# Assessment Rhine 2020

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

Contents



# Assessment Rhine 2020
# Summary


The implementation of the “Rhine 2020” programme, which has been ongoing since 2001, involves the further improvement of the Rhine ecosystem, including water quality, the reduction of flood risks and groundwater protection. “Rhine 2020” was supplemented by the resolutions of the Rhine Ministerial Conferences of 2007 and 2013 on the impact of climate change and the issues of low water and plastic waste. The Water Framework Directive (WFD - Directive 2000/60/EC) and the Flood Risk Management Directive (FD - Directive 2007/60/EC) have contributed significantly to the implementation of the ICPR programme.

The assessment clearly shows that many objectives of the "Rhine 2020" programme have been achieved or set in motion, but not all the objectives set at that time have been achieved in full. The goals that have not been achieved require further efforts as part of the implementation of the ICPR’s “Rhine 2040” programme. This also applies to new problems in the individual areas of ecology, water quality, flood and low water, taking into account the effects of climate change.


The outcome of the implementation of the “Rhine 2020” programme is as follows.

## Ecology

- Since 2000, around 140 km² of floodplains have been reactivated and 124 alluvial waters have been reconnected to the main Rhine river. The target set for 2020 of reconnecting 100 oxbow lakes and lateral water bodies to the Rhine was already well exceeded by the end of 2018. Considerable progress has also been made in protecting valuable floodplain ecosystems.
- It has only been possible to ecologically upgrade 166 km of the Rhine bank since 2000. Due to the river‘s intensive use as a shipping lane, this target falls far short of the 800 km target.
- Almost 600 migration obstacles in the Rhine and in the tributaries important for the reintroduction of migratory fish have been removed or equipped with fish passages. More than 28 % of the valuable salmon habitat areas have thus been reconnected to the Rhine and further opportunities for the spread of other fish and animal species have been provided.
- Today, several hundred salmon from the North Sea return to the accessible tributaries of the Rhine every year and reproduce naturally.
- A milestone for the restoration of the return of migratory fish from the sea to the Rhine and Meuse systems was achieved at the end of 2018 with the partial opening of the Haringvliet dam south of Rotterdam. With the construction of fish passages at four large weirs in the Upper Rhine, the goal of reopening the Rhine from the North Sea to Switzerland for fish migration is drawing closer, even if it has not yet been fully attained. Further obstacles to migration must be removed and habitats must be upgraded.

- Together with improved water quality, all ecological measures have created the conditions for increasing biodiversity and making the Rhine ecosystem more resilient to climate change. The experience gained in the states of the Rhine catchment area must be used and shared in further efforts.

## Water quality

- The nitrogen load from the Rhine catchment area into the North Sea and the Wadden Sea was reduced by 15 – 20 % by 2015 as a result of continuous upgrading, optimisation and expansion of municipal and industrial sewage treatment plants. It has not yet been possible to significantly reduce the contamination by nutrients from diffuse sources (with a focus on agriculture, but also on urban areas).
- Contamination from metals was already significantly reduced between 1987 and 2000. It has been further reduced since 2000 by the construction, optimisation and modernisation of municipal and industrial sewage treatment plants. The causes of pollution must continue to be monitored and measures must continue unabated.
- According to the 2017 assessment, active pharmaceutical substances as well as their degradation and transformation products are detectable in the entire catchment area of the Rhine. Based on the assessment, the ICPR issued in 2019 recommendations on how to further reduce micropollutant discharges into water bodies. It also explicitly dealt with active pharmaceutical substances and X-ray contrast agents.
- Emissions of pesticides have been significantly reduced by new legal regulations on substances, bans on use and approvals, and new application techniques. However, peak loads can still occur at times, particularly in smaller bodies of water. The ICPR recommendations of 2019 for the reduction of micropollutants are also aimed at agriculture.
- Communication via the International Warning and Alarm Plan (IWAP) for the Rhine works well, reliably and via the Internet across states and countries.
- Of the 22 risk areas identified in the 2009 Sediment Management Plan, remediation work was successfully completed at ten sites.
- The biota investigations in 2014/15 provide an overview of the contamination of biota (fish) with pollutants in the Rhine catchment area. Some substances, including mercury, are exceeding the specified environmental quality standards everywhere.
- The quantitative status of groundwater bodies is largely good (96 %). However, the chemical status of 33 % of groundwater bodies is poor, in particular due to excessive nitrogen contamination.

