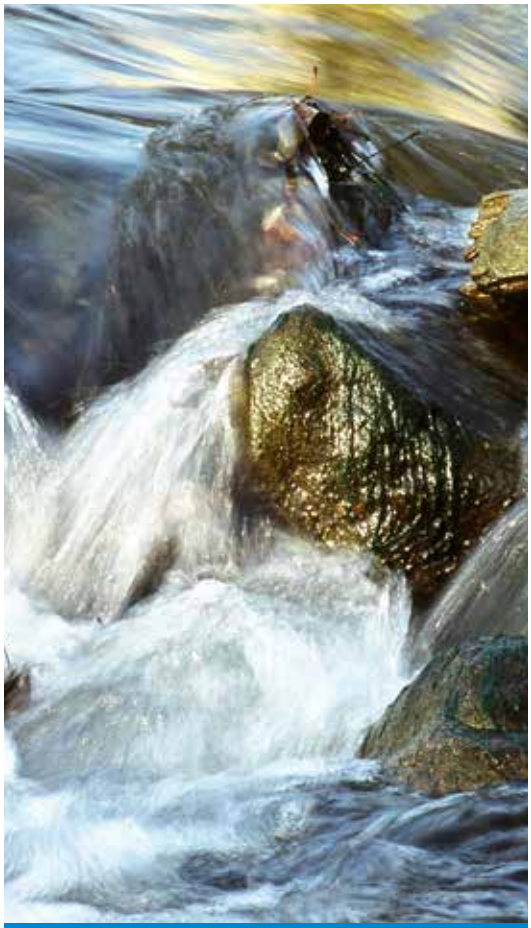
THE RHINE AND ITS CATCHMENT: AN OVERVIEW

- Ecological Improvement
- Chemical Water Quality
- Survey of the Action Plan on Floods



Internationale Kommission zum Schutz des Rheins

Commission Internationale pour la Protection du Rhin

Internationale Commissie ter Bescherming van de Rijn

International Commission for the Protection of the Rhine

THE RHINE AND ITS CATCHMENT: AN OVERVIEW

Ecological Improvement
Chemical Water Quality
Survey of the Action Plan on Floods

This report presents an overview over ecological improvement along the River Rhine and its present chemical water quality. Furthermore, it contains a survey of the implementation of the Action Plan on Floods.

The contamination of the Rhine was the reason for founding the International Commission for the Protection of the Rhine (ICPR) in the 1950s. The Conventions on reducing the contamination by chemicals and chlorides, the joint management of the Sandoz accident on 1st November 1986 and the consecutive activities of all Rhine bordering countries aimed at sustainably securing the quality of Rhine water have been extremely successful. While the intensive use of the Rhine catchment and its high population density, its high density of chemical sites and intensive agriculture remain unchanged, the Rhine water quality had, in 2000, all in all improved to such an extent that water production from Rhine water was possible and salmon as well as other sensitive fish species were again able to colonize the river.

The enhanced Rhine Convention signed in 1999 was an important step. It integrates the sustainable development of the ecosystem, securing the use of Rhine water for drinking water production, improvement of sediment quality, holistic flood prevention and flood protection taking into account ecological requirements and relief of the North Sea.

The current ICPR programme „Rhine 2020“ contributing to concretising the general targets of sustainable development along the Rhine is focussing on the main targets of further improvement of the Rhine ecosystem, flood prevention and protection and chemical water quality.

For the EU countries, the EC Water Framework Directive (WFD), its daughter directives and the EC Floods Directive represent essential tools for the implementation of the programme “Rhine 2020”. They imply a joint obligation of the EU states to take measures and emphasize the necessity of integrated management of rivers in river basin districts.
Furthermore, and since the last big floods of the Rhine in 1995, the states in the Rhine catchment have invested more than 10 billion € into flood prevention, flood protection and raising awareness for floods in order to reduce flood risks and to thus improve the protection of man and goods.

This ICPR progress report summarizes the more recent results for the Conference of Rhine Ministers in 2013.

Chapter 1 focusses on the major ecological improvements since 2000, chapter 2 describes the present chemical water quality. The effects of flood protection measures taken between 1995 and 2010 within the Action Plan on Floods in the different states of the Rhine catchment are the subject of chapter 3.

1 ECOLOGICAL IMPROVEMENT

1. Reactivation of floodplains
2. Reconnection of oxbow lakes and backwaters of the Rhine
3. Increase structural diversity on the banks of the Rhine and its branches
4. Restoration of river continuity
5. Alien plant and animal species in the Rhine
6. Summary and Conclusion

ECOLOGICAL IMPROVEMENT

The ICPR programme „Rhine 20202“ states precise targets to achieve by 2020 in order to improve the ecosystem along the main stream of the Rhine. These targets have been integrated into the summary of programmes of measure of the management plan for the international river basin district Rhine according to the WFD.

This balance presents a survey of progress achieved between 2000 and 2012 in the following sectors concerning the main stream of the Rhine:

- **Reactivation of floodplains**
- **Reconnection of oxbow lakes and backwaters**
- **Increase of structural diversity of the banks of the main river and its branches**

The programme waters for migratory fish as defined in the „Master Plan Migratory Fish Rhine“ have been integrated into the working area restoration of river continuity. Furthermore, one chapter looks into alien plant and animal species in the Rhine.

The target of the European Water Framework Directive (WFD) in force since 2000 is the good status of all water bodies. That means that, by 2015, among others, rivers such as the Rhine are to be not only clean, but also ecologically intact. The implementation of measures according to the WFD in the EU Member States along the Rhine has at the same time brought about progress for the programme „Rhine 2020“.

1. REACTIVATION OF FLOODPLAINS

The intermediate target for the reactivation of floodplains to be achieved by 2005 was set to 20 km². By 2005, almost 80 km² of floodplains were reactivated. Apart from the relocation of dikes, this surface also comprises the ecological flooding of flood retention areas behind the dikes. By the end of 2012 some further 42 km² had been reactivated, bringing the total surface of reactivated floodplains to almost 122 km². Thus, in spite of the density of uses along the main stream of the Rhine and including newly created, ecologically flooded retention areas, the target of 160 km² set for 2020 seems to be achievable.

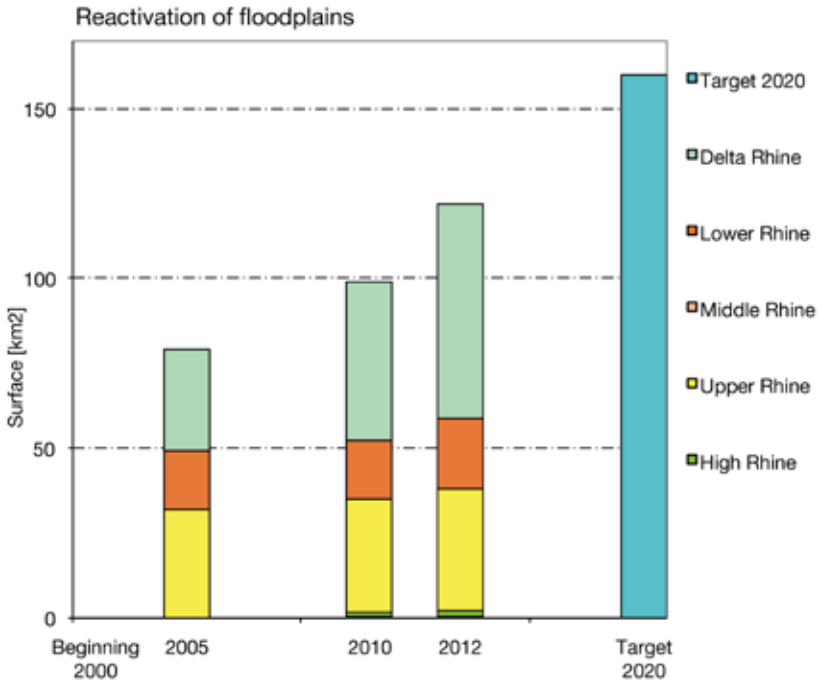
River meadows are low lying areas along a river characterized by the change of floods and low water. These areas are essential for the Rhine ecosystem, but also for man, as they increase water retention and are thus the best means of flood prevention. By reactivating overbank areas along the Rhine, further habitats for the flora and fauna living in the water, on its banks and in the floodplains will be opened up.

Due to natural features, the possibilities of reactivating overbank areas along the High Rhine and the Middle Rhine and for reconnecting oxbow lakes are very limited. In these regions, largely urban forelands were structured and, on a small scale, naturenear floodplains were restored which may have positive ecological effects and even act as stepping stones.

This assessment also includes recently established, controllable flood storage areas. When calculating the surfaces of these retention areas, only those surfaces were taken into account, which may be used for ecological flooding and thus develop towards floodplains. A linking with flood prevention measures must still be strived for, while maintaining qualitative ecological aims.

Reactivation of at least 20 km² of floodplain area by 2005 and 160 km² by 2020
Indications in km²; cumulated values

	State 2005	State 2010	State 2012	Target 2020
High Rhine	0,05	1,59	1,99	
Upper Rhine	31,50	33,12	35,91	
Middle Rhine	0,00	0,00	0,00	
Lower Rhine	17,54	17,54	20,88	
Delta Rhine	30,00	46,38	63,07	
Sum	**79,09**	**98,63**	**121,85**	**160**

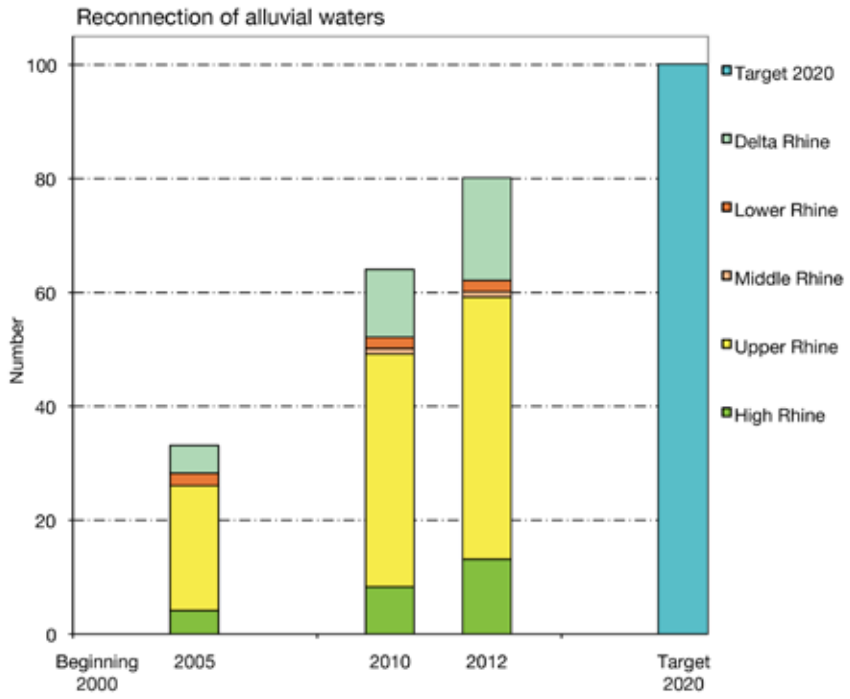


Black Kite (source: M. Wolke)

2. RECONNECTION OF OXBOW LAKES AND BACKWATERS OF THE RHINE

33 measures were implemented by 2005; the target of reconnecting 25 water bodies by 2005 has thus already been achieved. By the end of 2012, 47 more water bodies, thus 80 water bodies in all had been reconnected. It is not expected that the target set for 2020 to reconnect 100 oxbow lakes and side waters with the Rhine will be achieved.

