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RIVER ECOLOGY

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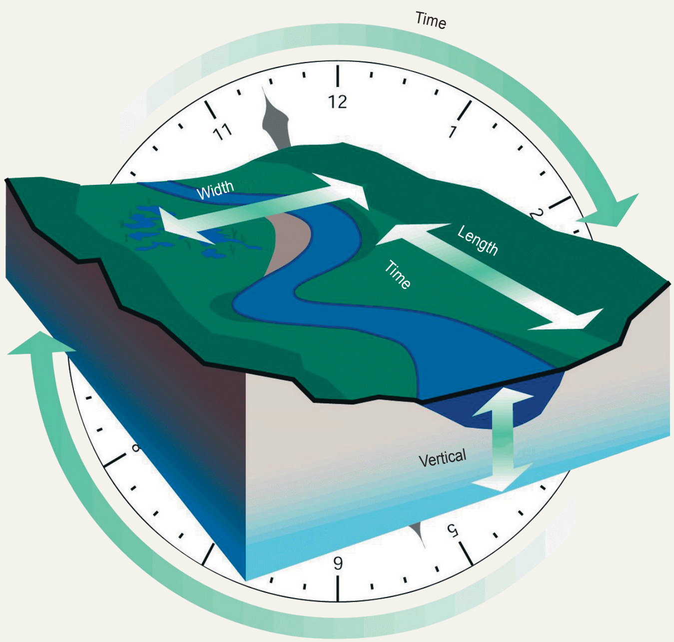
CONTENT

INTRODUCTION

The origin and development of human civilization are closely related to rivers. Over 90 percent of the human settlements in Bulgaria are located in the vicinity of a river. This may be why the word “river” evokes positive emotions and associations of things pure, clean, and calm. At the same time, being so close to human activities, rivers are subject to various and quite often negative impacts. For most people, a river means water flowing from the mountains to the sea. However, flowing water is only one (essential) component of the living body called “river”.

We frequently overlook the fact that rivers have four spatial dimensions – length, width, height (depth) and time (Fig. 1). Actually, even if it seems that the river height is the water level and the width is the distance between its two banks, this is not a completely accurate perception considering the contemporary concepts of the river, its ecosystems and the river corridor, which are much broader.

Fig.1. The river corridor in time and space



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THE RIVER AT LENGTH

Longitudinal structure of the river corridor

All rivers, regardless of their type, have the same stages of structural changes from source to delta.

The profile of every river can be divided into three zones (Fig. 2).

- Source zone (headwaters) – mountain streams that slope rapidly downhill and form V-shaped river valleys, often forming waterfalls. These rapids shape and carry large-size sediments downstream.

- Transfer zone – characterized by a lower altitude. The flow velocity is slower, the river bed becomes wider, and meanders form. Some of the larger sediments settle at the interim area between the source zone and the transfer zone, thus forming the so-called sediment cones. Other sediments are carried further downstream. Erosion and deposition processes are in equilibrium in the transfer zone. Most of the lowland water courses in Bulgaria belong to this zone, including the Bulgarian section of the Danube River.

- Deposition zone – of rather low slope; flow velocities are slow, forming wide meanders. Most of the sediments, including the finest ones, settle in this area. The river mouth often opens into a wide delta bottomed by fine sediments, and the river splits into many arms. In Bulgaria such zones are formed only in the lower course of rivers that flow directly into the Black Sea.

According to Miller, Jr., G. Tyler, 1990. Living in the Environment: An Introduction to Environmental Science, 6th Edition, în FISRWG (10/1998). Stream Corridor Restoration revised and added by Stoyan Nikolov, Stoyan Mihov and Ivan Hristov

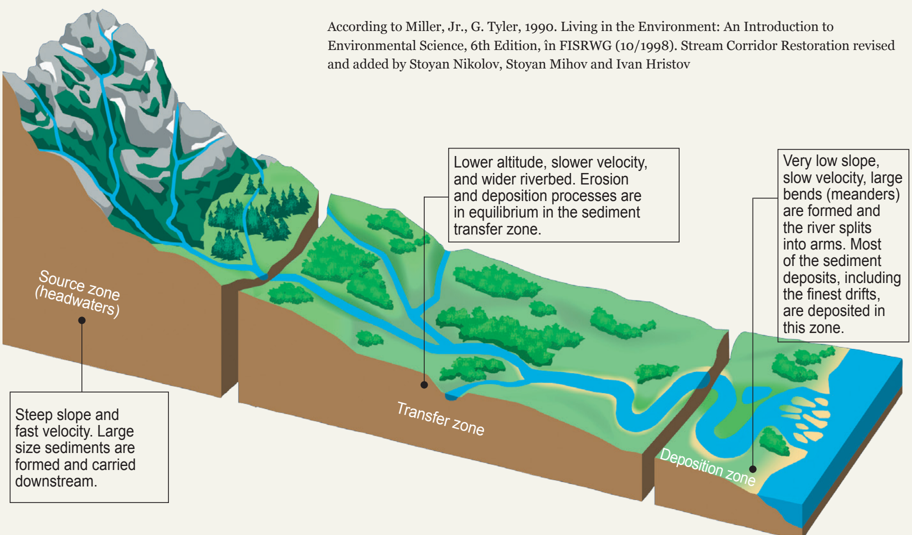

Fig. 2 Length-wise zoning of a river

Sinuosity

Natural rivers are never straight. We can calculate the sinuosity index by dividing the mid-river length by the length of the river valley. When the sinuosity index is more than 1.3, the river is defined as meandering (Fig.4).

This index is invariable for the relevant river section. This means that if the river course becomes straight as a consequence of human interference or natural "shortcutting" of a meander, disbalance will occur and the river will try to restore its previous sinuosity (Fig. 10).

Riffles and pools

Regardless of the form of their beds, all rivers have equidistant sequencing of shoals and deeper sections, called riffles and pools. They are linked to the river midstream – a line which benchmarks the deepest section of the river and where the water flows fastest. Pools are formed in the midstream, next to the outside bank of a watercourse bend. Riffles are formed between two bends where the midstream goes from one river bank to the other (Fig. 3). The distance between two pools or two riffles – a common feature for all rivers – is 5 to 7 times the width of the river, measured at its highest water level.

The sequencing of pools and riffles within a river section, and the existence of various habitats illustrates the variety of life adapted to both fast and slow currents and serves as a precondition for a well functioning river ecosystem.

Such successive sequencing is also a precondition for quick and complete dissolution of pollutants. It is not by chance that straightened (regulated) rivers with altered sequencing of pools and riffles lose not only a significant part of their fish population and other aquatic life, but also most of their self-purification capacity.

Fig. 3. Regular sequencing of pools and riffles.

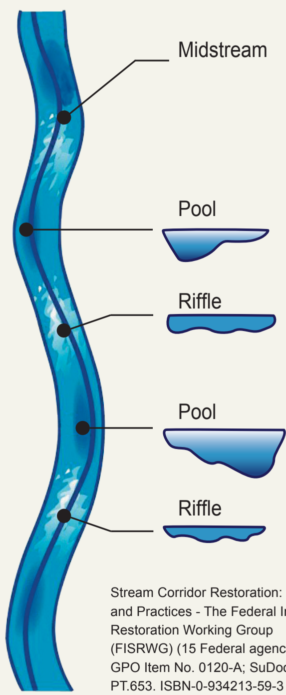

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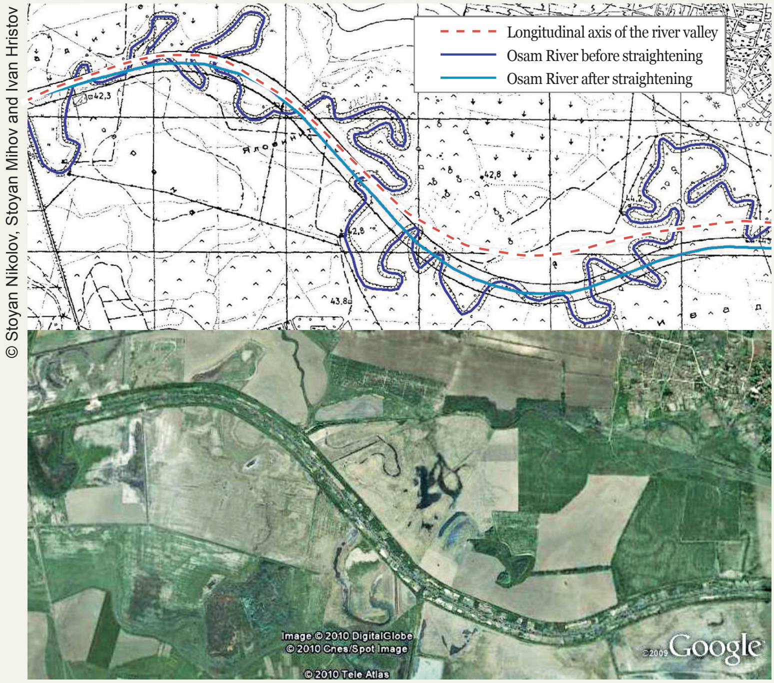
Fig. 4. The Osam River at Obnova village before and after its straightening.



Before the straightening of the Osam River, the sinuosity index in the illustrated section was 3.55, which defined it as strongly meandering. After the straightening, the index became 1.02 which defines the river as "straight". The shortcut of the river course reduced its length more than 3 times its natural length.

THE RIVER AT WIDTH

Horizontal structure of the river corridor

The basic component of river corridor is the riverbed. This is a naturally lowered landform usually used as a passageway for flowing water. The next component is the floodplain – this is the neighbouring part of the riverbed, flooded by high water at different intervals varying from very often to seldom. The floodplain may be situated on either one or both river banks, depending on relief. The next component is the transition upland fringe, which begins above the floodplain and forms the frontier between the river corridor and the adjacent landscape.

Riverbed (bottom)

The shape and size of the riverbed are defined by the equilibrium of four basic factors – the energy of the water stream (slope and water velocity) and the resistance of substratum (particle size of the sediment and its runoff). If we illustrate this on a scale where we have the sediments on one side and the water energy on the other, every decrease in the water energy will result in smaller sediment particles and in the widening of the riverbed. The river equilibrium is reached when all four variables are balanced (Fig. 5).