## Floods

- The states in the Rhine catchment area successfully implemented the Flood Action Plan on Floods (APF) between 1995 and 2020 at a cost of more than 14 billion euros.
- The most important objective of the APF (1998), the “reduction of flood damage risks by 25 % by 2020”, has been achieved.
- The APF target of “reducing extreme flood levels downstream the impounded section of the Upper Rhine by up to 70 cm by 2020” has not been achieved. Numerous measures to lower water levels have been implemented since 1995. In 2020, a retention volume of around 340 million $m^3$ for major floods will be available on the Rhine. By 2030, the planned volume will be around 540 million $m^3$. However, the reduction of 70 cm will only be achieved in some places in 2020 and only for a few floods. The implementation of the retention measures by 2030 must be intensified and accelerated.
- The awareness of flood risk among the population has been strengthened among other things by the publication of flood risk maps.
- The flood announcement system has been improved. Since 2005, the forecast periods have been extended by 100 % compared to 1995. Every year all the flood announcement and forecasting centres on the Rhine - from Switzerland to the Netherlands - exchange information with a view to optimising the system.

## Low water

- Based on an inventory carried out in 2018, the ICPR has set up a uniform low water monitoring system throughout the Rhine. In future, it will communicate more intensively on low water events, their consequences and measures.

## Climate change

- There are ICPR studies on the effects of climate change on the water balance, water temperature and ecology.
- Based on discharge scenarios for the near (by 2050) and remote (by 2100) future, the ICPR has issued in 2015 its climate change adaptation strategy, which will be updated shortly.

## Integrated approach

- The Rhine catchment area already has many examples, including cross-border ones, showing synergies between flood protection, water protection and nature conservation; this kind of integrated approach will be promoted in future.
- An ICPR workshop in 2018 identified key factors for the successful implementation of integrated measures such as the development of shared visions, objectives and projects by various stakeholders. Compromises must be found. Important elements are awareness-raising and the appropriate use of the remaining available area.

# 1. Introduction

The „Rhine 2020"[1] programme, the implementation of which was decided by the 13th Conference of Rhine Ministers in Strasbourg in 2001, focused on the further improvement of the Rhine ecosystem, the reduction of flood risks and groundwater protection. The continuous monitoring of the state of the Rhine and the further improvement of water quality were also important aspects of water protection in the last 20 years. In the interests of sustainable development, the various areas should be given equal and comprehensive consideration.

[1] *Rhine 2020 - Programme on the sustainable development of the Rhine (2001)*

The International Commission for the Protection of the Rhine (ICPR) was founded in 1950 with the initial aim of improving water quality. After the catastrophic Sandoz accident on 1 November 1986 in the Basel area, in which several tonnes of toxic pesticides were released into the Rhine with the extinguishing water from a burning warehouse, killing the aquatic communities for hundreds of kilometres, the ambitious Rhine Action Programme was launched. For the first time, ecological objectives were included in an ICPR programme with the repopulation of the Rhine with fish species that were previously present, such as salmon. After the floods of the Middle and Lower Rhine in the 1990s, an Action Plan on Floods (APF) was adopted and the range of topics covered by the ICPR was expanded once again.

The extended Rhine Convention[2], signed in 1999, integrated the sustainable development of the ecosystem, the securing of the use of Rhine water for the production of drinking water, the improvement of sediment quality, holistic flood precautions and flood protection, taking into account ecological requirements, and the protection of the North Sea.

[2] *Convention on the Protection of the Rhine (1999)*

The EU Water Framework Directive (WFD)[3] and the EU Flood Risk Management Directive (FD)[4] have also been in force since 2000 and 2007 respectively. These directives and their respective daughter-directives are important instruments for the EU states in the ICPR, not least for implementing the „Rhine 2020" programme.

[3] *Directive 2000/60/EC*

[4] *Directive 2007/60/EC*

The states in the Rhine catchment area have been working together successfully for 70 years to align the diverse uses and protection of water bodies. The member states of the ICPR - Switzerland, France, Germany, the Netherlands, Luxembourg and the European Community - work hand in hand with the other states in the Rhine catchment area - Austria, Liechtenstein, Italy and the Belgian Walloon region.
In 2013 the ICPR was awarded the European RiverPrize and in 2014 the International Thiess RiverPrize for its successful work since 1950. Detailed information on the ICPR can be found by visiting www.iksr.org.