Reconnection of at least 25 oxbow lakes, lateral water bodies etc. by 2005; 100 by 2020				
	State 2005	State 2010	State 2012	Target 2020
High Rhine	4	8	13	
Upper Rhine	22	41	46	
Middle Rhine	0	1	1	
Lower Rhine	2	2	2	
Delta Rhine	5	12	18	
Sum	**33**	**64**	**80**	**100**



3. INCREASE STRUCTURAL DIVERSITY ON THE BANKS OF THE RHINE AND ITS BRANCHES

Until 2005, measures were implemented along 49 km of river banks (on the left or right bank of the Rhine). The target to increase structural diversity along 400 km of river banks by 2005 was thus not achieved.

By the end of 2012, measures had been implemented along some further 56 km of river banks, thus along 105 km in all. Taking into account the density of uses along the main stream of the Rhine, the target for 2020 - 800 km - seems to be very ambitious and will be difficult to achieve.

However, the assessment only takes into account construction measures requiring a planning permission hearing and not environmentally sustainable river bank maintenance which has today become common in many places. Thus, the length of river banks in fact improved along the Rhine is considerably longer than what is presented here.

Increasing structural diversity in the river bed and on the banks may enhance species diversity and further habitats can be created for plant and animal species in the water body and on its banks.

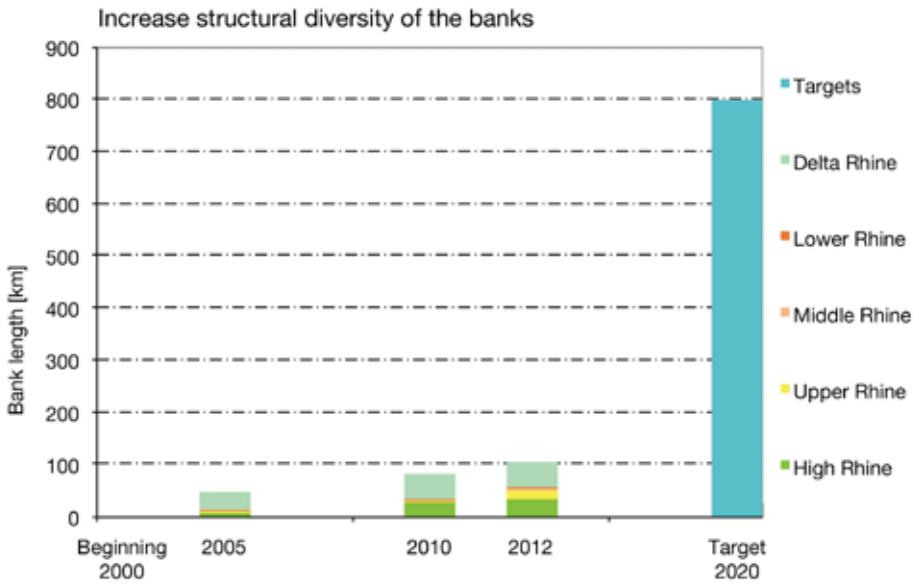
Economically speaking, it is difficult to implement this ambitious target, as, on the one hand, much land is required and certain construction measures must be financed and, on the other hand, there is an obstacle of sociological acceptance from sides of the users and the population which are often reluctant when it comes to changes in practices and landscape. Again and again, conflicts of interests arise around the uses of the riverbank areas and the required aquatic environment. Often, ecological improvements are only possible when combined with compensatory measures in connection with concession negotiations or constructions (construction of sluices, roads, relocation of dikes, retention areas, etc.). This is where good cooperation with navigation and the time factor play an important part.

However, first experience shows that these restoration measures are possible and do have a positive effect on the aquatic environment and on the population living on the banks of the river which can win the river back as a habitat. Thus, efforts aimed at implementing the aforementioned compensatory measures must be reinforced.

Increase structural diversity along the banks of the Rhine and its branches along 400 km by 2005 and 800 km by 2020

Indications in km; cumulated values for left and right bank

	State 2005	State 2010	State 2012	Target 2020
High Rhine	6,26	27,46	33,82	
Upper Rhine	3,9	4,45	19,17	
Middle Rhine	0	0,5	1,0	
Lower Rhine	1,9	1,9	1,9	
Delta Rhine	36,51	47,92	49,53	
Sum	**48,57**	**82,24**	**105,42**	**800**



4. RESTORATION OF RIVER CONTINUITY

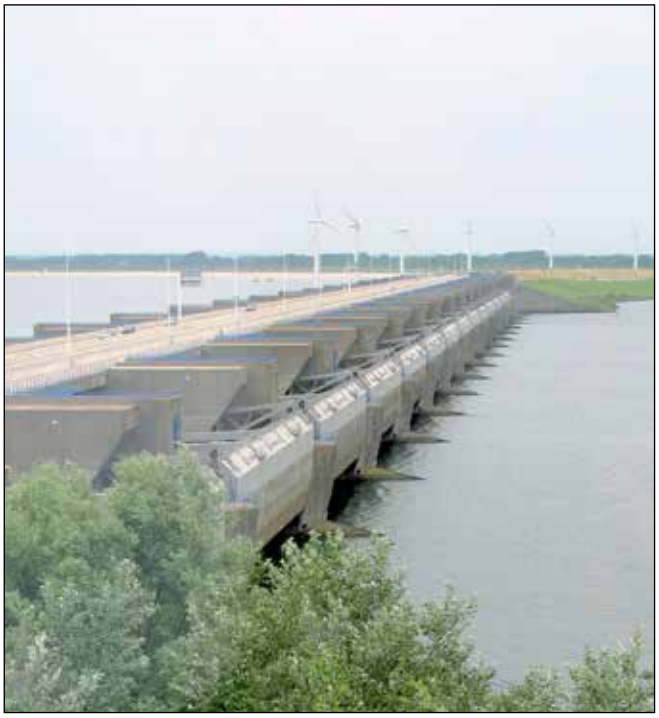
To survive and spread, migratory fish such as salmon, sea trout, sea lamprey, allice shad and eel which spend one phase of their life in fresh water and one in salt water, essentially require free migration between the sections of a river. Migratory fish are at the same time pilot and indicator species for the living conditions of numerous other organisms. The Lake Constance lake trout is the pilot species for the Alpine Rhine and Lake Constance.

The states in the Rhine catchment strive to progressively restore river continuity in the main stream of the Rhine as far as Basel and in certain programme waters. The „Master Plan Migratory Fish Rhine" has been drafted with a view to achieving this target (see www.iksr.org – Report no. 179): In order to build a self-sustained stock of salmon and lake trout, access to a maximum number of identified spawning and juvenile habitats in the Rhine catchment must be restored or these habitats must be revitalised. On the whole, with these measures, all in all more than 1,000 ha of spawning and juvenile habitats are supposed to be opened in the Rhine catchment.
During 2000 - end 2012, river continuity has been improved at 481 barrage weirs in the programme waters.

The most important fields of action in the main stream of the Rhine and its major tributaries are:

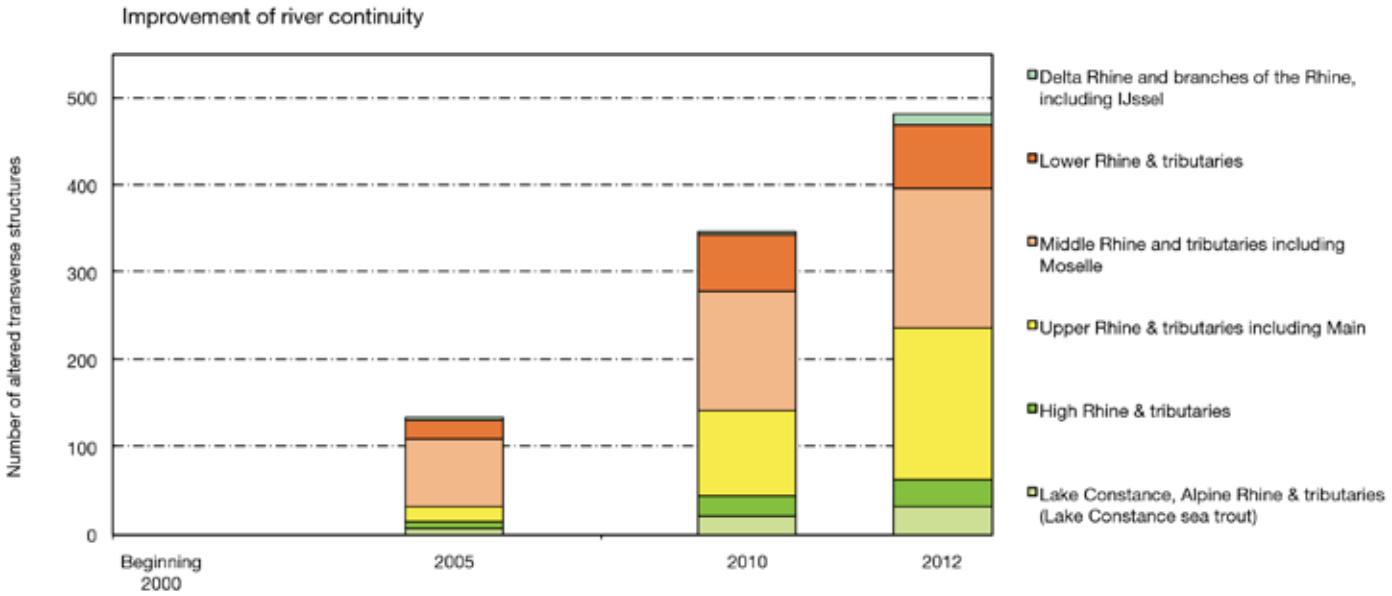
- Improve fish migration at the Haringvliet sluices and at the closure embankment of Lake IJssel;
- The two dams in the Upper Rhine upstream of Gambsheim (Strasbourg by 2015, work in Gerstheim to begin before 2015 in order to open the way into the Elz-Dreisam system in the Black Forest);
- Existing fish passages at four dams in the High Rhine (Rheinfelden, Ryburg-Schwörstadt, Albbruck-Dogern, Eglisau) have been improved; concerning the Rheinau power plant, negotiations aimed at a higher residual water flow are going on;
- Reconstruction of several big dams in the navigable tributaries Moselle (10), Main (6), Lahn (20), Neckar (3), etc.

In addition, several hundreds of individual measures will be implemented at smaller barrages in suitable tributaries where most spawning habitats are found (see figure page 11).
Previously, the programme „Rhine 2020" did not set any target for the number of transverse structures to be altered. The figure gives clear evidence of the acceleration of measures brought about by the implementation of the programmes of measure under the Water Framework Directive.



Haringvliet sluices

Improved river continuity of the Rhine and its tributaries, in particular of programme waters for migratory fish			
	State 2005	State 2010	State 2012
"Lake Constance, Alpine Rhine & tributaries (Lake Constance sea trout)"	7	21	31
High Rhine & tributaries	7	23	31
Upper Rhine & tributaries including Main	18	97	174
Middle Rhine and tributaries including Moselle	77	137	159
Lower Rhine & tributaries	22	65	73
Delta Rhine and branches of the Rhine, including IJssel	3	3	13
Sum	**134**	**346**	**481**

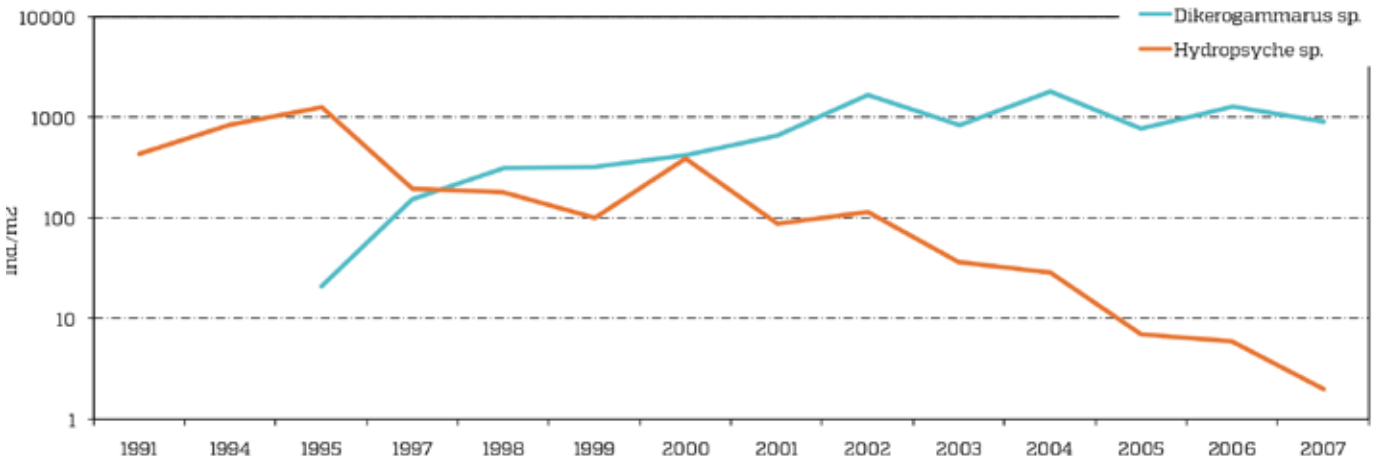


5. ALIEN PLANT AND ANIMAL SPECIES IN THE RHINE

Invasive species are ecdemic, thus alien animal species from other regions. Among others, numerous species from the Black Sea region which have immigrated through the Main-Danube-Canal since 1992 are found in the Rhine. Often, considerable biomasses of these invasive species settle in the main stream and in tributaries and, attached to vessels, they even spread upstream - often at the expense of the native fauna.