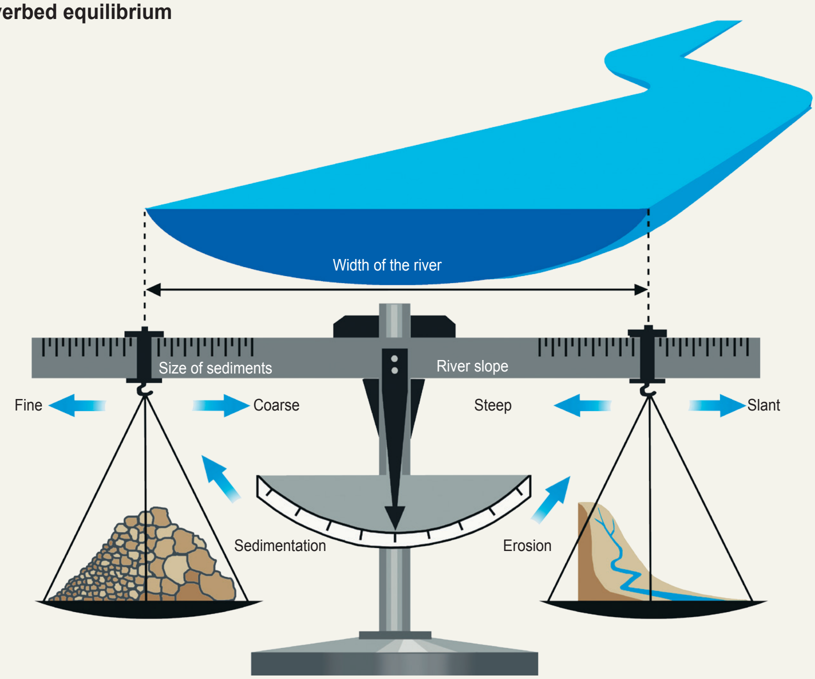
Floodplain

The floodplain is theoretically divided into two parts: hydrologic floodplain and topographic floodplain (Fig. 6).

The hydrologic floodplain is an area inundated about two out of every three years. The topographic floodplain includes the hydrologic floodplain up to the altitude reached by a flood peak of given frequency (every 100 or 500 years). The topographic floodplain is used in spatial planning and development, and all the activities therein must consider the risk of flooding. **For instance, no human settlements or important infrastructure facilities should be developed in the floodplains.**

The floodplains, especially those downstream, are dynamic systems with many various components that undergo a continuous process of formation or disappearance (Fig. 6 and Fig. 7).

Fig. 5 Riverbed equilibrium



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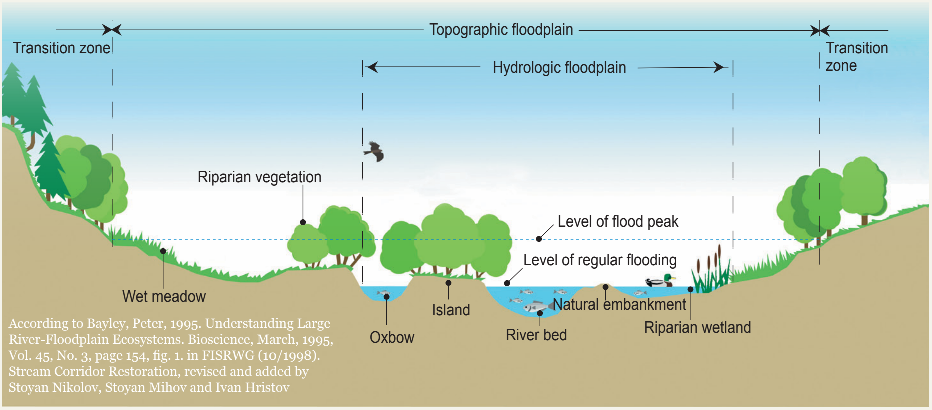
• Meander scrolls – old alluvial deposits that mark the former passageway of the riverbed.

• Oxbow lakes or abandoned river bends – former river meanders that were gradually cut off the riverbed. They can be in different stages of development – from those still linked to the river to those which are rather far away and almost dried up.

• Natural levees or sand-bars – these are formed during flooding when large amounts of sediments are carried out by waters that disperse, losing most of their energy and depositing the coarser sediments on one of the river banks, thus forming an embankment.

Fig. 6 Transverse structure of the river corridor



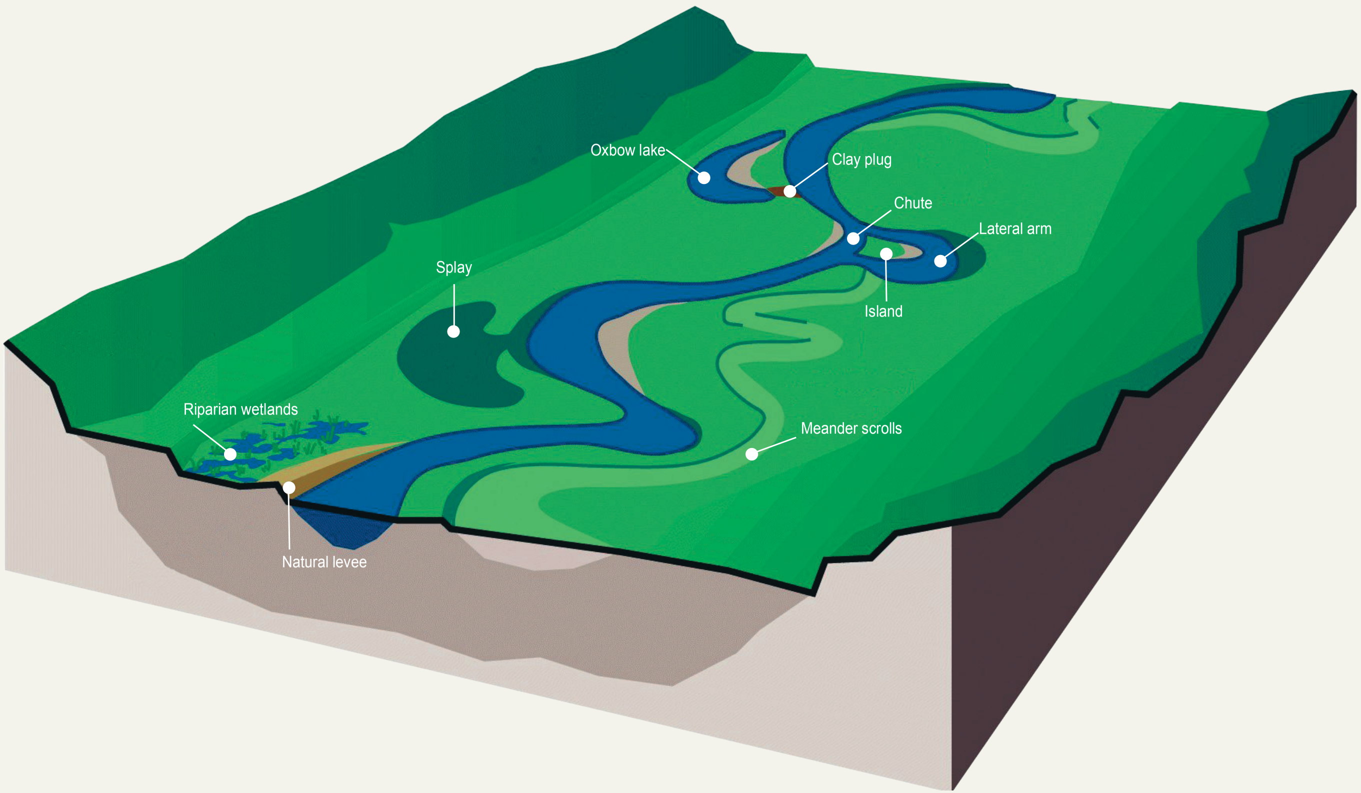
According to Bayley, Peter, 1995. Understanding Large River-Floodplain Ecosystems. Bioscience, March, 1995, Vol. 45, No. 3, page 154, fig. 1. in FISRWG (10/1998). Stream Corridor Restoration, revised and added by Stoyan Nikolov, Stoyan Mihov and Ivan Hristov

• Splay – structures that form at high water when streams under pressure break through natural levees and spread deposits into a fan-shaped structure.

• Backswamp – wetlands that are formed after high water as a result of natural levee formation which prevents water going back to the riverbed, thus prolonging the flooding period.

Wildlife in rivers depends on all these floodplain components. For instance, many of the carp species need backswamps and oxbow lakes to spawn. These are also the places where fish fry find food and shelter amongst the water vegetation. Draining of riparian wetlands or cutting off their link with the river is one of the main reasons that downstream fish population decreases.

Fig. 7 River components in floodplains



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RIVERS IN DEPTH

Vertical structure of the river corridor

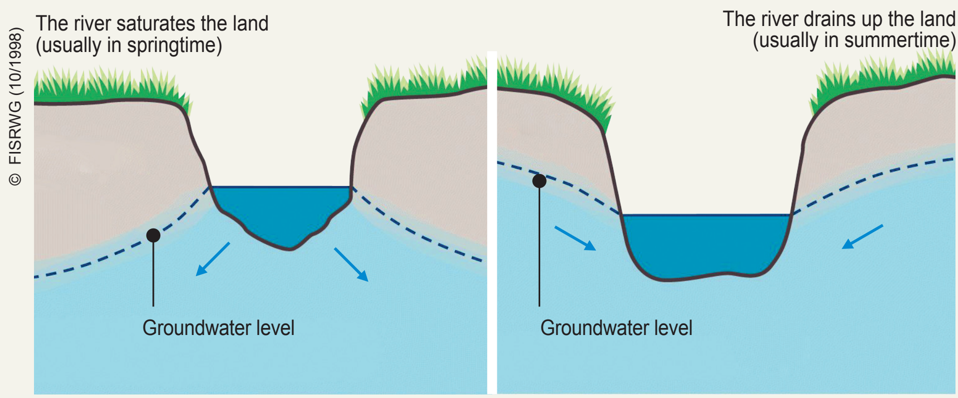
The water level of most rivers varies greatly depending on the season. The seasonal level of rivers usually varies between 10-20 cm and 6-7 m (such as the Danube). The seasonal increase of water level has an important role in supporting river ecosystems. Rivers often link to adjacent wetlands only at high water level, which is often the only possibility for fish populations to migrate.

