; and thus can distributed so that they are carried during favourable water levels and with an optimum capacity utilisation. One may thus proceed on the assumption that the further development of the Austrian Danube section east of Vienna would not lead to remarkable increases of transported goods by waterway transport and, if the development did not occur, this would not lead to a loss of transported goods either. The improvement of the competitiveness of waterway transport on the Danube depends on measures other than a further development of the channel depth on the Austrian Danube east of Vienna.

Nevertheless, the required bed stabilisation may be used to improve waterway transport conditions. Presently the navigation channel depth of 25 dm is only guaranteed for a waterway width of about 100 m. According to the recommendations of the Danube Commission a minimum width of the navigation channel of 120 m for a depth of 25 dm should be guaranteed on this section. The stabilisation of the bed may, in any case, be connected with a respective broadening of the channel. A further increase of the channel depth by means of groynes and training walls would also imply an increase in the flow velocity in the navigation channel and would thus result in higher fuel needs and pollutant emissions on the vessel's way upstream, as well as causing safety problems for downstream traffic.

The "large-scale river engineering project" for the development of the Danube east of Vienna is thus to be evaluated primarily from an ecological and financial point of view.

The planned granulometric stabilisation of the bed requires a net underkeel clearance of 5 dm. This value is needed to protect the propeller from damages caused by sucked gravel grains. Thanks to a granulometric bed improvement obtained by means of a large-scale gravel carpet of 25 cm, the water level is lifted by about 20 cm. This lower lifting of the water level is due to the smaller width of the fixed bed in proportion to the width of the water level. As a result, navigation conditions worsen slightly as well. A complementary low-water regulation by constricting the discharge cross-sections in the low-water area (by means of groynes and training walls) appears to be appropriate for maintaining a minimum navigable depth of 25 dm for a channel width of 120 m. The extent of constriction determines the minimum navigable water depth. The possibilities reach from maintaining the present condition (25 dm below LNRL), up to a maximum development of 32 dm below LNRL.

For the ecological evaluation one will have to consider carefully, between a greater or lesser increase of the water level (from 15 to 40 cm), a more or less extended shallow water area with a low flow in the riparian zones or a more or less pronounced gradient between shallow water area and navigation channel.

An extensive comparison of the ecological consequences for different development variants (25 dm, 27 dm, 32 dm) is however not available at the moment.

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Glossary

Inland transport waterway
River, canal, lake or water section, that may naturally or due to artificial intervention be used by vessels.

Navigation channel
Part of a river designed and provided with buoys in a way to guarantee the safety of waterway transport.
In general the navigability of a channel is determined by its minimum dimensions (width, depth, radius of curvature), related to the LNRL, and by the overhead clearance under bridges and the height under outdoor cables, related to the highest navigable water level (HNW).

LNRL (Low Navigation and Regulation Level)
According to the directives of the Danube Commission, the LNRL is considered as the water level that corresponds to a discharge duration of more than 94 %. To determine the flow duration curve a period of 40 years (1924 – 1963) has been examined. Ice periods have not been considered.

Highest navigable water level (HNW)
Water level with a duration of 1 %, determined for the whole navigable stretch between Regensburg (km 2379) and Sulina (km 0), based on the discharges observed during a period of 40 years (1924 – 1963) with the exception of ice periods.

Minimum depth of the navigation channel
Guaranteed depth of the navigation channel within the limits of the smallest width of the navigation channel at LNRL or the lowest impounded water level.

The data concerning the navigation channel depth strongly depend on the observed sequence of years. River engineering measures (groynes, training walls, dredging) alter the minimum navigable water depth. Data concerning the minimum navigable depth always have to be linked with the measuring period of the gauges to allow a controllable and serious evaluation.

Width of the navigation channel
Width of the river with a homogeneous water depth for waterway transport.

Overhead clearance of a waterway span
Vertical distance between the water level at HNW and the lowest limitation by a bridge or any other construction crossing the waterway.

Loaded draught
Vertical distance measured between the water line of the swimming vessel and the lower edge of the vessel bottom.

Negative surge
Immersion occurring through dynamic effects during navigation, complementary to the loaded draught.

Draught
Loaded draught plus surge for the dynamic effects of the loaded vessel while moving (negative surge, trimming)

Net underkeel clearance
Water depth between the lower edge of the bottom of the vessel in speed and the river bed.

Bulk goods
Goods that may not be transported as single items or that may be poured at the moment of loading and unloading

Parcelled goods
Goods that may be transported as wrapped or unwrapped single items.

Dead weight
The dead weight is understood as the difference in weight between the completely loaded and the empty vessel. The dead weight comprises load, fuel, water, lubricating oil, crew and provisions.

Pushed convoy
Rigidly or flexibly tied vessels composed of one pushboat with one or several barges, or a pushing motor craft and one or several barges.

Ro-Ro vessel
Motor craft vessel or pushed barge which is provided with special equipment for horizontal (ship-to-shore) transloading of vehicles or rolling carriers.

Barge
Mainly non-powered vessel used for the carriage of goods on inland waterway transport waterways.

Motor craft vessel
Powered vessel used for the carriage of goods and passengers on inland waterways.

WWF is one of the world's largest and most experienced independent conservation organisations, with almost 5 mio. supporters and a global network active in over 96 countries.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by:

- conserving the world's biological diversity
- ensuring that the use of renewable natural resources is sustainable
- promoting the reduction and wasteful consumption.