On the Middle Rhine, such relationships have e.g. been proved for the predatory *Dikerogammarus sp.* introduced from the Black Sea and the native caddis worm *Hydropsyche sp.* (see fig. page 12). During the past years, among the fish species, above all gobies (Gobiidae, Odontobutidae) appear in high numbers and density of individuals. So far, 4 immigrated species have been detected in the Rhine; two further species are expected to appear in the near future. Today, the most frequently met goby species in the Rhine are the Round Goby (Neogobius melanostomus), the Bighead Goby *(N. kessleri)* and the Monkey Goby *(N. fluviatilis)*. Regarding certain native species, among others, competition for food, habitats and spawning grounds are feared. Furthermore, food organisms (native invertebrates, small fish or fish eggs and larvae), the predator populations (predator fish, cormorant) may be impacted and parasites might be introduced.

Neogobio kessleri (Source: BfG)



Abundance of the predatory Dikerogammarus sp. and of the caddis worm Hydropsyche sp. along the Middle Rhine

Also, during the last biological survey of the Rhine, alien water plant species (neophytes) were found in the Rhine, such as the Nuttall's waterweed (Elodea nuttallii). The 2012/2013 survey pays particular attention to invasive species and neophytes and the native species they impact. It is most likely that alien plant and animal species can no longer be suppressed substantially.

Existing pressures of alien species on the stocks of native species - among others caused by climate change - will possibly continue. Measures aimed at re-naturing and improving river continuity and targeted programmes in support of species may contribute to fight the mass development of alien species.

SUMMARY AND CONCLUSION

However, by the end of 2012, the targeted increase of structural diversity along 800 km of river banks along the main stream of the Rhine had only been achieved along 105 km. But restoration measures carried out in river bank areas so far prove that these have a positive effect on the water biocoenosis and that the population living on the banks of the Rhine again considers the Rhine to be an attractive recreational area and living space.

Since 2000, the possibility of bypassing barriers in programme waters of the Master Plan Migratory Fish has been improved at 481 weirs. This particularly concerns upstream migration.
Numerous national measures within the implementation of the EU Water Framework Directive have considerably enhanced the success by 2005 for the Rhine ecosystem within the ICPR programme „Rhine 2020". Notable improvements have been achieved, even though, in one sector, much remains to be done before the target set for 2020 will be attained.

2 CHEMICAL WATER QUALITY

1. Municipal wastewater
2. Industrial wastewater
3. Diffuse substance inputs - nitrogen and phosphorous
4. Diffuse substance inputs - plant protection agents
5. Diffuse substance inputs - other origins
6. Instances of environmental damage relevant for the Rhine

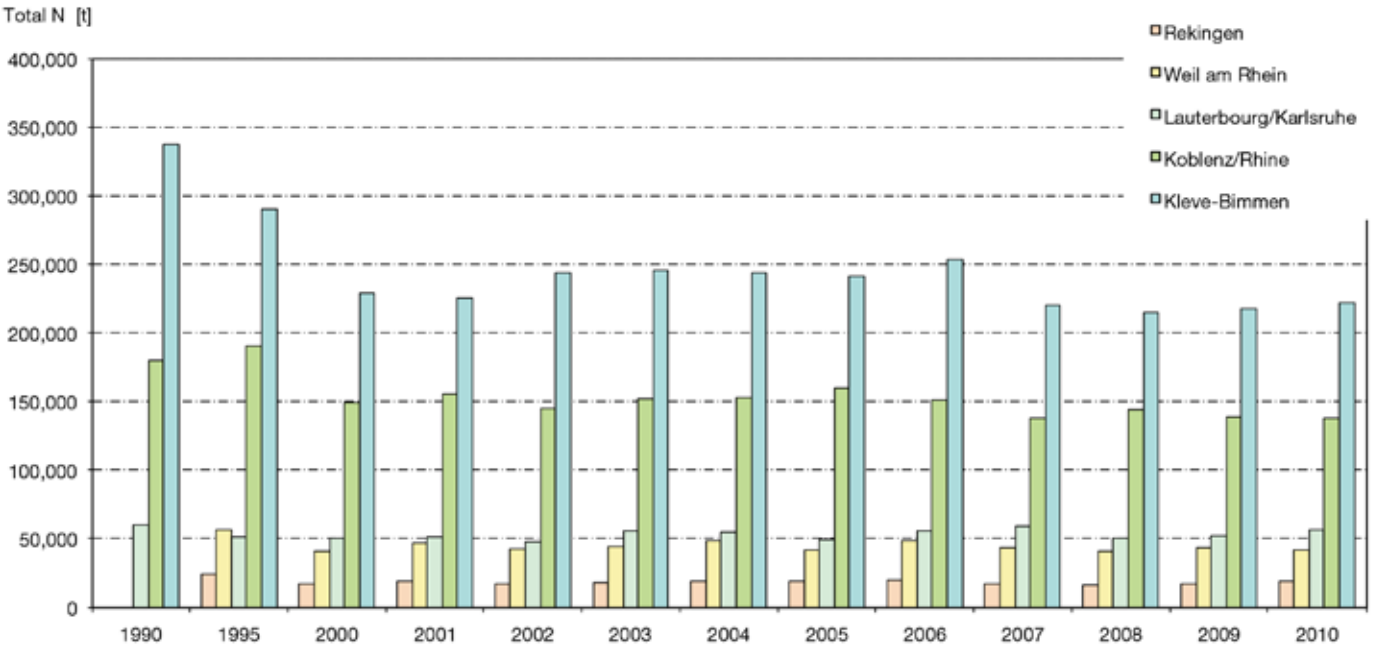
1. MUNICIPAL WASTEWATER

During the past decades, industry and municipalities have already made considerable efforts towards reducing the contamination of water bodies. 96 % of the households of the about 58 million inhabitants of the Rhine catchment are connected to municipal wastewater treatment plants. The total treatment capacity of these wastewater treatment plants is even higher (about 100 million inhabitant equivalents), as these plants also treat wastewater originating from industry and trade. About half of the total amount of wastewater of the Rhine catchment is treated in wastewater treatment plants with a capacity beyond 100,000 inhabitant equivalents (less than 4 % of all of the approx. 5,000 treatment plants of the survey).

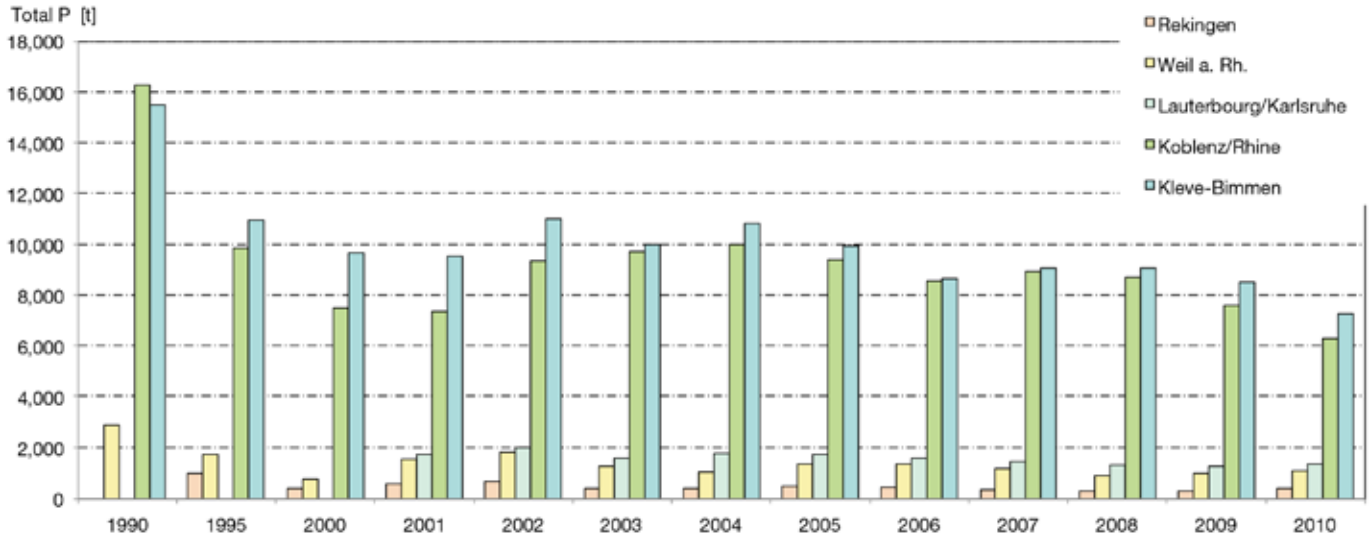
In most of the wastewater treatment plants, oxygen depleting substances are decomposed by more than 90 %, nitrogen and phosphorous are removed by about 80 % and 85-90 % respectively and more. In smaller wastewater treatment plants, the rate of decomposition tends to be lower. During 2000 to 2010 and in some states, the purification performance for nitrogen improved by about 15 %, that for phosphorous by 5 % or more.

The programmes of measures of the states in the Rhine catchment include further measures, such as an adjustment to the best available technology, operation improvements and expansions for further purification, among others by improving the elimination of nitrogen and phosphorous.

The efforts of the past years towards reducing the nitrogen concentration in municipal and industrial wastewater and - to a lesser degree - in agriculture have resulted in a reduction of nitrogen concentrations in coastal waters by approximately 25 % (1985 - 2009). In particular, the reduction of the nitrogen concentrations transported by the Rhine by 2000 is a result of measures implemented in municipal wastewater plants.
The today still measurable amounts of nitrogen are, to a considerable extent, due to applications in agriculture. The required reduction measures for this sector are set out in chapter 3.



Long-term development of annual amounts of total nitrogen (in tons) at the international monitoring stations along the Rhine.