Unique vegetal systems develop on the banks of rivers with higher variations of water levels, especially in the lower course; they are very well adapted to such conditions. These are the floodplain forests. One characteristic feature of their vegetation is the impenetrable lianas.

Due to their appearance and extremely rich variety of animals and plants, the floodplain forests in Bulgaria are reminiscent of an equatorial jungle. In the past, floodplain forests were widespread in Bulgaria. Today such forests are only partly preserved along Danube islands, the rivers of Kamchiya, Ropotamo, Tundja, and the islands of the Maritsa River; on the other hand such floodplain forests have been completely destroyed along the Iskar, Vit, Osam, Yantra and Sturma rivers.

River depth does not end where its bottom lies. The riverbed usually lies on water-saturated, old river sediments. This groundwater runs to or from the river down the river valley. The stream in the riverbed is usually just a small part of the water flow running through the valley. The level of groundwater depends on the level of water in the riverbed. In dry seasons, surrounding areas drain into the river bed and groundwater runs towards it. During flooding, the groundwater direction may reverse (Fig. 8).

Fig. 8 Relation between river and groundwater



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Until the mid-20th century the wild carp made up 60% of the fish capture in the Danube. After that dams were built and much of the marshes dried up. As a result, by the end of the 20th century wild carp was included into the Red Data Book of Bulgaria and researchers consider it an extinct species in our section of the Danube. Nowadays the river hosts different "wild" varieties of the cultured carp, which only morphologically imitate the appearance of their ancestors; they make up about 6% of the fish capture (noting that the total fish capture is nearly ten-fold lower).

THE RIVER IN TIME

Processes occurring in river corridors

"You cannot step twice into the same river" – next time the river will not be the same. This maxim of the ancient Greek philosopher Heraclitus probably describes most precisely the dynamic nature of rivers.

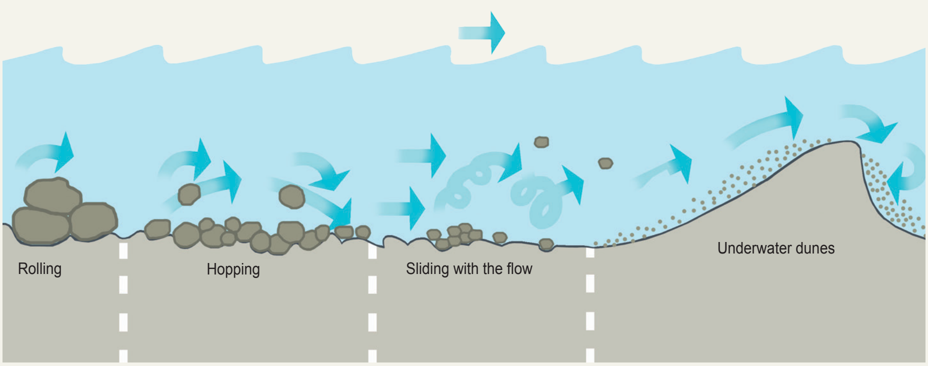
River runoff and flooding

Water transfer from precipitation into rivers and oceans and vice versa, including its vaporization, is known as the "water cycle". This is the main driving force of the river ecosystem. River runoff is the quantity of water that moves through a spot of the river over certain time. This indicator can vary within very wide limits for the same river. For instance, in some torrential catchment basins (almost half of the basins in Bulgaria), the runoff may increase 100 times after a downpour.

The seasonal increase of water runoff and associated flooding are natural and unavoidable processes.

With regard to people, flooding may cause serious consequences – from positive (the ancient Egypt civilization developed on the banks of the Nile River) to disastrous ones.

Fig 9. Forms of sediment movement



According to Dunne, Thomas; Leopold, Luna B., 1978. Water in Environmental Planning, W. H. Freeman and Company in FISRWG (10/1998). Stream Corridor Restoration, revised and added by Stoyan Nikolov, Stoyan Mihov and Ivan Hristov

Flooding does not "damage" nature. On the contrary, this is a cyclic process that serves an important role for the normal functioning of the river corridor. Spring high water is a prerequisite for fish migration.

The "fight" against flooding has been particularly evident in the 20th century. Numerous massive structures have been erected to combat or limit the effects of flooding. Now we can see that many of these technical solutions are effective against small and medium floods, but not against the big ones. Sometimes they even increase the damage. Reconsideration of this concept started in the middle of the 20th century. Nowadays in Europe and globally we do not speak about a "fight" (or even about "defense") against flooding, but about flood control and reduction of damage.

This is the main concept in the new European Directive 2007/60/EC on flood risk assessment and management. The occurrence or non-occurrence of flooding is not in our hands, but it is up to us whether flooding will significantly damage human settlements and important infrastructure, or will impact forests and grasslands with minimum or no damage. It is a question of choice and management – should we decide to build within the river floodplain or let it be used for other purposes considering the risk?

The regular water flow through riparian wetlands is also important because it carries away dead organic material and cleans the area. Many backswamps exist due to periodical flooding. If this process and the link with the river is broken, these areas will silt up, the succession or "natural aging" will accelerate and they will finally disappear.

Sediment transport

The movement of eroded soil and rock particles in water flow is called transport of sediments. Sediment transport is measured by the number of undissolved particles that pass through a river spot over a certain time. The energy required to carry the particles and move them downstream relates to the difference between the velocities of water in different strata.

Water in bottom layers moves more slowly due to higher friction, while water in upper layers flows faster due to lack of friction. Thus a whirlpool, or vortex, is formed between the two water layers – this spiralling movement carries particles off the river bottom. They roll, hop or slide in the water depending on their size and density (Fig 9).

The sediment load of a river consists of suspended and bedload sediment.

- Suspended sediments are fine particles which are easy to move by turbulence in the bottom layer. These particles can be taken up high in the water column and transported a long distance with no further contact with the riverbed as long as the water has enough turbulence. The main part of the river solid load (50-90%) consists of suspended sediments. The

source of suspended sediments is the entire river basin and the fine particles brought by rainwater and as a result of the soil erosion on the river banks.
- Bedload sediments are the bottom particles, which are dense and big enough to move downstream mainly by rolling or hopping. The size of bedload sediment is the same as that in the river bed in the given river section. The source of bedload sediments is the riverbed itself and, to a much lesser extent, the erosion of the banks and other sources.

One of the most popular examples for the importance of the link between river and riparian wetland is the lake of Srebarna. High spring water in the past used to carry away tons of nutrients, organic material, and even floating reed islands. With the building of a dam in 1948 between the lake and the Danube River, the conditions in the lake suffered an abrupt change. The lake started filling up with mud and organic waste, the open water surface began to shrink, and many fish and birds disappeared. The first attempt to partly restore the junction with the Danube was made in 1963. A sluice-gate was built into the retaining dam wall, but was abolished soon after that. In 1979 a section of the highest west zone of the dam was demolished. This made it possible for the high waters of the Danube River to enter the lake reserve.

This was an important step, but far from being enough, because it only enables water movement in one-way (from the Danube River to Srebarna) once in several years. The problems continue to intensify. In 1993 the reserve was about to be taken off the UNESCO World Heritage List.

In 1994 a canal with a sluice-gate was built to let Srebarna “breathe”. Thanks to this, Danube water can enter into the lake every year. It slows down succession process, but it does not solve the problem. As long as both the natural inflow of Danube waters to the lake and the equally important water runoff from the lake into the Danube are not provided, the Srebarna reserve will still be in danger.

Riverbed processes

The processes of erosion, sediment transport, and deposition interacting with vegetation make river corridors very dynamic ecosystems. Rivers constantly change shape and location. New meanders and arms are formed, old ones are abandoned; the riverbed itself shifts (Fig. 10). This phenomenon is called migration of the river corridor.

Sand dunes in the lower part of the river course also shift from their initial location. Sometimes they surface over the water and form small islands that may be carried away and destroyed by the next high floods. Riparian vegetation takes possession of some of these islands which can exist for several decades, continuously relocating and changing their shape

(Fig. 11). We can find most of the riparian islands in Bulgaria along the Danube and Maritsa Rivers (there are about 120 to 140 islands in the Romanian-Bulgarian section of the Danube River). Being aware of and monitoring riverbed processes are of key importance when planning human activities in river valleys – especially in floodplains. Sometimes it is not difficult to forecast the shifting of a river, and thus spare considerable funds for reinforcement of bridges, roads etc.