This report provides an overview of developments in the fields of ecology, water quality, floods, low water and climate change. It presents the goals and success achieved as well as those that still have not been achieved.

# 2. Ecology

## a. Introduction

The ICPR's "Rhine 2020" programme has set concrete targets for 2020 with a view to sustainable improvement of the ecosystem, including

- the reactivation of 160 km² of floodplains along the main stream of the Rhine;
- the connection of at least 100 oxbow lakes or lateral water bodies to the dynamics of the Rhine;
- increasing the structural diversity of 800 km of riverbanks along the Rhine;
- and the restoration of the ecological continuity of the Rhine to Basel and in the tributaries from the Migratory Fish Programme for upstream and downstream migrating fish (specified in the Rhine Ministerial Conferences 2007 and 2013).

The objective of restoring ecological continuity for the upward and downward migration of fish was set not only for the Rhine itself, but also for those tributaries containing significant habitat areas for migratory fish (programme waters). At that time, no target was set for the number of migration obstacles to be made passable. The "Master Plan Migratory Fish Rhine"[5], updated in 2018, shows how migratory fish species can be preserved and permanently reintroduced in the Rhine area.

[5] *ICPR Technical Report No. 247 (2018): Master Plan Migratory Fish Rhine 2018*

Every six years, the Rhine Monitoring Programme Biology investigates fish stocks, macrozoobenthos (invertebrates), macrophytes (aquatic plants), phytobenthos (fixed algae) and plankton in the main stream.

A further objective of the "Rhine 2020" programme is to restore the former network of biotopes typical of the Rhine, the habitat patch connectivity.

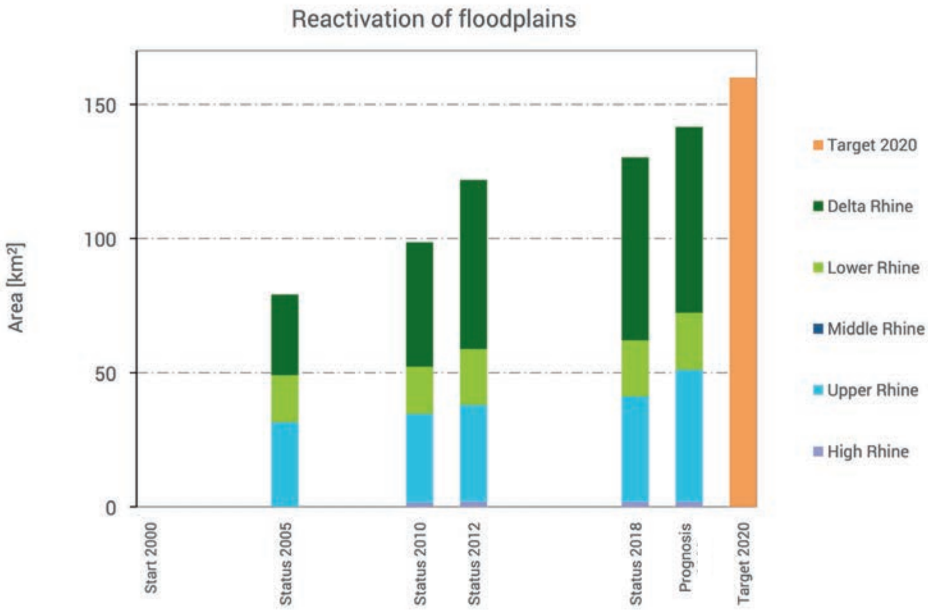
[6]ICPR Technical Report No. 223 (2015): Survey Report on the Development of the „Habitat Patch Connectivity along the Rhine“ 2005-2013

The progress achieved was last described[6] through positive examples of projects for each section of the Rhine for the period 2005 to 2013. The ICPR is examining whether, in future, it will be possible to carry out complete monitoring of success on the basis of satellite data throughout the Rhine floodplain.

### b. Reactivation of floodplains

**By the end of 2018, more than 130 km² of floodplains in the Rhine had been reactivated. More than 10 km2 are expected to be added by 2020. The target of 160 km² set for 2020 has become steadily more attainable over the last few years.**

Floodplains are the areas along a body of water characterised by high and low water, which have a variety of functions for the ecosystem and people. By reactivating flood plains, i.e. by allowing natural flooding to continue and by allowing the typical floodplain processes such as erosion and rearrangement to take place, valuable habitats for animal and plant species typical of the Rhine will be reclaimed. In low water situations, the floodplain can act as a buffer. The dynamic exchange between floodplain and groundwater also improves the soil ecosystem and the associated self-purification capacity of water bodies.