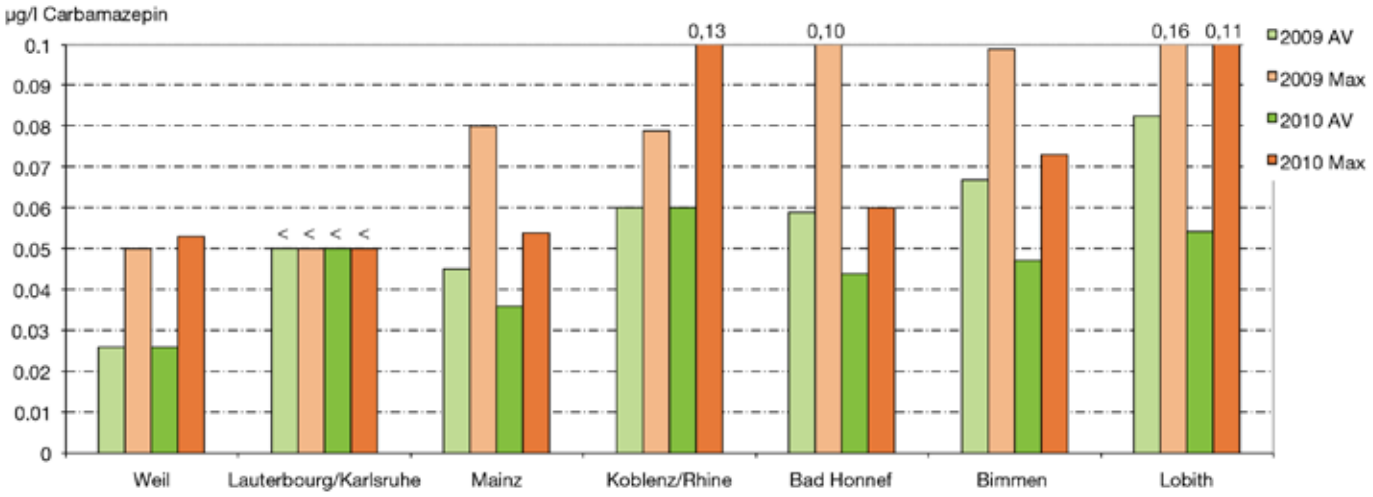


Long-term development of annual amounts of total phosphorous (in tons) at the international monitoring stations along the Rhine.

An assessment of the water pollution (concerning concentrations and amounts) reveals that, apart from nitrogen, phosphorous, metals and some other „well known" substances many further substances are found in the treated municipal wastewater, e.g. residues of household chemicals, personal care products and pharmaceuticals, which are not or not sufficiently broken down or removed in existing municipal wastewater treatment plants according to the best available technology. An assessment of the effects on the environment is partly possible for individual substances but not yet possible for the sum of individual substances. Certain micro-pollutants may detrimentally affect the Rhine ecosystem or drinking water production and drinking water quality. Many of the substances considered are discharged together with the treated municipal wastewater which means that households, industry and trade are the most important sources.
Inputs may be reduced by taking measures at the source (registration, restrictions concerning the use of substances in production processes, disposal regulations), by direct treatment of wastewater split streams (decentralized measures) and by measures in municipal wastewater plants (centralized measures). Furthermore, wastewater treatment plants may be extended by a supplementary treatment stage implying ozonisation or activated carbon. First experience made in wastewater treatment plants shows that a wide range of micro-pollutants may thus be reduced. For pharmaceuticals, biocides, oestrogens and odoriferous substances considerable improvements of the elimination performance have been achieved. This does not apply to all pharmaceuticals and e.g. not for radiopaque contrast agents either. The degree of elimination thus achieved depends on the substance. In the following, the relationship between the use and the discharge of a substance and the concentration of that substance at Rhine monitoring stations is explained for two groups of substances.

Medicinal products for human use

Medicinal products for human use are a vital part of our life. The base material or their transformation products may reach the municipal wastewater together with human excrements or inappropriate disposal in toilets.
Annually, on average 500 - 1,000 mg of carbamazepine (pharmaceutical treating epilepsy and mood swings) are used per inhabitant in the Rhine catchment which corresponds to some 30 to 60 tons of this substance in the entire Rhine catchment. Annually, some 6 tons are measured at the Bimmen-Lobith monitoring station which means that a considerable amount of this pharmaceutical reaches the water bodies in the Rhine catchment.
As far as medicinal products for human use are concerned, bezafibrate (pharmaceutical treating lipometabolic disorder) is comparatively well eliminated, while carbamazepine is not eliminated in wastewater treatment plants. Many medicinal products for human use can be detected in concentrations distinctly above 1 µg/l at the outlet of municipal wastewater treatment plants. For individual agents, emission sources, such as hospitals (e.g. antibiotics) or production works (production of active material) may be relevant. Certain medicinal products for human use are even found in the raw water of drinking water productions plants and partly also in drinking water. Concentrations measured are far below the dosage having a therapeutic effect for man. These pollutions are undesirable, even though they are not dangerous for man. Furthermore, detrimental effects on the ecosystem cannot be entirely excluded, even though there are no binding environmental quality standards (EQS).As shown in the next figure, the concentrations of carbamazepine increase from Weil am Rhein near Basel until the German-Dutch border (Bimmen). During 2006 to 2011, concentrations at the Bimmen monitoring station varied between 0.02 and 0.12 µg/l.

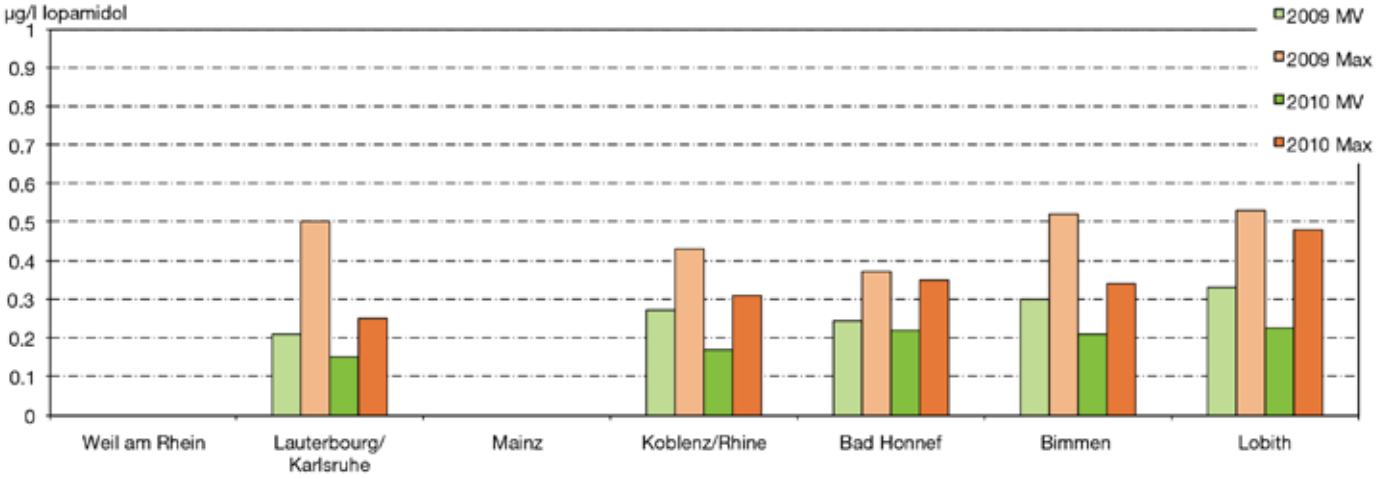


Development of carbamazepine concentrations (µg/l) in the longitudinal profile of the Rhine - international monitoring stations
(< = below limit of detection)

Radiopaque contrast agents

Radiopaque contrast agents are almost exclusively used in hospitals and institutes of radiology and are largely excreted unaltered within 24 hours. Contrary to pharmaceuticals used for therapeutic (curative) purposes they are however being developed as biological inactive substances. The share coming from households depends on the time the patients spend at hospital or in the radiological institute. Production plants only have their share in individual cases. In general, radiopaque contrast agents reach municipal wastewater by means of the wastewater of hospitals, radiological institutes and households and mainly reach surface waters via municipal wastewater treatment plants (e.g. 90 % for iopamidole). In general, only small amounts (~ 8 %) can be eliminated by biological treatment.

Since these substances were developed as biologically inactive substances, they are considered to have low eco-toxicological effects. So far, there are no binding EQS.
As shown in the next figure, the concentrations of iopamidole slightly rise in the longitudinal profile of the Rhine. During 2006 to 2011, concentrations at the Koblenz monitoring station varied between 0.05 and 0.75 µg/l.



Development of iopamidole concentrations (µg/l) in the longitudinal profile of the Rhine

2. INDUSTRIAL WASTEWATER

Since the beginning of the seventies, when the Rhine was called the sewer of Europe, intensive measures aimed at avoiding and reducing substance inputs have been implemented. In the Rhine catchment, production water used in several thousands of plants is being directly or indirectly discharged into water bodies. Today, a priority of most works is to avoid wastewater production. In plants, where this is not entirely possible, purification technologies are used often implying several wastewater focussed treatment stages.

The best available technology for treating certain industrial wastewaters and concerning specific substances is being described. But it equally applies to industrial wastewater that, apart from „well known" substances, further substances are to be taken into account which have so far not been regulated at EU level. Many of these substances are measured at the Rhine monitoring stations. Findings may trigger search reports passed on by the Warning and Alarm Plan for the Rhine (see chapter 6). In such cases, the origin of pollution will be investigated and reduction technologies jointly developed by authorities and industrial plants will be implemented. Some examples are given below.

Perfluorinated chemicals

Perfluorinated chemicals (PFT) are chemicals used in many applications, e.g. in non-stick coatings for frying pans, weather protection in garments, fire fighting foam or for paper refinement and are thus largely discharged into surface water bodies via municipal wastewater treatment plants.

As far as environment protection and water abstraction is concerned, perfluorooctane sulfonate (PFOS) is an individual substance of particular importance and used in different applications, such as photography, printing techniques, paper production or galvanic processes.

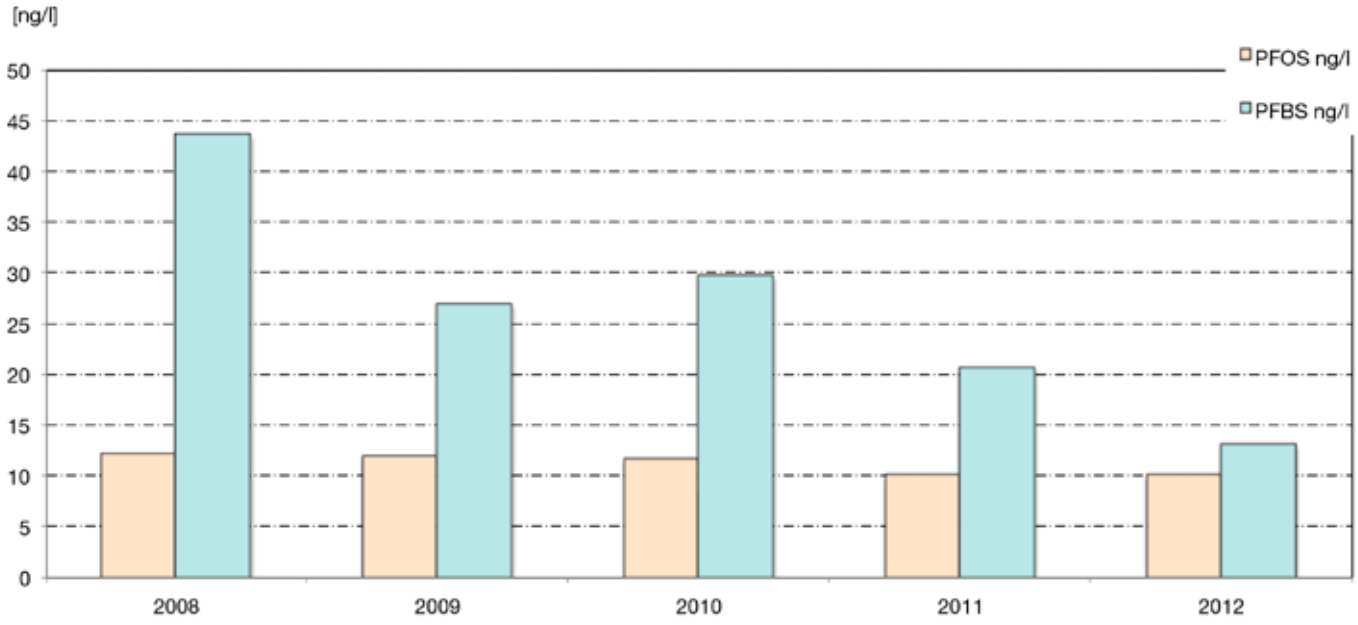
The directive 2006/122/EC largely prohibits the use of PFOS in the EU and worldwide the use of these substances has been restricted by the Stockholm Convention.