Fig. 10. River corridor migration - the same river section is shown in four different successive periods

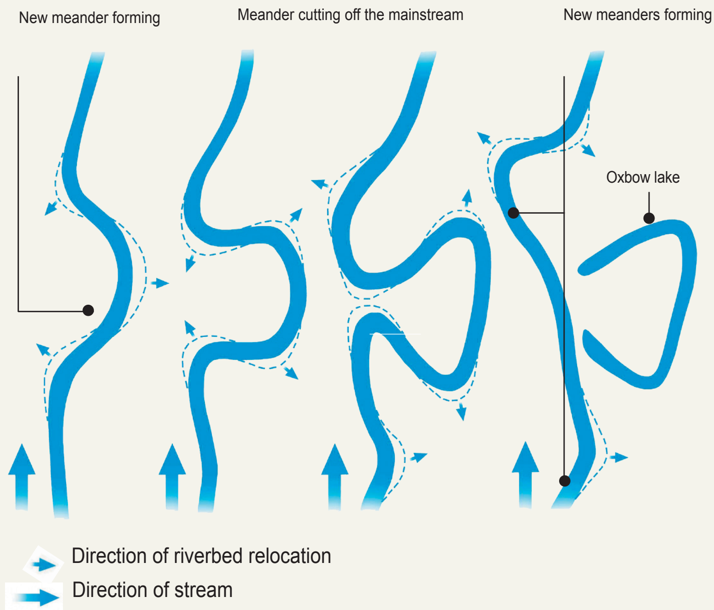
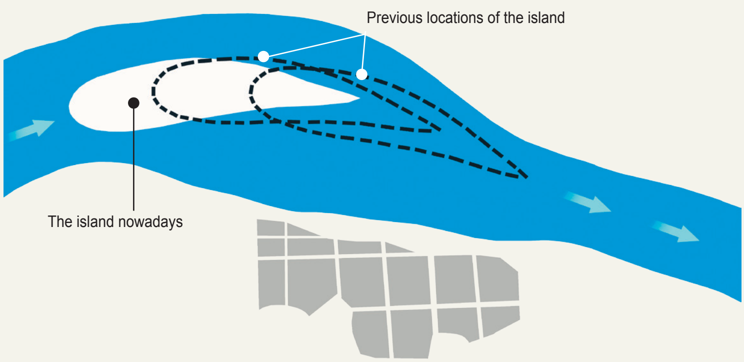


Fig 11. Riparian island relocation



RIPARIAN VEGETATION

Riparian vegetation is a very important component of the river corridor, and its ecosystem significance is even higher. Specific wood species adapted to the river conditions develop along all rivers. With regard to natural rivers, this vegetation forms a continuous belt from the river spring to the mouth. The most typical species in Bulgaria to be found along the streams are willows and alders. River banks in the mountains are covered by green alder. Downstream its place is consecutively replaced by white and black alders. Different species of willow, white and black poplar and elm gradually become present. The sycamore is another riparian tree species typical only for the lower courses of our southern rivers (Struma, Mesta, tributaries of Arda, etc.).

Wood canopy along smaller rivers may completely cover and overshadow the riverbed, while this effect is only partial along larger rivers. The overshadowing or "doming" of the water course by riparian vegetation has an extremely strong influence on water temperature and sunlight penetration, which favours the development of phyto-plankton.

Fig. 12 Roots of the Black alder

Riparian vegetation plays an important role in river bank consolidation and prevention of coastal erosion.
The roots of the black alder are entangled under the water into specific flat netting which retains even the finest particles of the bank layers.

Other riparian species such as willows have similarly entangled roots but less potential to protect against erosion (Fig. 12).

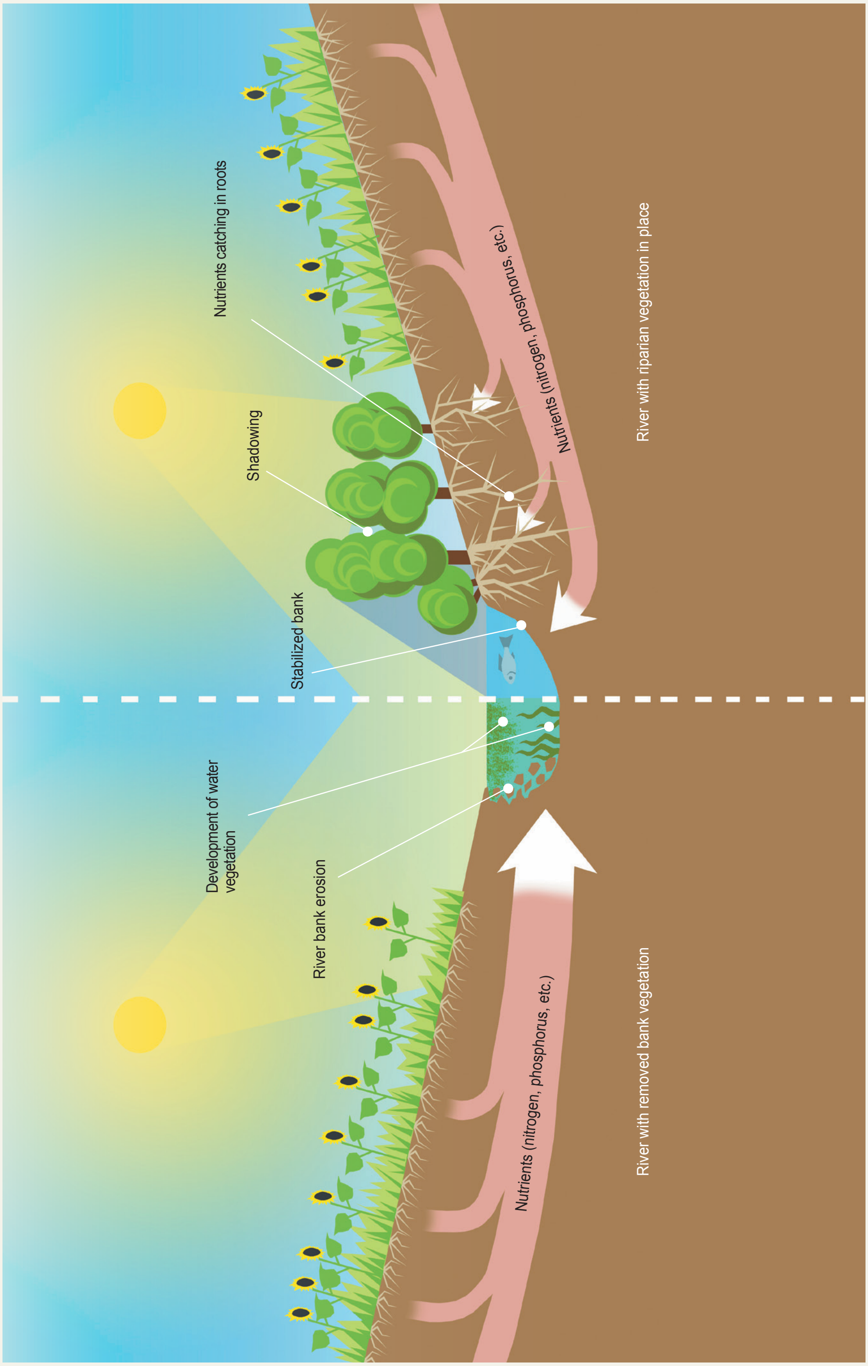
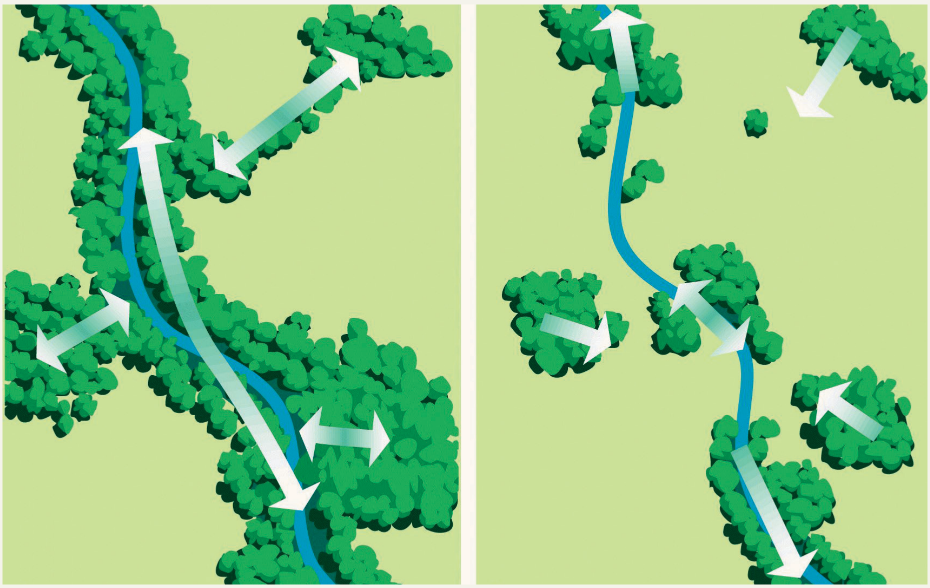


Fig. 13. The role of riparian vegetation

The roots of riparian vegetation also serve as a filter that "swallows" most of the nutrients dissolved in groundwater before reaching the river (Fig. 13). Once again, the black alder appears to be a remarkable tree. It is a species that has one of the highest capacities to extract nutrients from groundwater. Therefore sometimes even a thin (10-15 m) riparian belt of alder forest can "clean" some 80% of the nutrient pollutants that would otherwise flow into the river.

Vegetation in catchment basins considerably slows down rainwater runoff to the river, thus decreasing the risk of a high tide. The abundant vegetation controls evaporation from earth surface and keeps groundwater near the surface.

Fig. 14. Rivers are migration corridors for organisms which depend on the water and the forest habitats



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RIVER BIOCORRIDORS

Rivers are important migration corridors. We know that water wildlife migrates with the purpose of feeding, breeding and to compensate for the river flow both upstream and downstream the river. The possibility to migrate enables water life to avoid unfavourable river sections, such as temporarily polluted places, gravel pits etc. It is even more important for water life to be able to go back and re-colonize an area when conditions are restored. For instance, fish may leave a river section which suffered a severe pollution discharge impact and then restore its population in neighbouring river sections. If there are functional barriers in the biocorridor such as dams, strongly polluted sections, or concrete riverbeds, migration is hindered and the relevant river section may remain with no fish for long time even if the conditions improve.

Another key component of the river biocorridor is the continuous belt of riparian vegetation. This is a basic interlink for many animals in the course of their regular migrations.

In the past, vast forests covered the lowlands. Nowadays forests in the lowlands are fragmented and small. They are dotted amongst vast areas of farmland, urban developments, and highways, which are an overwhelming barrier for forest wildlife.

River corridors are often the only natural link between isolated forest areas and the survival of a large number of plants and animals that depends on them (Fig. 14).