Another substance toxic for man and the environment, less important than PFOS but which must equally be reduced for precautionary reasons is perfluorobutane sulfonate (PFBS).

Contrary to PFOS with its numerous sources from which it gets into water bodies, this substance is discharged into the Rhine by one distinct industrial point source.

Specific individual measures have been able to reduce this water contamination.

Measurements at the Bimmen monitoring station prove the success of measures carried out at EU level and of individual measures. For both substances, the annual average values amount to approx. 10 nanogrammes per litre. It is not yet clear whether a further concentration reduction will on the medium term be achieved by implementing the above mentioned measures.



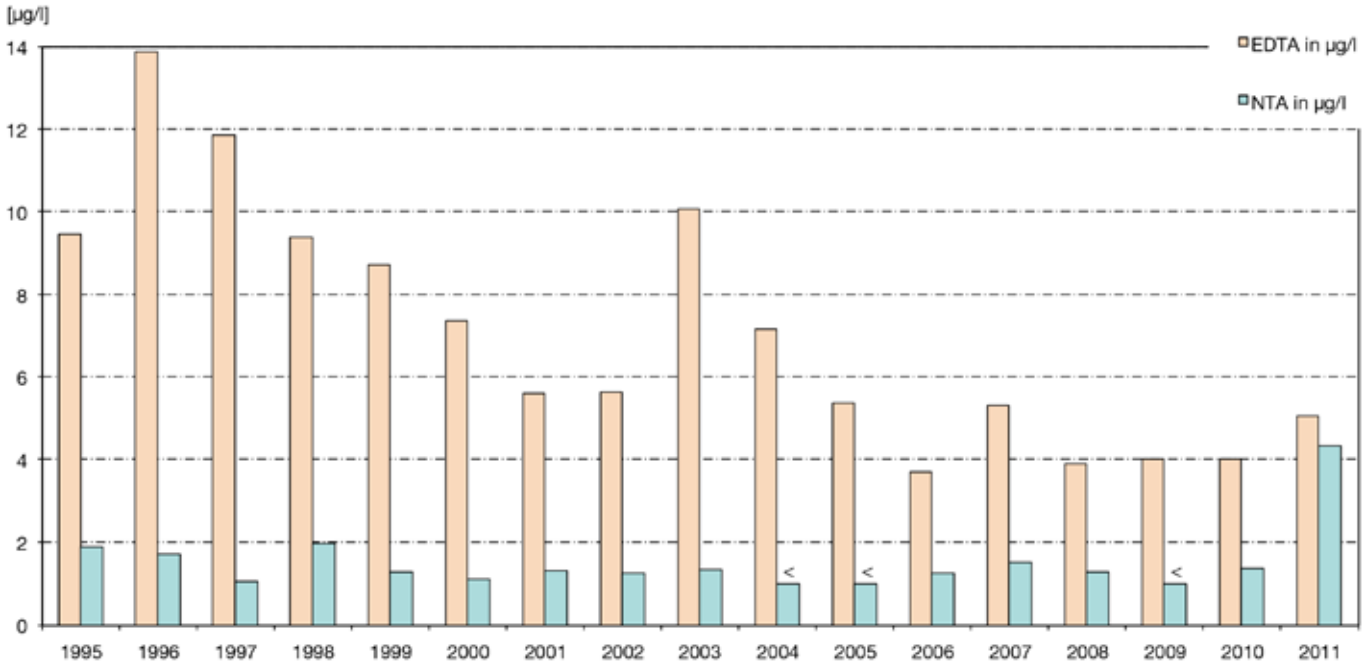
Development of PFOS and PFBS concentrations (ng/l) in the Rhine at the international monitoring station Bimmen.

EDTA

Mainly, EDTA (ethylenediaminetetraacetic acid) is used in the photo and textile industry as well as in several minor applications. On average, between 2005 and 2009, 11,000 tons of EDTA were annually applied in the Rhine catchment.

In 1991, a „Declaration on the Reduction of Water Contamination by EDTA“ was signed in Germany. Later on, numerous reduction measures have been implemented, cutting down EDTA concentrations by half. In the meantime, the EDTA discharges of a big chemical plant have been cut by a further 50 % by applying technical improvement measures.

On the other hand, it must be criticized that for years and increasingly EDTA has been replaced by other complexing agents. The development is illustrated in the next figure.



Development of EDTA and NTA concentrations (ng/l) in the Rhine at the international monitoring station Bimmen.
(< = below the limit of detection)

3. DIFFUSE SUBSTANCE INPUTS - NITROGEN AND PHOSPHOROUS

Excessive concentrations of nitrogen or phosphorous may impair the biological water quality of surface water bodies. In particular, high concentrations of nitrite and ammonia pose a problem. Additionally, increased nitrogen loads pollute the marine environment, in particular that of the Wadden Sea. The ecosystem of the coastal waters is evaluated to be moderate, the Wadden Sea is poor.
Since comprehensive measures aimed at reducing nitrogen and phosphorous in wastewater treatment plants have been and are still being implemented (see chapter 1), the relative share of inputs from agricultural surfaces has increased. Washout, erosion and inputs via soil drainage and indirectly via groundwater from agriculture contribute to the contamination of surface waters. However, the importance of the different discharge pathways differs for nitrogen and phosphorous.
Intensive agriculture has contributed to the often high nitrate concentrations in the groundwater. It takes much time before they reach the surface waters. Even if all measures aimed at reducing surplus nitrate stocks are implemented, inputs into the North Sea will only be reduced very gradually.
Regulations at EU level and the following agri-environment measures of the EU and the individual states reduce surplus nitrate stocks:

- Guidance programmes for farmers on less water polluting agriculture.
- Subsidy programmes with financial help for agricultural holdings implementing water protection measures under national or European programmes. Subsidy possibilities may differ from one region to the next.

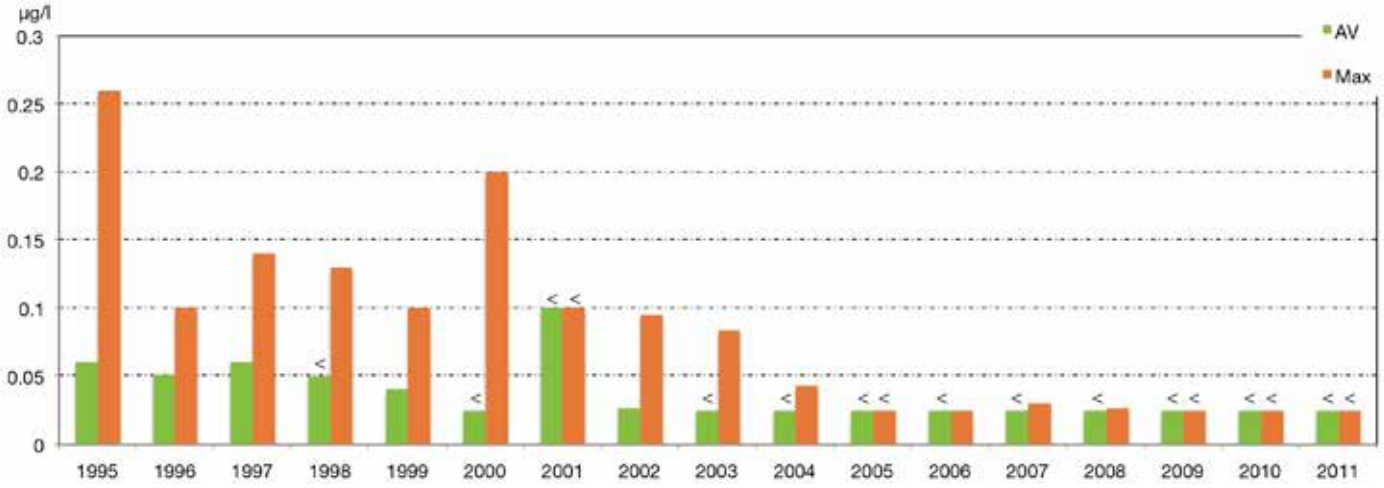
It is important that the subsidy policies for agriculture and for other fields of action do not counteract water protection measures.

4. DIFFUSE SUBSTANCE INPUTS - PLANT PROTECTION AGENTS

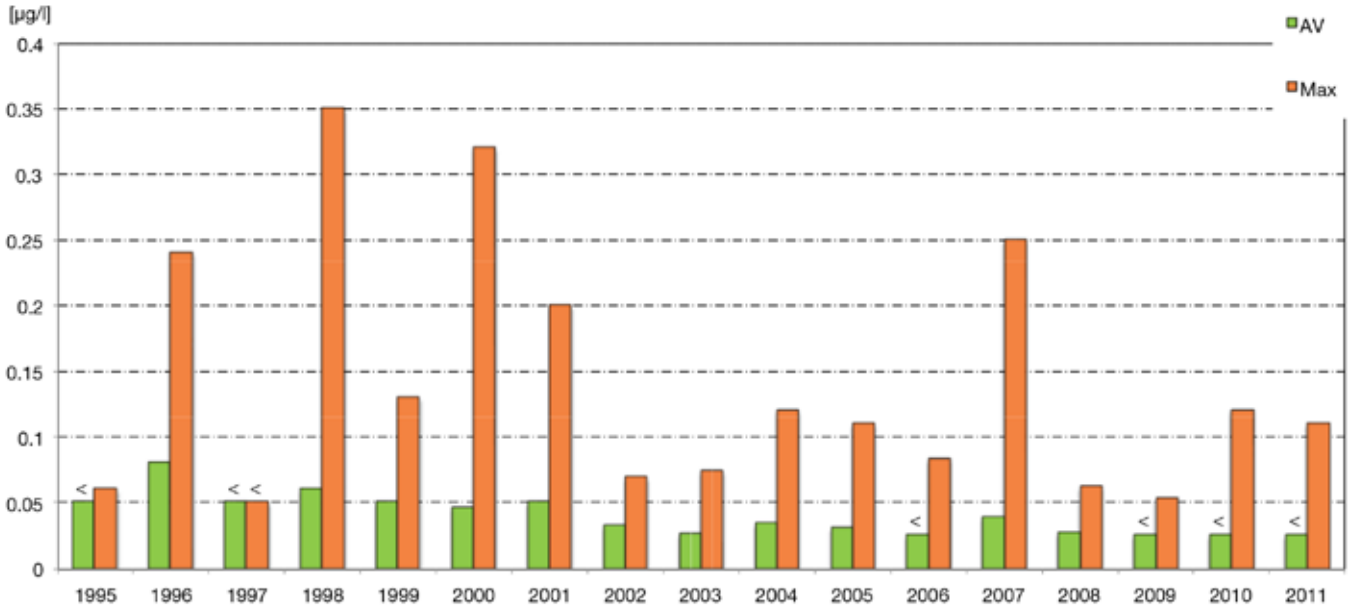
The contamination with plant protection agents continues to be a problem for the Rhine ecosystem and particularly for producing drinking water from Rhine water. Intensive efforts of the contracting parties have resulted in a reduction of the contamination of the Rhine with certain substances. Two examples illustrate this statement.

Plant protection agents

The application of the substance atrazine has been prohibited in the entire Rhine catchment and illustrates the success of measures taken at EU level. For years, the concentrations of atrazine in the Rhine at the Bimmen monitoring station are normally below the limit of determination and always distinctly below the target value set to 0.1 µg/l.



Development of the atrazine concentrations (µg/l) and maximum annual values (µg/l) for atrazine in the Rhine at the international monitoring station Bimmen (< = below the limit of detection).