WATER QUALITY

The quality of water is of paramount importance for the functioning of river corridors. Even if the river is in a good hydro-morphological and hydrological condition and is not subject to straightening, even if it preserves its riparian vegetation, and even if there are no dams or artificial lakes built along it, any disturbance of the physical and chemical features can make the river corridor non-functional. Some of the more important water parameters are as follows:

Suspended solids

Suspended solids or suspended sediments are a natural component of the physical and chemical characteristics of the river. If they exceed the normal quantities, this may generate serious problems in the river corridor. Their high concentration and continuous impact may lead to asphyxiation of wildlife that use gills for respiration such as fish, invertebrates, larvae of amphibians, and fish eggs. Suspended solids can also serve as a "carrier" of pollutants, such as micro-organisms and toxic substances, which adhere to the bottom particles and can thus be carried a long distance. The source of dissolved substances, as mentioned above, is mainly erosion, both natural and induced by man. Gravel extraction from rivers is one of the main causes for continuous turbidity of water.

Dissolved oxygen

The most important feature of any water course is its oxygen content. Most of the aquatic organisms "breathe" dissolved oxygen. Its concentration in water depends mostly on water temperature and salinity. Sources of oxygen are the atmosphere and the photo-synthesis of river plants and algae. When the oxygen concentration is under 3-4 mg/l, a few fish can survive, while under 2 mg/l the environment is considered anaerobic; if such concentration persists longer, it can result in completely "dead" water body. Extinction caused by low oxygen concentration often occurs in the smaller, channelled and "cleaned" rivers in the plains. This is often induced by high temperatures combined with water pollution from different oxidizable organic or other substances (deoxydation from re-suspended organic sediments in the Iskar River is illustrated below).

Water temperature

This is also a basic water characteristic for it determines the oxygen concentration in water, and furthermore, many aquatic organisms have very narrow limits of tolerance to changes in water temperature. Thus, every single temperature change results in changes of their metabolism, breeding capacity and even viability. Moreover, many chemical processes in water depend on temperature, such as sorption of organic toxicants, which has an indirect impact on the living organisms. Water temperature depends mainly on three factors – air temperature, earth temperature and sunlight. For instance, if riparian vegetation is cut away and the stream is exposed to sunlight, the temperature would go up and the oxygen contents in water would decrease. As a consequence, the flora and fauna will change. Water temperature is also influenced by the inflow of higher or lower temperature streams – this is the so-called temperature pollution. The most typical examples are the increased temperature of a Danube River section resulting from the cooling plant of the Kozloduy nuclear power station and the dramatic decrease in temperature in Vacha and Arda Rivers downstream the dams of Krichim and Studen Kladenets.

pH

The acidity or alkalinity of water is also of key importance to aquatic organisms. Most aquatic organisms are adapted to live in water with a pH between 5 and 9 (distilled water is pH 7), and many organisms are adapted to specific pH limits where any deviations lead to problems in reproduction processes, ion exchange and viability. Water pH depends on both the substratum in the river course and rainwater. For instance, if sulphate or chloride ion concentration in air is high, rainwater will be acid and the acidity of river water will increase. Abrupt changes in pH also occur when wastewaters are discharged into the river.

Nutrients

Besides oxygen, CO_2 and water, all plants, including algae, need nitrogen, phosphorus and other chemical elements in the form of various soluble compounds. These chemical substances are called nutrients. The deficiency of some of these elements limits the growth of plants. On the other hand, the excess of nutrients results in eutrophication, usually characterized by an excessive development of algae or an "algal bloom". The "algal bloom" or "sliming" of water, as often referred to, is actually extensive development of single-celled algae. Eutrophication leads to oxygen depletion in water during the night, when plants breathe but there is no photosynthesis and it often results in the death of fish and other aquatic organisms that breathe dissolved oxygen. Apart from changes in fauna and flora, such rivers suffer deterioration of water quality. The water becomes unsuitable for many industrial and farming purposes. In ecosystems affected by human impacts, the main sources of nutrients are agriculture (fertilizer leaching into groundwater) and sewage systems. Nowadays nutrients are identified as one of the main pollutants of freshwater ecosystems.

Toxic (poisonous) substances

Under natural conditions water may contain small quantities of different chemical compounds that are toxic to water life. As a result of human activities, the concentration of many of these substances exceeds the safety limits. Man has created many toxic substances that do not occur in nature such as biocides – pesticides, herbicides etc. Heavy metals are also extremely toxic and can accumulate in living organisms. Sources of toxic elements are again agriculture and wastewater.

ANTHROPOGENIC CHANGES IN RIVER CORRIDORS AND THEIR IMPACTS

River Straightening

One of the most negative anthropogenic impacts is the so-called straightening and the construction of embankments in the mid and lower streams of almost all large rivers of Bulgaria during the mid-20th century. The main purpose of these actions was to provide more farmlands for developing the economy and to combat flooding. The consequences of these activities are very serious and in many cases do not solve, but intensify the problems. The main consequence of river "straightening" by building dikes and cutting off meanders from the rivers is that the river becomes shorter and steeper (Fig. 4). The new river is narrower due to the dikes built on its banks (Fig. 15). All of this result in faster water flow and higher water levels during floods (Fig. 16). The faster flow itself results in intensified erosion of both the river banks and bottom, i.e. the river starts "eating" its own bed and digs into the ground until it reaches harder bedrock. The increased erosion results in higher water turbidity, which is a big problem for all aquatic organisms because it reduces the penetration of sunlight into the water. Fine particles clog to the gills of the animals that breathe dissolved oxygen.

Another, even more serious problem related to riverbed incision is the lowering of groundwater levels. The problem is particularly exacerbated where these processes are combined with the gravel extraction. The river and neighbouring groundwater are interconnected bodies, and the drop of water levels in the river (in some cases down 5 or 6 m) leads to a parallel decrease in the groundwater level because the river acts as a draining channel. The lowering of groundwater levels results in withering of riparian trees and a general drainage of adjacent farmland; wells run dry and boreholes dry up. This problem affects virtually all the main rivers in our country.

The Maritsa, Dzherman, Struma and Iskar are amongst the most severely impacted rivers. Even the Danube River bed has lowered. According to WWF research during the last 40 years, the average sinking of the Danube in the Bulgarian section is over 1 m.

These changes affect all the components of riparian ecosystems – riparian wetlands, wet meadows and floodplain forests dry up (Fig. 17). The loss of meanders and pools leads to the extinction of many species of plants and animals associated with slower and deeper waters.

River straightening reduces the river's self-purification capacity because of shortened contact of the water with the bed layer (this is where self-purification processes mainly occur). Changing the bottom substrate also results in a thorough change of benthic communities and dominance of rheophile species that are adapted to fast streams.

Fig. 15. Straightening of the Lesnovksa River in Ravno Pole

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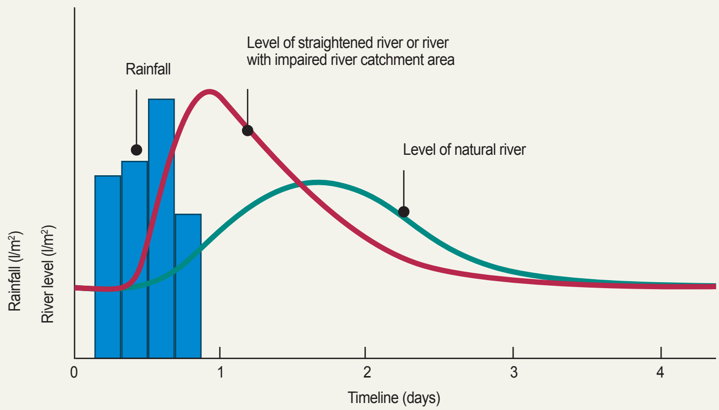
Gravel extraction

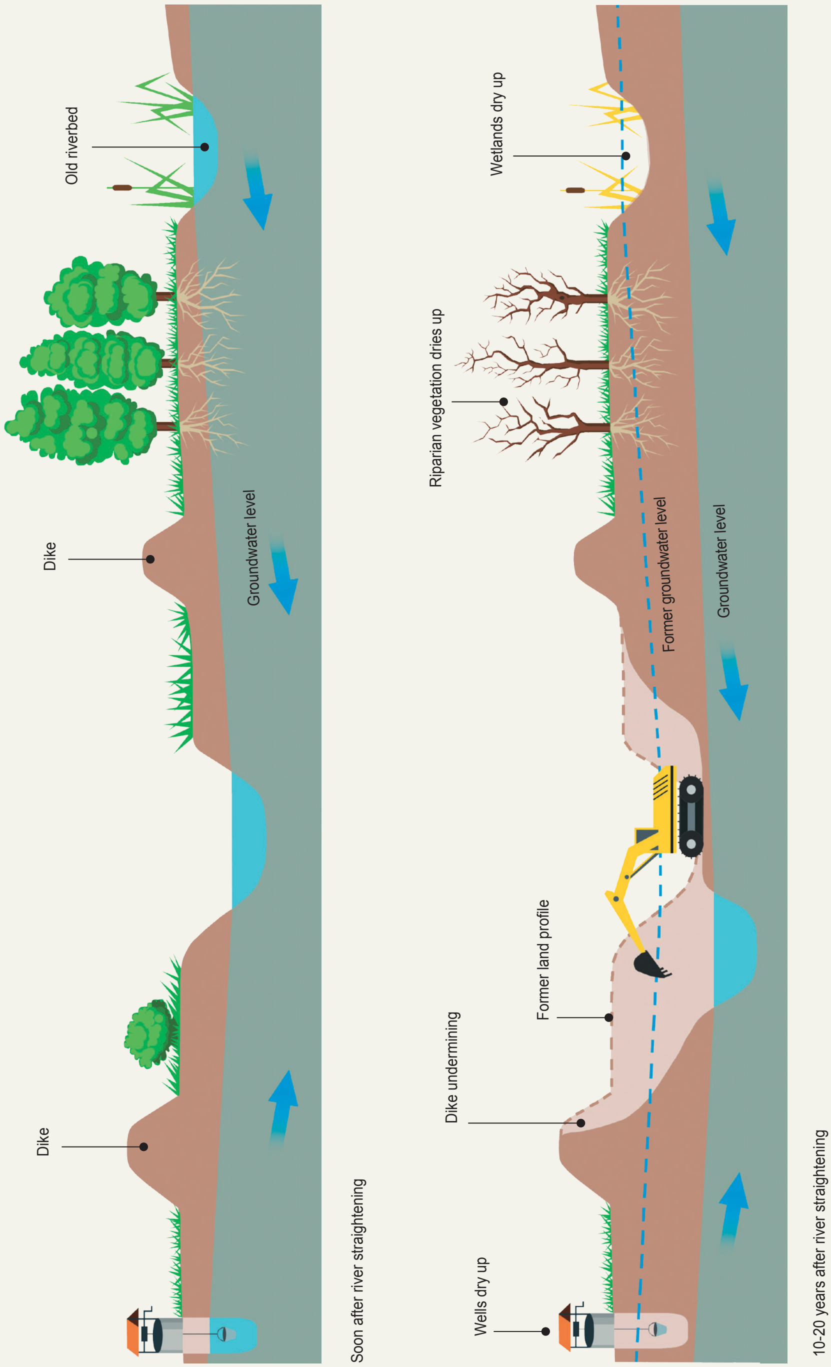
Gravel extraction is also a serious problem for river systems. On one hand, it speeds up the erosion process of both the banks and the river bottom, and on the other hand it has a huge impact on the biological system. This impact includes direct eradication of organisms – with the extraction of bottom sediments all the immobile or slow moving life forms are removed from their habitat. The new bottom is sterile; it has no bacteria or other organic substances. Re-colonization of such a sterile bottom is a slow and gradual process which, depending on the extent of damage, may take years to restore the equilibrium. The first inhabitants will be inferior organisms followed by more superior ones and so on, up to the highest level of food chain, namely fish, birds and mammals. The river bottom is the main biological filter "responsible" for the self-purification of streams. Recovering of the self-purification ability can take several decades.