Development of the isoproturone concentrations (µg/l) and maximum annual values (µg/l) in the Rhine at the international monitoring station Bimmen between 1995 and 2011 (< = below the limit of detection).

For isoproturone, the successor of the interdicted atrazine, the situation is different. On the whole, a reduction is stated, but nevertheless peak values above 0.1 µg/l are determined for this substance in Bimmen. Above all, the pollutant concentrations appear during unfavourable meteorological conditions after soil application (see chapter 6).

5. DIFFUSE SUBSTANCE INPUTS - OTHER ORIGINS

The contamination of the Rhine results not only from households, industrial wastewater and agriculture.
For example inputs of zinc and copper result from rainwash of contaminated dust. Contaminated sediments whirled up may contaminate the water quality of the Rhine with substances which have not been used in the catchment for decades. In the following, diffuse substance inputs and successful reduction measures are illustrated by the examples of zinc/copper and PCB/HCB.

Zinc and Copper

According to the management plan drawn up in 2009, the contamination of the Rhine with copper and zinc is due to the following sources:

- *Construction activities (corrosion of water pipes and gutters);*
- *Traffic (copper in brake linings and zinc in car tyres);*
- *Road equipment (zinc in crash barriers);*
- *Navigation (copper and zinc in vessel coatings);*
- *Agriculture (copper baths in cattle breeding, copper and zinc in fodder and livestock droppings).*

The ICPR contracting parties have already implemented several reduction measures. In the field of storm water treatment, pollutants have increasingly been withheld, particularly in densely settled areas by building new sewerage systems or by adapting existing ones. A recent assessment shows that, during 2000 to 2010, the load of zinc measured at the monitoring station Bimmen-Lobith was reduced by 13 %, that of copper by 44 %.

PCB and HCB in sediments

In the Rhine, sediments still exist, which store the pollutant concentration of past decades and centuries and which may still be whirled up. The ICPR has adopted a Sediment Management Plan aimed at reducing the contamination of sediments.
It is to be expected that, on the long run, reduction measures taken at the source and the implementation of the Sediment Management Plan will reduce substance concentrations in suspended matter / sediments and that the contamination of fish will diminish.

PCB

In many of the 22 areas at risk designated by the Sediment Management Plan high concentrations of PCB are being measured. In the meantime, 8 sites have been cleaned up. The most important remediation activities have been carried out at the site Ketelmeer-West (Netherlands), where more than 2 million m³ of contaminated sediments have been dredged and stored in the land fill IJsseloog.

Hexachlorobenzene

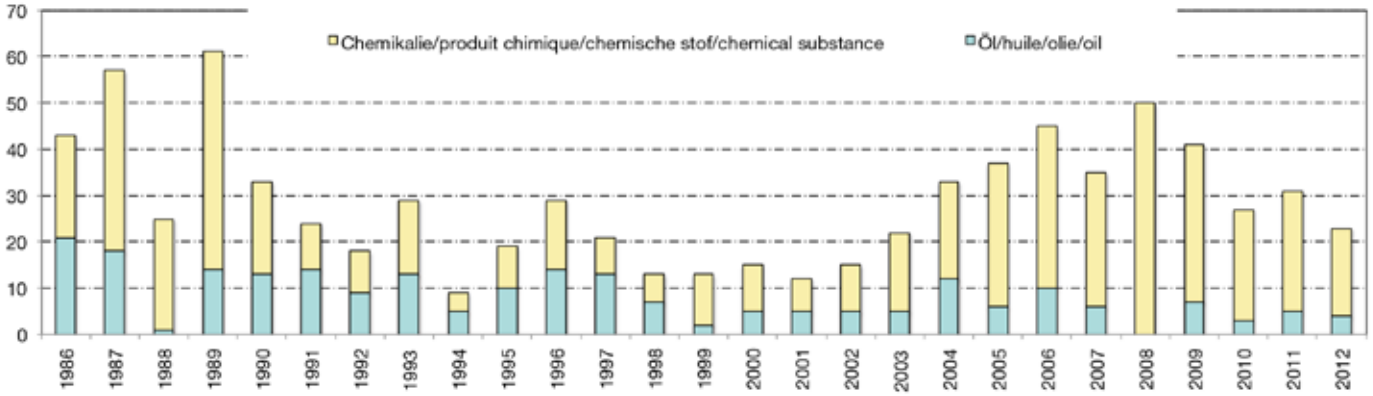
Several decades ago, industrial plants stopped the discharge of hexachlorobenzene (HCB) into water bodies. Numerous investigations during the last years suggest that for many years the HCB pollution has spread from the original location of vast discharge near Rheinfelden (former production of pentachlorophenol and chlorosilane) to the chain of barrages in the Upper Rhine.

In 2009, the situation was as follows: the pollution with HCB of the big impoundments Iffezheim and Gambsheim as well as of the impoundments Gerstheim and partly Strasbourg was comparatively low (average value 130 – 150 µg/kg HCB), but the criterion for the re-deposition of dredged material set out in the Sediment Management Plan was still not respected. The recommendations of this Management Plan require precise agreements for the remediation.

In this connection, in 2012, further investigations were made in the impoundments Gerstheim and Strasbourg, which did not reveal any contamination to remediate in the impoundments mentioned. Based on these results the possibilities for what to do with the contaminated sediments in the areas of risk of the impoundments Marckolsheim and Rhinau are now being looked into.

6. INSTANCES OF ENVIRONMENTAL DAMAGE RELEVANT FOR THE RHINE

Another aspect not to be neglected and which was thoroughly discussed within the ICPR after the accident near Basel (Sandoz) is the protection of the Rhine against pollutions due to accidents and operational disruptions in industry. Following intensive discussions, the contracting parties have implemented the jointly adopted measures. In this connection, the contracting parties and the industrial plants along the Rhine have implemented numerous measures concerning the handling of substances hazardous to water. Additionally, different monitoring stations along the Rhine have been designed such that, with respect to several hundreds of substances, Rhine water quality is continuously and intensively monitored in realtime.
If water pollution is detected, the Rhine Warning and Alarm Plan (WAP) is triggered. The staff of 7 main international warning centres works on stand-by duty to receive, assess and pass on reports on accidents or elevated substance concentrations in the Rhine to those upstream and downstream, in particular to drinking water works. The national laboratories as well as those of the German federal states closely cooperate in order to rapidly detect the site of discharge and to assess the effects on water supply and the ecosystem.
These reports are annually documented, assessed and classified. In the course of the years, the number of operational disruptions in industrial plants has distinctly fallen and today reports on discharges originating from navigation prevail. Additionally, the seasonal contaminations with plant protection agents described in chapter 4 are still regularly stated.



Development of the number of WAP reports on chemical pollution for the period 1986 to 2012

Form the end of the 80s to the end of the 90s, the overall number of WAP-reports on chemical pollution fell. Until 2002, its number was constant: 10 reports (thereof annually on average one warning). Since 2003, the number of reports concerning chemical substances is increasing and reached a peak with 50 reports in 2008. In 2012, the number fell to 19 reports. The increased number of reports on chemical substances from 2003 and onwards is in particular due to the improved possibilities of analysis in the monitoring stations. The stated fall in the number of reports since 2008 is due to the lower number of MTBE / ETBE reports. On the basis of data available today, the contribution of individual factors, e.g. the quantities transported on the Rhine or the number of undetected, illegal discharges to the observed fall in MTBE/ETBE pollution events of the Rhine with originating from navigation cannot be unambiguously determined.

Examples of contamination waves affecting drinking water production:

Diglyme

Diglyme is a solvent above all applied in industry the highest concentrations of which were measured in the downstream section of the Rhine in 2009. Waves of diglyme which were more often measured in the Rhine prior to 2006 have been reduced due to measures taken in one important industrial discharging site.

Metolachlor

At the end of Mai 2012, a wave of metolachlor (weedkiller) was measured in the Rhine. Heavy rainfall in the corn growing region of the southern Palatinate, northern Alsace and eastern Rhinehessen might have induced this wave of metolachlor.

Isoproturone

At times of cultivation of fields for winter and summer cereals isoproturone contaminations in excess of 0.1 µg/l of the Rhine are particularly measured at the Bimmen monitoring station, when application periods are followed by heavy rainfall.

3 ACTION PLAN ON FLOODS

1. Implementation 1995 - 2010: Major results
2. Explanations on individual action targets
   a) Reduce flood damage risks
   b) Reduce flood levels
   c) Improve flood awareness
   d) Improve flood announcement systems
3. Outlook

THE ACTION PLAN ON FLOODS

During the 12th conference of Rhine Ministers on 22 January 1998 in Rotterdam, the ICPR decided to implement the “Action Plan on Floods”. This Action Plan had been triggered by two extreme winter floods in December 1993 and in January/February 1995. This also applies to the Action Plan on Floods of the International Commissions for the Protection of the Moselle and the Sarre (ICPMS). The target of the Action Plan on Floods to be achieved by 2020 is to improve the flood protection of man and goods along the Rhine and its tributaries and, at the same time, to ecologically improve the river and its floodplain. The Action Plan is based on five general guiding principles (see figure below) and four action targets (see table next page) including deadlines convened for the implementation of measures. The implementation of the Action Plan on Floods is coordinated within the ICPR, measures are implemented on a national or regional scale.

The five guiding principles of flood risk management applied to the implementation of the Action Plan on Floods

Water is part of the whole

meaning that we have to accept floods as a natural event.

Store water –

meaning that rainwater, melting snow etc. should be led into the tributariers and the main stream as slowly as possible.

Let the river expand –

meaning that the river needs room to inundate during floods.

Be aware of the danger –

meaning that people possibly at risk should on the one hand be aware of flood risk and its possible effects and eventual damages. On the other hand, they should also know what preventive measures they can take themselves and how to act in an emergency situation.

Integrated and concerted action –

meaning that ALL must be active and join forces.

In 2001 and 2006/2007, the ICPR extensively reported on the state of implementation of the Action Plan on Floods. This chapter informs about the most important results achieved during 1995 - 2010 and presents a view of the next steps, among others the pending implementation of the European Floods Directive (FD). The ICPR has been in charge of the coordinated implementation of the Floods Directive in the Rhine catchment since 2007. Thus, ICPR actions in the field of flood risk management will in future not only concern the catchment area north of Lake Constance, but also the Alpine Rhine, Lake Constance, Lake IJssel and the Dutch coast (Rhine delta).

For detailed information on the Action Plan on Floods and its implementation (see technical reports no. 199 and 200), and on the Floods Directive please see the website www.iksr.org.

1. IMPLEMENTATION 1995 - 2010: MAJOR RESULTS

Numerous measures aimed at progressively achieving the four action targets of the Action Plan on Floods have already been implemented at national and federal level.

Outline of the four action targets of the Action Plan on Floods and state of achievement by 2010

Action targets of the Action Plan on Floods for the target year 2020 compared to the reference year 1995	Results of the implementation of the Action Plan on Floods by 2010 compared to the reference year 1995
1 **Reduce flood damage risks by 25 % by 2020**	In 2005 and based on rough estimates a reduction of damage risks was stated as compared to the state in 1995. Along the non diked sections of the Rhine, the reduction lies within the target set, however, in the diked sections, it is considerably lower. New and more detailed results are expected for 2014.
2 **Reduction of flood levels - Reduction of extreme flood levels by up to 70 cm by 2020 downstream the impounded section (60 cm due to water retention along the Rhine and approximately 10 cm due to water retention in the Rhine catchment)**	Retention measures implemented along the Rhine itself prove to have the greatest effect on the reduction of flood levels of the Rhine. In 2010, approximately 230 million m³ of retention volume were available along the Rhine. This volume and the measures currently planned will however only achieve the maximum target set, i.e. 60 cm, in individual cases and for few floods. The target set would only be permanently achievable, if more retention areas were created and combined with measures improving runoff.
3 **Increasing flood awareness by drafting and spreading flood risk maps for 100 % of flood hazard areas**	This target has been achieved for the main stream of the Rhine. The maps on flood hazard and flood risk available since 2001 (see ICPR Rhine Atlas 2001) have contributed to increasing the risk awareness of the population and present a valuable means of raising awareness. Additionally, many further awareness raising measures have been implemented. Based on new data the atlas will be updated by 2014.
4 **Improve the flood forecasting system - short term improvement of flood forecasting systems due to international cooperation. Prolong forecasting periods by 100 % by 2005**	Until 2005, the forecasting periods along the Upper and Middle Rhine were already extended from 24 to 48 hours, along the Lower Rhine from 48 to 96 hours. In spite of many new developments in the past years, prolonged forecasting periods cannot be assumed to be as reliable as more short-term forecasting.

Early 1998, the total costs of measures under the Action Plan on Floods until 2020 were roughly estimated to 12.3 billion €. By end 2010, 10.3 billion € had already been spent, as the construction of retention polders, dike relocations, the lowering of foreshores and the maintenance and strengthening of dikes are particularly expensive. Further billions will have to be spent for measures to be implemented by 2020 and will go far beyond the initially estimated sums. The following table indicates results achieved by the end of 2010.

‚Rhine' Action Plan on Floods: Measures as difference between periods and costs in the total period

Categories of measures	Measures		Cost in Mio. €
	1995-2005	1995-2010	1995-2010
Water retention in the Rhine catchment			
Renaturing (km)	>2,400	>4,000	880
Reactivation of floodplains (km^2)	>200	>300	
Agricultural extensification (km^2)	>4,600	>14,000	3,160
Nature development, afforestation (km^2)	>900	>1,000	
Enhance seepage of precipitation (km^2)	60	>60	510
Technical water retention (million m^3)	40	>60	780
Water retention along the Rhine			
Reactivation of floodplains (km^2)	30	60	740
Technical water retention (million m^3)	50	70	570
Technical flood protection			
Maintenance and strengthening of dikes, adaptation to general and local levels of protection, including local protection along the Rhine and in its catchment (km)	1,160	>1,400	3,560
Preventive planning measures			
Raise awareness	Using websites, brochures, events and flood exercises.		90
Draft hazard and risk maps	100 %	100 %	
Flood forecasting			
Prolong forecasting periods	100 %	100 %	10
Improve flood warning and announcement systems	Improve systems and data basis, draft websites, etc.		
Sum			**10,300**

2. EXPLANATIONS ON INDIVIDUAL ACTION TARGETS

a) Reduce flood damage risks

The overall target of the Action Plan on Floods is to reduce flood damage risks by one fourth by 2020 as compared to 1995. The different measures under the other action targets contribute to reduce the risk. The ICPR Atlas on the Rhine of 2001 illustrates the damage risks along the Rhine from the outlet of Lake Constance until the Rhine estuary into the North Sea in case of extreme floods (see www.iksr.org). Currently, and based on national maps of flood hazard and flood risk drafted for the Floods Directive, this Atlas is being updated.

Protection of buildings

Along **non diked sections of the Rhine** risks have been successfully reduced. Recurring flood experience has led to distinct flood awareness and thus more willingness to take individual prevention measures. Along these sections of the river, many inhabitants know how to get information on rising floods, how to prepare and how to protect goods (see example and ICPR brochure: „Flood Prevention: Measures and their Effectiveness“).

If, additionally, protection measures lowering water levels are taken, the probability of inundation will change, that is, floods will occur more seldom and their peaks will be lower. This considerably contributes to reducing the risk.

Non diked section of the Rhine (Middle Rhine; Source: Klaus Wendling, MULEWF Rhineland-Palatinate)

Diked section of the Rhine (Upper Rhine)

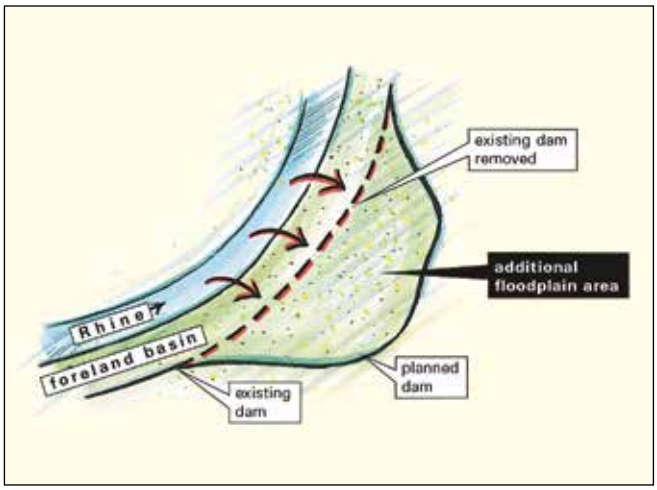
There is little or no reduction of damage potential along **diked river sections**, as, due to a higher degree of protection, the owners of houses rarely or never think about protecting buildings behind the dikes. Breaches of dikes might lead to considerable damage.

Due to the strengthening of dikes, improved flood-proofing and low probability of inundation, the damage risks along some river sections are less than in 1995.

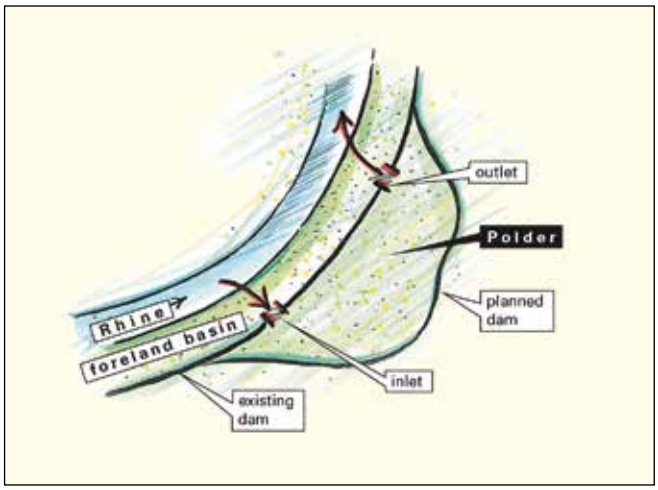
b) Reduce flood levels

Some examples for effective measures liable to reduce extreme flood levels are presented in pictures:

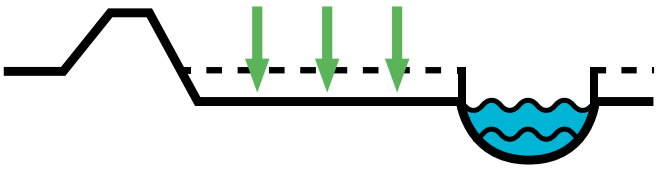
- **Relocation of dikes in order to reactivate floodplains**
- **Flood retention polders**
- **Lowering of foreshores**



Relocation of dikes:
Relocate a dike further inland and thus regaining foreshores giving more room to the river.



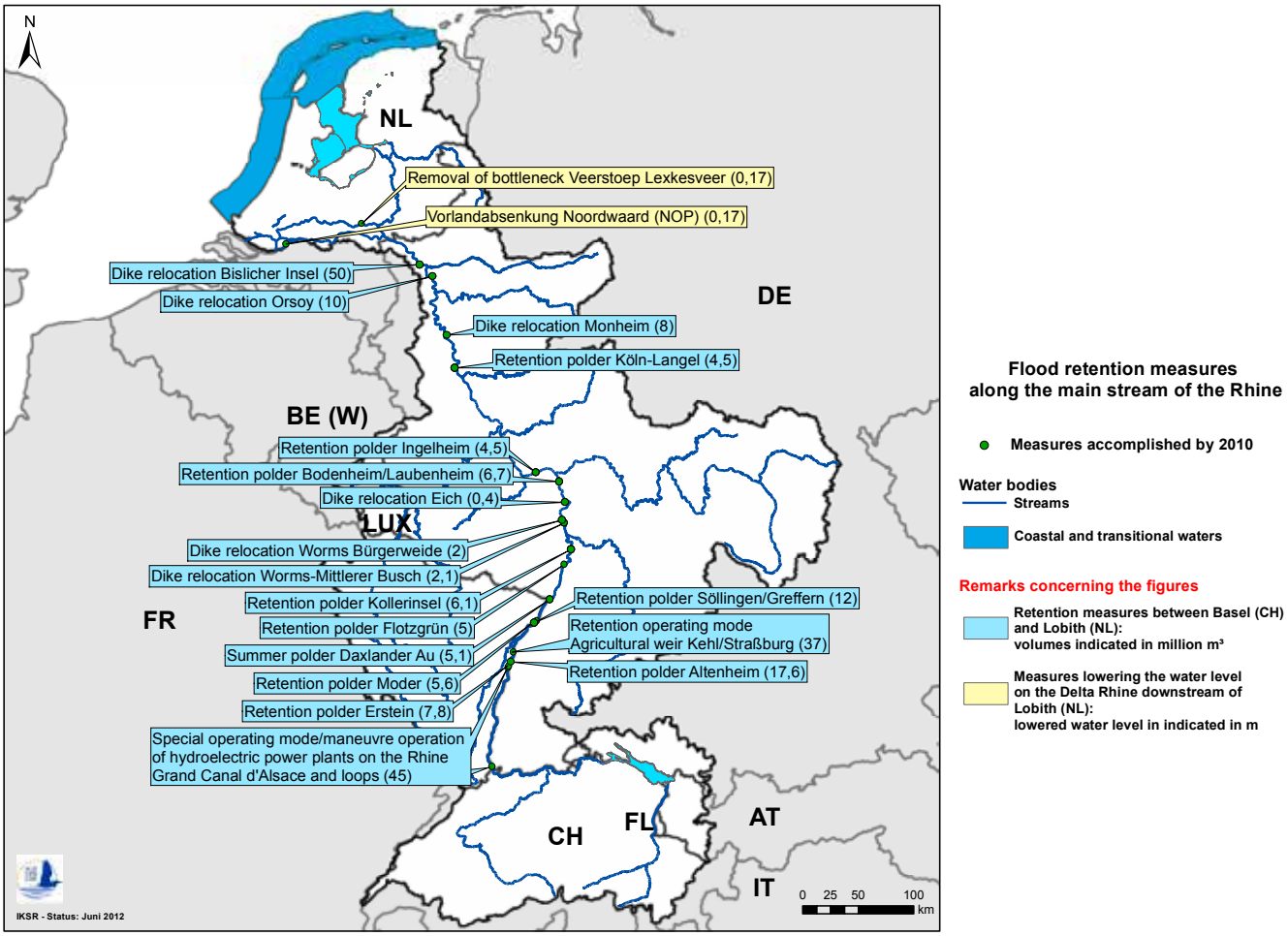
Flood retention polder:
Retention polders are areas which may be flooded in particular cases (targeted flooding). In that case, the Rhine water flows through the polder and, with a certain delay, back into the Rhine through a discharge structure.