Fig. 16. Straightened rivers are shorter, narrower and steeper than the natural ones.



Quite often the pits left after gravel extraction become traps for organic matter due to accelerated sedimentation. They quickly fill up with branches, leaves, dead plants, fine organic particles and other decaying organic matter, thus taking up the oxygen and releasing toxic gases like hydrogen sulphide, which kill any remaining life forms not only in the pit, but also further downstream. This impact is of particular concern regarding rivers that run through densely afforested areas. It is extremely severe when high waters run through such a place and transport all the decaying matter. This uses all the oxygen kilometres

Fig. 17. Riverbed lowering as a result of erosion and gravel extraction



downstream and leads to extinction of life forms.

Water turbidity caused by the presence of suspended solids prevents sunlight from penetrating into the water and hinders photosynthesis. The suspended solids also asphyxiate gilled aquatic organisms – mainly mussels, fish, snails, and crustaceans. Turbid waters hinder fish breeding because the fine suspended particles clog the mucous membrane of fish eggs and asphyxiate the fry.

Interruption of the river continuum by dams, hydropower stations, artificial lakes, trout thresholds

Interrupting river courses by dams, hydropower stations, artificial lakes, and so on, has a serious impact on migrating aquatic life. This impact is most severe to fish because many of the fish species perform seasonal breeding, feeding and other migrations up and down the stream. This impact is also of particular concern regarding species that migrate for breeding, such as the Common Nase (Chondrostoma nasus) and the Zarte (Vimba vimba), for their survival depends on their access to the breeding sites usually located in the upper sections of the river. The presence of migration barriers may completely destroy the population of these species in the short term (Fig. 18).

Dams also modify the hydrological regime of the river. Depending on the height of the dam wall, an artificial lake of a different size takes shape behind it. Water therein is much slower and conditions are created for accumulation of fine sediments. This completely changes the flora and fauna of the environment. The accumulation of organic matter and sediments behind the dam wall may lead to mass extinction of water life. In the case of larger dam walls, e.g. dozens of meters high, water is usually released from the bottom layers of the lake where it is not only short of oxygen, but also very cold. This kind of temperature pollution is quite often neglected, but it is very serious and impacts large sections of the rivers. In some cases aquatic communities change completely.

Another problem is the dramatic daily change of river levels after the hydropower station (hydropeaking). This unnatural process can kill riparian communities, putting a lot of stress on the remaining ones. When a dam is built, sediment transport downstream is suspended, which results in incision of the river bed after the dam, increased erosion and all the other negative consequences described above (Fig. 19).

On September 10, 2008, the Lakatnik hydropower station situated on the Iskar River released more water than anticipated for several hours. As a result, the sediments in the artificial lake behind the dam came up to the surface, dissolved into the water and killed tens of thousand of fish downstream. There is no statistical data about other small aquatic life forms. It should be noted that this happened only four months after the hydropower station was put into operation, and the amount of sediments was much less than it would be after years of operation.

Stream management – water intake

For our everyday needs, industry and farmland irrigation we use huge amounts of fresh water. Most of it comes from rivers or from underground sources which feed the rivers. This naturally leads to water decrease in rivers, resulting in serious consequences: many rivers dry up in their upper sections, where most of the catchments areas for potable water are located. In other places the water volumes drop under their critical minimum and the riparian vegetation dies.

Cutting down riparian vegetation, "clearing" river beds

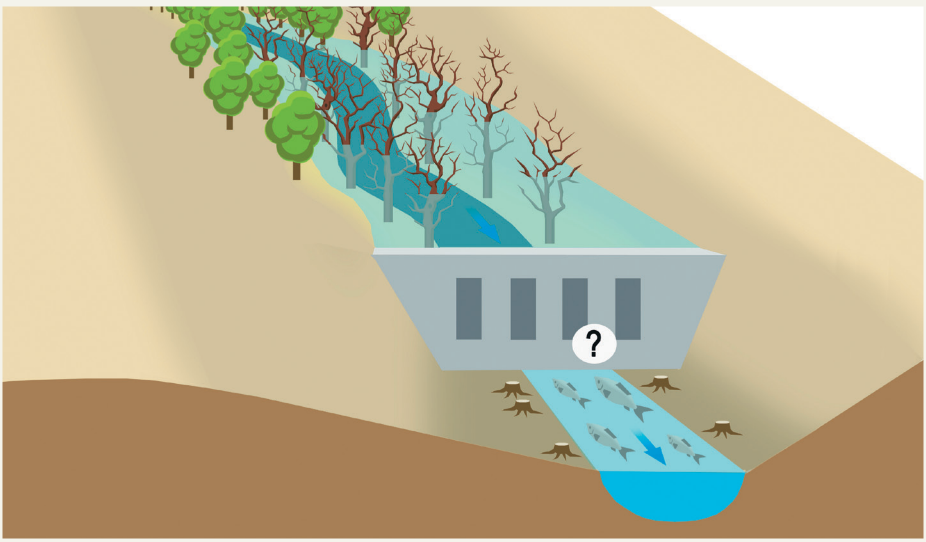
Cutting down riparian vegetation – whether to clear the riverbed, to combat flooding or to reclaim land for farming – leads to:

- Increase of water temperature, especially in small mountain tributaries where riparian trees fully overshadow the river course and prevent water overheating. The removal of this vegetation leads to increased water temperature and changes in river ecosystems. This is of particular concern regarding the trout area, where the removal of riparian vegetation results in the extinction of trout population.

- Increase of nutrient pollution. The absence of riparian belt of vegetation leads to unhindered passage of nutrients via groundwater from the farmland. Where there is a vegetation belt, up to 90% of the nutrients are captured and absorbed before reaching the river.

- Intensified erosion of river banks. The roots of plants and especially those of trees have an important structural role on the reinforcement

Fig. 18 Interruptions in the river corridor and habitat changes caused by dams (hydropower station, artificial lakes and other man-made structures)



of river banks because they retain the soil particles and prevent the water from carrying them away.

Water pollution

This is one of the best known and most commented negative impacts of human activity on water. Until recently it was considered the most significant problem of river health. As a consequence of wide discussion and measures taken, there is a decrease in pollution of rivers in Bulgaria and worldwide.

Decreased retention capacity of watersheds

Deforestation, transformation of areas into arable land for farming, urban development and cutting off floodplain areas result in a decreased water retention capacity of watersheds, which take in, retain and gradually release precipitation water into the rivers. As a consequence, the runoff is considerably changed. Floods are more frequent with higher waters, and dry seasons become longer.

It is well known that deforested areas easily erode, which favours torrents. Different forests have different retention capacities depending on the root systems and forest floor. Research has shown that old deciduous forests have the highest water retention capacity.
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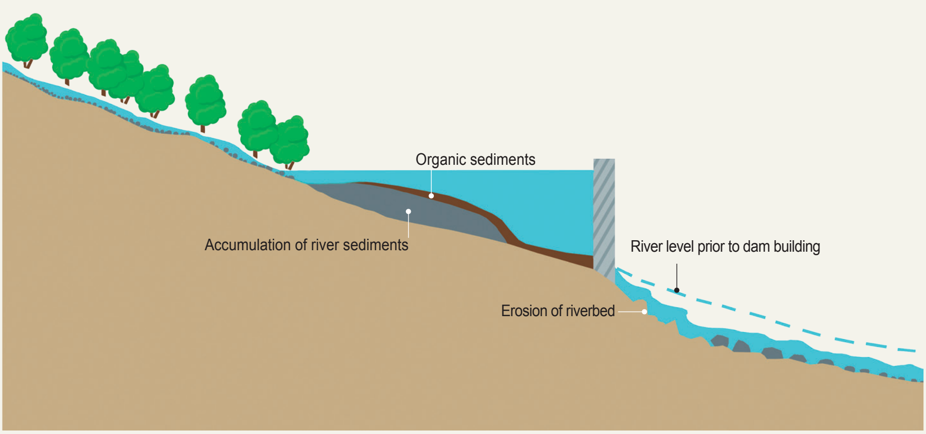
In urbanized areas, where the possibility for rainwater infiltration is virtually zero because of impervious areas covered by asphalt and concrete, it takes less time for rainwater to reach the rivers than in natural environs. This eventually leads to serious flooding because at downpour huge amounts of water reach the river at the same time, and the river does not have the capacity to

Fig. 19. Changes in sediment transport resulting from dams



take it in.
Riparian floodplains act as buffers where the overflow spreads out and subdues the flood peak. Later, part of the water goes gradually back into the river reducing the period of low water. In the 20th century dams and other hydrotechnical structures cut off almost 80% of the floodplains that provided retention areas along the Danube River. The situation is similar for the floodplains along the other rivers of Bulgaria.

Bulgarian forest engineers have a long and rich experience in mastering erosion and torrents in over 2,000 water courses of Bulgaria. Since 1905, when the first Flood Control Office was established, a number of erosion control activities were implemented, including reforestation of 0.82 million ha. These measures are effective in reducing soil erosion, retaining water in forests, reducing the erosion of riverbeds, strengthening the rivers banks and decreasing the transfer of sediments.

A typical example of successful erosion control measures was set with the Iskar Dam Lake. After its construction in 1954, erosion control measures were taken to decrease the sediment amount in the lake, which was about 930,000 m^3 per year. Over 20 years, 19.7 thousand ha within the dam watershed were afforested and a series of other erosion control activities were carried out. These measures successfully reduced the annual transfer of sediments to 447,000 m^3 per year.

RIVER RESTORATION IN BULGARIA

In the recent years of changing environmental perceptions, the understanding of natural river services mentioned above together with the awareness that most of the so-called natural disasters are actually induced by human activity, triggered the first attempts to restore the natural state of rivers. Below are three examples of the activities carried out in Bulgaria by WWF for integrated restoration of pilot sections of the Danube, Yantra and Rusenski Lom rivers.

Restoration of the link between the Danube River and the wetlands of Persina Island near Belene

The wetlands of Persina Island (Belene) in Persina Nature Park are among the most important breeding sites in the lower Danube for various water birds and most of the Danube fish species. After protection dikes were built around the entire island in the mid-20th century, the wetlands began to gradually dry up, losing to a large extent their important ecosystem role. In 2007 the wetlands of Persina Island were re-linked to the Danube River under the “Project for Wetlands Restoration and Pollution Reduction” as part of the “Lower Danube Green Corridor” initiative. The project was carried out by the Ministry of the Environment and Water in Bulgaria and the main donor was the Global Environment Facility (GEF).

The restoration of the wetland on Persina Island was achieved by opening the protection dike at three points; in addition two-way gateway locks and connecting channels to the marshes were built. The farmlands in the western part of the island, where the prison inmates of Belene used to work, are protected by an intermediate dike and a new draining canal with an automatic drainage pump station (Fig 20).

The restored wetland is a human-controlled floodplain of about 2,200 ha. The depth of flooding varies up to 2.5 m. At this water level, four relatively large marshes shape in the eastern part of the island – Murtvo Blato, Peschina, Staroto Blato and Dyulova Bara, as well as several smaller ones.

Already in the first year after the lock was opened, tons of fish came into the marshes to spawn their eggs; birds came back as well. Nowadays, hundreds of rare bird couples nest in the marshes, consisting of ferruginous duck, pygmy cormorant, greylag goose, great crested and red-neck grebes, terns, herons and others. A group of Dalmatian pelicans comes regularly to the island and in the near future they will probably start nesting there again for the first time after half a century of absence.

The Danube marsh of Kalimok – not far from the town of Tutrakan – was restored in the same way and under the same project. It had also dried up in the mid-20th century and turned into hatcheries, which proved unsuccessful. Thus, almost 2,000 ha have been re-flooded by Danube waters and large colonies of birds went back to hatch there as they did in the past.

Restoration of Veselina River Meander near the Mindya Village

The Yantra River runs through a terrain of a small displacement and is characterized by a very high coefficient of sinuosity, which means that it has many meanders. Most of these meanders have been cut off and the riverbed straightened. The consequences of this “straightening” were described above. WWF together with local people from Mindya village in the region of Veliko Turnovo, restored the connection of the Veselina River, a tributary of the Yantra, with its former meander near the village. When the river meander was cut off in previous times, the river dug nearly 150 cm deeper into its bed, so now a threshold had to be built to raise its level enough for enabling it to run back to its old bed (Fig. 21). Nowadays the Veselina River flows again down its old meander, where slower and warmer waters provide breeding conditions for many fish species like chub, pike, carp, as well as amphibians and birds; it also provides additional protection at high water.

Fig. 20. Restored wetlands on Persina Island (Belene) in Persina Nature Park

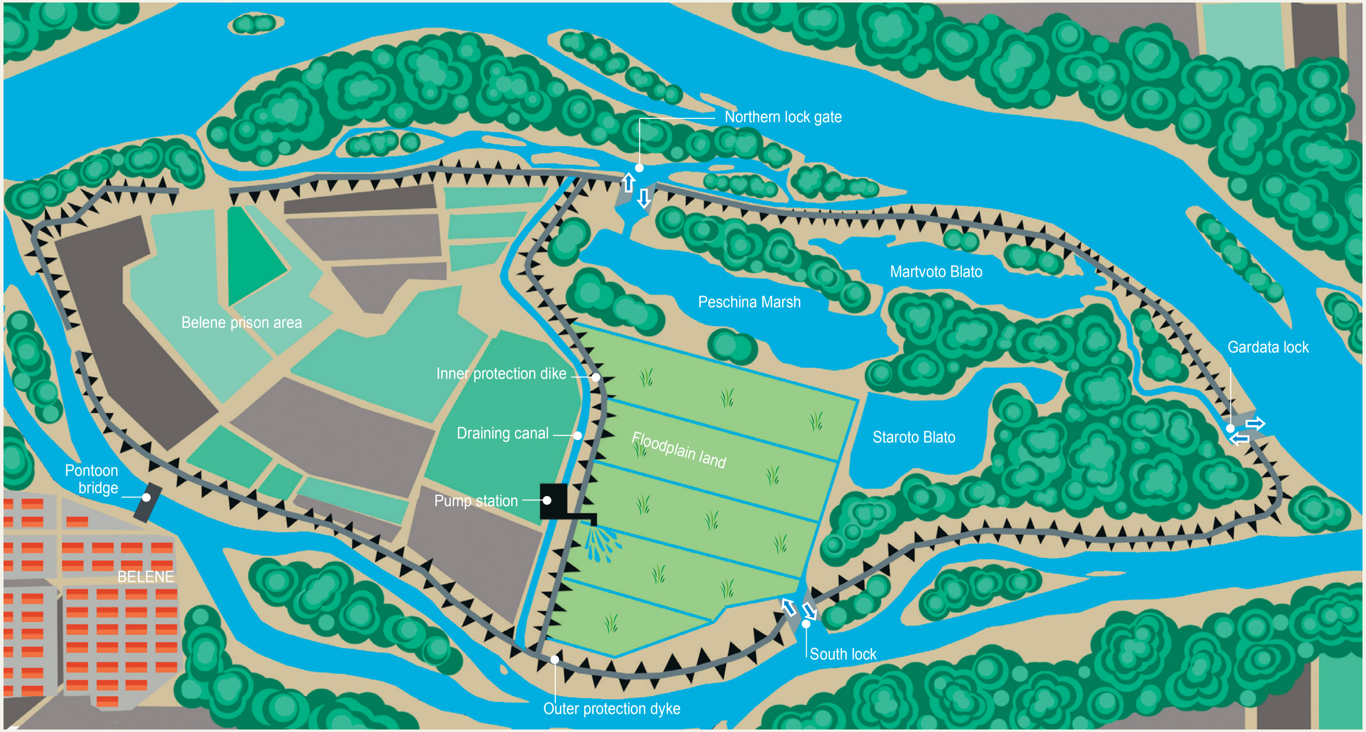
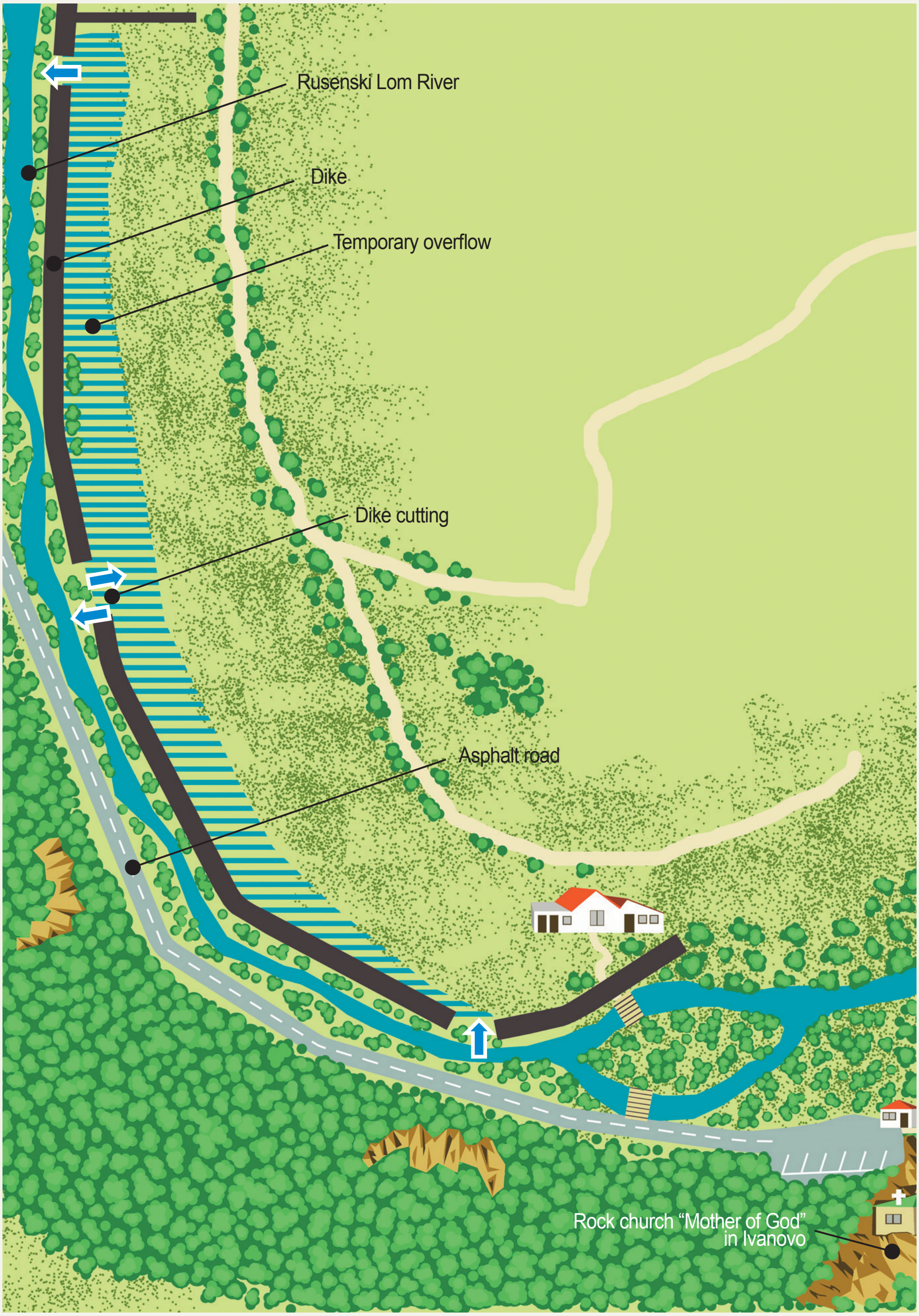