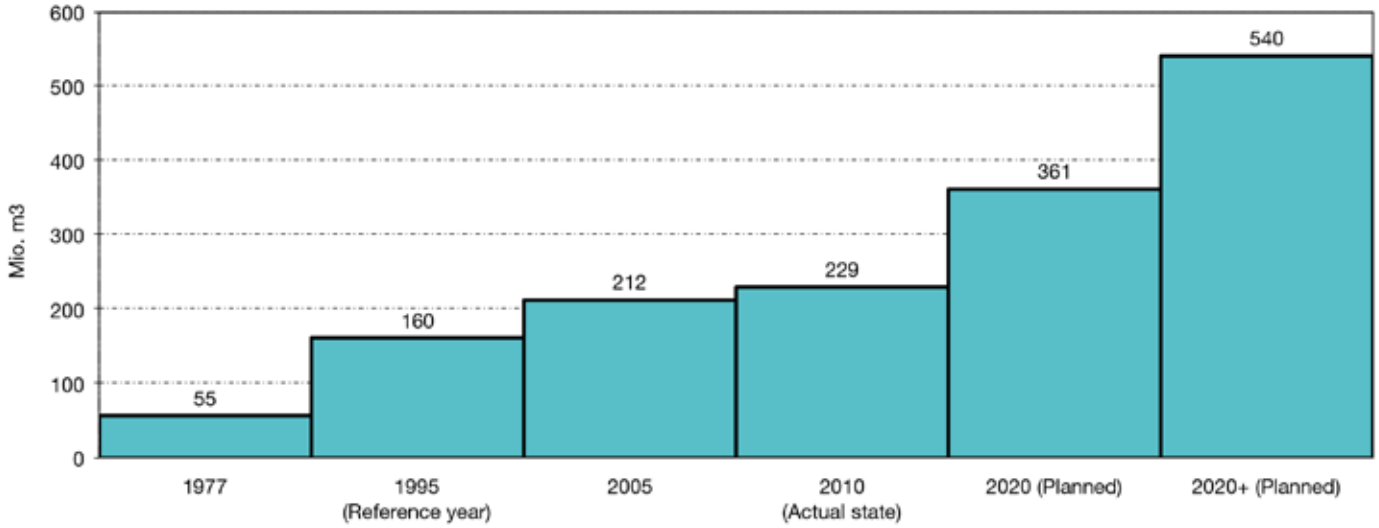
Lowering of foreshores:
By digging off foreshores (or parts of them), the river is given more room.

Source: RWS, Ruimte voor de Rivier

The following survey map indicates retention measures accomplished by 2010 and available retention volumes.



The following figure shows the available retention volumes in 1977, 1995 (reference year for the Action Plan on Floods), 2005 and end 2010 taking into account the measures accomplished in each of the years mentioned (= development condition). Indications for 2020 and after 2020 (2020+) correspond to the state after the accomplishment of all measures planned.



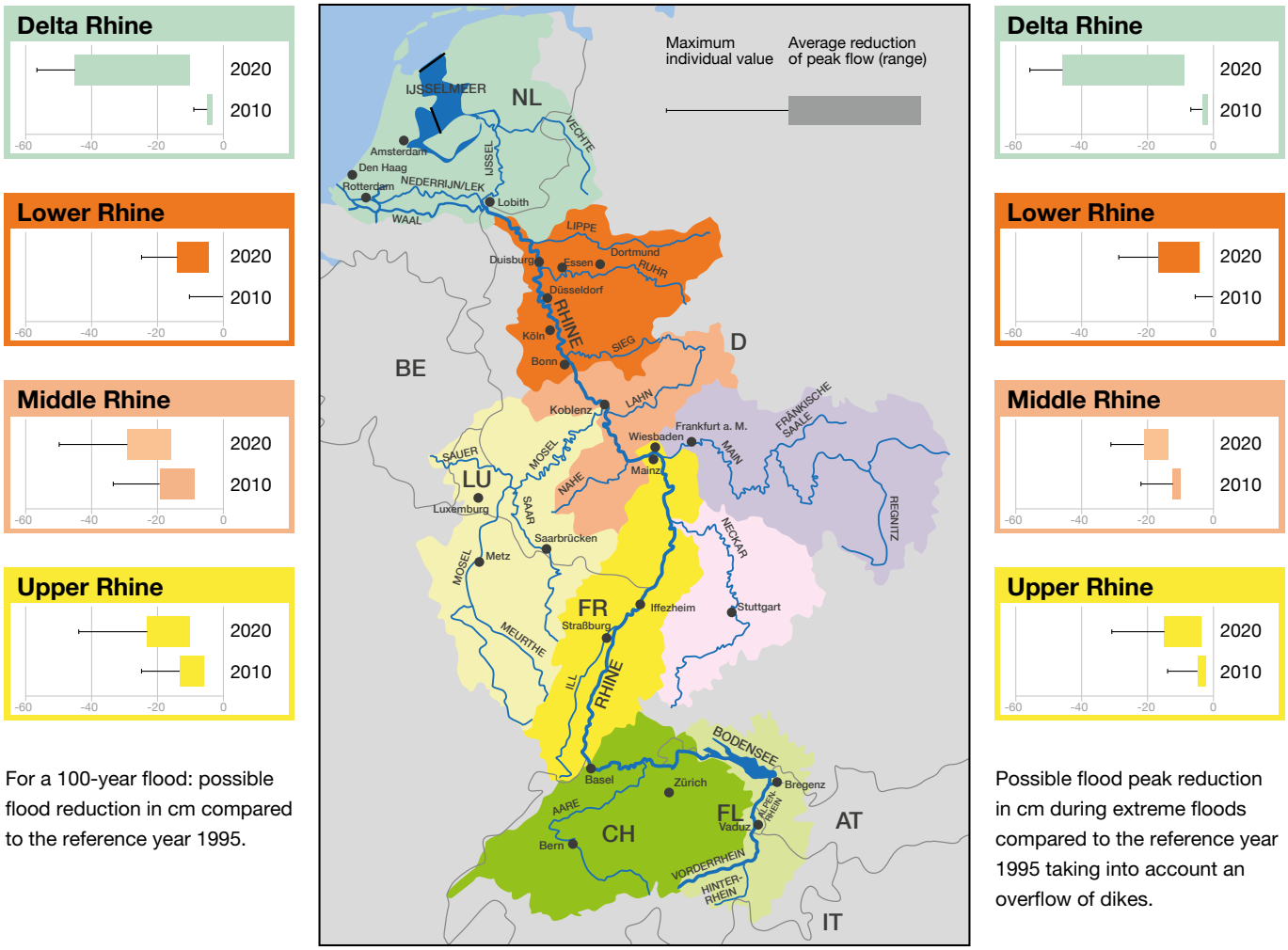
Retention volumes along the Rhine according the ICPR report no. 200

For the elaboration of this balance, the entire main stream of the Rhine and its retention areas have for the first time been modelled for a large number of flood events. Also, the results permit a first well founded assessment of the possibility to achieve the targets set out in the Action Plan on Floods.

Results show **average changes of water levels** for the different development conditions of the Rhine in 2010 and 2020 along the different **sections of the Rhine for a 100-year flood and an extreme flood**. They include the most representative average reduction values of flood levels at the gauges of the Rhine or sections of the Rhine to be expected due to flooded retention areas and measures widening the river bed and are illustrated by the following figure.

For the **actual situation** in **2010** (max. 229 million m³ retention volume available) and the **forecast for 2020** the following reductions of flood peaks will **on average** be achievable for a **100-year flood (HQ100)** once the measures have been carried out by end 2010 and by end 2020 (reference year 1995) - see figure on the left.

Taking into account dike overflow, the following reductions of flood peaks are **on average** achieved by the measures accomplished by 2010 and 2020 for the **actual situation 2010** and the **forecast for 2020** for an extreme flood **(HQextreme)** (reference year 1995) - (see figure on the right).



For a 100-year flood: possible flood reduction in cm compared to the reference year 1995.

Possible flood peak reduction in cm during extreme floods compared to the reference year 1995 taking into account an overflow of dikes.

Remark: The Delta Rhine consists of the three branches Nederrijn/ Lek, Waal and IJssel. Measures aimed at lowering water levels in the Netherlands have different effects on these three branches of the Rhine. The greatest lowering of water levels concerns the IJssel; in the rivers Waal and Lek results are less tangible. The diagram illustrates the range of average reductions of all three branches (Delta Rhine).

[1]Extreme floods may flow over the dikes. The calculations take these effects into account.

Taking into account the effects of all flood retention measures accomplished during 1977 - 2010, the reduction of water levels proves to be considerably more consequent and may amount to 20 - 40 cm on the Upper Rhine. The reduction of water levels on the Middle Rhine is exclusively achieved by flood retention measures taken along the Upper Rhine. With respect to a reduction of flood peaks, there are no considerable differences between the actual situation in 1977 and in 1995.

c) Improve flood awareness

Atlas on the risk of flooding and potential damage due to extreme floods of the Rhine (Rhine Atlas 2001) as interactive map under www.iksr.org.

Immediately after a flood, the hazard awareness will be very distinct. If, during a longer period of time, there is no flood or if there are no regular awareness campaigns, the awareness of the potential hazard will rapidly decline.

The target of the Action Plan on Floods to increase flood risk awareness by drafting and publishing **risk maps for 100 % of the floodplains along the Rhine** was already achieved in 2005, when the ICPR Atlas of the Rhine indicating flood hazard areas and potential damage was published.

Additionally, since 1995 and apart from maps, the states, federal states and regions have developed and used websites, brochures, exhibitions and exercises. Furthermore, partnerships have been created between municipalities and associations in order to improve flood prevention. These means are used in order to inform the population about flood issues, e.g. the rise of a flood or the importance of private precaution.

d) Improve flood warning systems

Flood warning centres in Switzerland, France, the German federal states Baden-Württemberg and Rhineland Palatinate as well as in the Netherlands are in charge of international cooperation in matters of flood forecasting and flood warning along the Rhine. With a view to assuring optimal forecasting for the river Rhine, and based on local knowledge and models, each flood warning centre establishes forecasts for the catchment area in its area of responsibility and rapidly passes them on to the downstream flood warning centres. Experts meet once a year to exchange experience and to further develop the forecasting chain.

During the past years, the hydrological forecasting systems used by the flood warning centres on the Rhine have been considerably improved and refined. The prolonging of forecasting periods by 100 % targeted by the Action Plan on Floods was achieved as early as in 2005.

Different means make information on floods of the Rhine and its tributaries available to competent authorities and water management, civil protection, the population concerned, industry and trade, the larger public and media.

In particular, forecasting is spread by websites (and mobile applications), e.g. www.hochwasser-rlp.de. A map published on the website of the ICPR (www.iksr.org) includes all links to the flood forecasting and flood warning centres. Before or during a flood event, updated status reports are drafted and published several times per day (internet, radio, tv, etc.).

Flood warning centre Cologne (source: STEB Cologne)

3. OUTLOOK

Between 1995 and 2010, the Rhine bordering states successfully implemented the Action Plan on Floods and its numerous measures. The flood risk management approach already included into the Action Plan on Floods will be resolutely continued when drafting the flood risk management plan for the Rhine to be presented by 2015. Apart from technical flood protection measures, the further development of which will lead to a further increase of the retention volume along the Rhine between 2010 and 2020, measures will above all focus on reducing flood risks. Risk surveys will not only take into account the protection of man and economy, but also the protection of the environment and of cultural heritage.

The EU Floods Directive (FD) is an important instrument to continue present action, to readjust and to enhance it in certain core areas. Also, it obliges the Member States to draft maps of flood hazard and flood risk by the end of 2013. In this context, the ICPR Atlas of the Rhine 2014 is being updated.

The effects of climate change are a challenge for the future: by 2050, the average discharge of the Rhine and its tributaries could increase by 20 % in the winter months and decrease by 10 % during the summer months. Therefore, flood hazards may increase in winter and draught hazards might increase in summer.

Thus, the Rhine bordering countries continue their efforts towards making those concerned by floods aware of flood risks and to prepare them accordingly. The priority target in the Rhine catchment remains to reduce the flood risk in cooperation with those concerned and the numerous actors in this field.

IMPRINT

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Photos (where no source is indicated)
Title: Left: bank of Rhine (BfG), Middle: flowing water (BMU), Right: Shutterstock; p. 2: Rhine near Bingen (Klaus Wendling); p. 6: torrent (M.-H. Claudel), p. 14: wastewater treatment plant Koblenz (Stadtentwässerung Koblenz); p. 18 and 20: Laboratory (Flussgebietsgemeinschaft Rhein, Worms); S. 10 Haringvliet sluices (ICPR); p. 27 above (STEB Köln), below right (ICPR); p. 32: Rhine near Kaub (Klaus Wendling); p. 33: Middle Rhine (Klaus Wendling)

Internationale Kommission zum Schutz des Rheins

Commission Internationale pour la Protection du Rhin

Internationale Commissie ter Bescherming van de Rijn

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