Fig. 21. Restored river meander of the Veselina River near Mindya village

Fig. 22. Master plan of the restoration of the Rusenski Lom River near Ivanovo



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Straightening of the Rusenski Lom River near Ivanovo Rock Monasteries

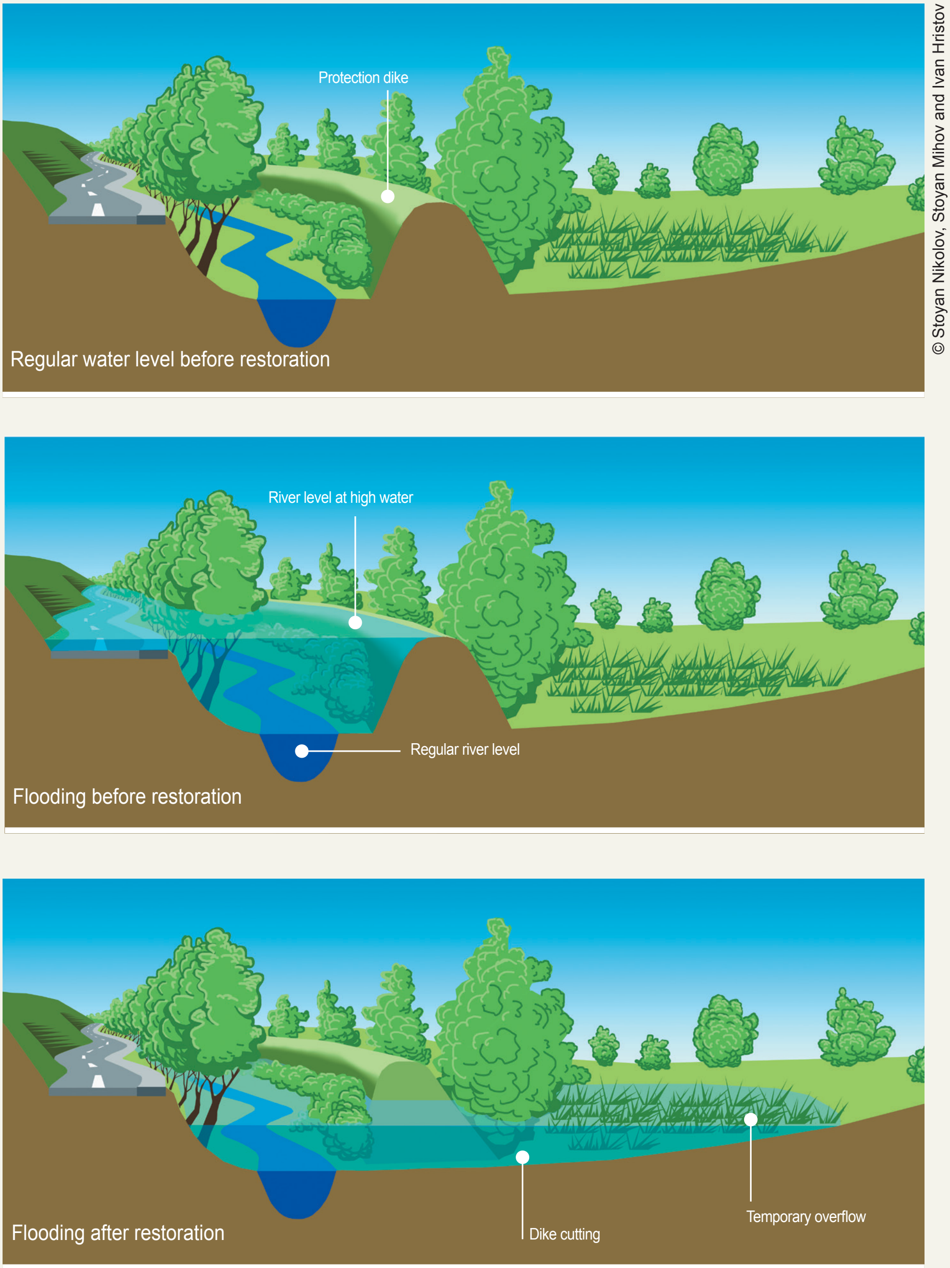
In the mid-20th century most of the lower flow of the Rusenski Lom River was fully diverted. This measure was unsuccessful at some sections because of frequent flooding and high groundwater. Therefore, most of the land "reclaimed" from the river has been converted into fishponds, which proved to be economically inefficient and quite often destroyed during times of high water. That is why many of these fishponds today are out of operation and abandoned.

Such is the case of the Rusenski Lom river section near the Ivanovo rock monasteries. The asphalt road to the rock monasteries is situated atop of the river protection dike. Part of the visitor infrastructure to the archaeological reserve is also established at the same ground level. On the right bank of the river behind the protection dike, there are several fishponds that no longer serve their initial purpose. High water floods the road, preventing access to the rock monasteries and damaging the infrastructure. When water overflows the dike, it can no longer go back into the river. The flood in 2006 washed away the bridge and the alcoves on the island once again. The dike partly broke in three places. The flooded land remained under water over one year. WWF started restoring the river and measures were completed in 2009. In this case, the water itself suggested the solution to the problem. The dike was further opened in three places. It is the first example in Bulgaria for application of the principle "more space for the river – more safety for people", proven yet in mid-20th century.

Thanks to this approach, now during high water the river may spread out, settle down and go back into its bed without flooding the surrounding land (Fig. 22 and Fig. 23).

At the same time, overflows in the floodplain terrace provide feeding places for the black stork, habitats for rare water plants and breeding places for a number of fish and amphibian species. The project was implemented in 2009 by the Rusenski Lom Nature Park Directorate, "Friends of Rusenski Lom" Club and WWF with the support of the Bulgarian Ministry of Culture, and was funded by WWF and the German Federal Ecological Foundation DBU.

Fig. 23. Rusenski Lom River at flooding



WWF is one of the world's leading independent environmental organizations with 5 million supporters and a global network, which operates in more than 100 countries. In the Danube-Carpathian region WWF is implementing projects focused on the conservation of protected areas and wetlands restoration along the Danube and its tributaries.

On June 5th 2000, at the WWF initiative, the Ministries of Environment of Bulgaria, Romania, Moldova and Ukraine signed the Lower Danube Green Corridor Agreement, recognizing the importance of creating a network of sustainably managed protected areas and the need to reconnect and restore Danube's floodplain to the natural dynamics of the river. The Lower Danube Green Corridor, is the most ambitious wetlands restoration initiative in Europe.

WWF promotes the concept "more space for rivers, more safety for humans" through the restoration of the floodplain/wetlands along the rivers, which will help reduce floodrisk. 80% of Danube's floodplain was lost and converted into agricultural land, losing thereby one of its most important functions: storing water during floods and releasing it back into the Danube during the periods between the floods. The restoration of at least 300.000 ha along the Danube would contribute significantly to reducing flood risk and would generate valuable environmental benefits and services to the local communities. WWF is implementing a few pilot wetlands restoration projects along Danube and in the Danube Delta.

WWF is lobbying for sustainable solutions for transport development on the Danube, which will not jeopardize the biodiversity and its natural processes specific to the Lower Danube – the last free-flowing sector of the river. Plans and projects in different phases of implementation, such as the one which concerns the common sector Romania-Bulgaria, the Călărași-Brăila sector, Bâstroe canal, are thretening the natural balance of the river, adding yet to other pressures (pollution, dredging etc.). The Lower Danube, downstream Iron Gates, is also the last segment of the migration route of the sturgeons fom the Black Sea upstream in the Danube for spawning. The implementation of such projects without taking into account the environmental issues will contribute to the extinction of already endangered species. WWF's slogan ,,Fit the ships to the river, not the river to the ships,, is promoting the use of inovative technologies for building new types of ships, interventions that will not alter the free-flowing conditions and use of River Information Systems.

WWF is also working for an adequate management of the protected areas along the Danube. Thus, optimal conditions will be created in order to protect endangered species such as the Pygmy Cormorant and Ferruginous Duck as part of a Life (EU) Nature Project - ,,Green Borders,, - implemented in Romania and Bulgaria. Approximately 18.000 pairs of Ferruginous Duck and 39.000 pairs of Pygmy Cormorant are found in Europe at the moment. The Lower Danube hosts a significant part of these two species: 7% of the Ferruginous Duck population and 17% of the Pygmy Cormorant population are living in this area.

River Ecology

100%
RECYCLED

80%

More than 80% of the length of the Danube has been regulated

177

Today only a third of the world's 177 large rivers remain free-flowing, unimpeded by dams or other barriers

€20 BILLION

For the period 2010-2027 the measures necessary to improve water quality in the Danube were estimated at 20 billion Euro

20 MILLLION

The Danube provides drinking water for 20 million people

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To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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