Measures implemented since 2000 include the relocation of dykes, the ecological flooding of flood retention areas behind dykes (see Chapter 4 „Floods“) and the more natural design of estuaries of Rhine tributaries. More and more projects are following an integrated approach, i.e. they aim at ecological improvement and improved flood retention as well as other objectives at the same time. For example, within the framework of the Dutch “Room for the River” programme in the Rhine delta, many areas were reclaimed for flood retention while being ecologically upgraded at the same time. The renaturation of the estuaries of the Emscher and Lippe tributaries of the Lower Rhine, the integrated EU-LIFE project on the Lahn and the Alpine Rhine development concept are further examples of holistic approaches in the international Rhine catchment area.

The “Rhine 2020” programme was also aimed at better protection of valuable floodplain ecosystems. Major progress has been made. Thus, the French-German wetland “Rhin supérieur - Oberrhein” (47,500 ha) was included in the Ramsar[7] list, large Rhine floodplains were classified according to the Habitats Directive and the Birds Directive[8] and several areas were declared nature reserves.

*[7]Ramsar Convention 1971: Convention on wetlands, in particular as habitats for wading and water birds of international importance*

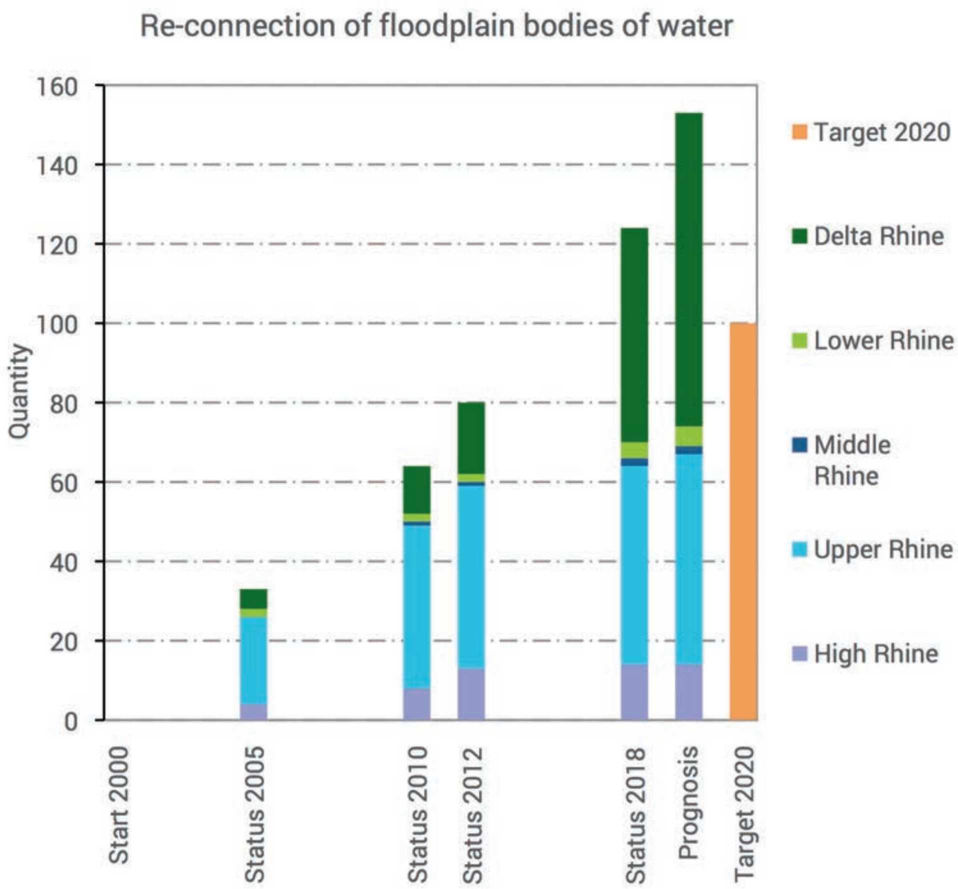
*[8]Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC) and Directive on the conservation of wild birds (79/409/EEC)*

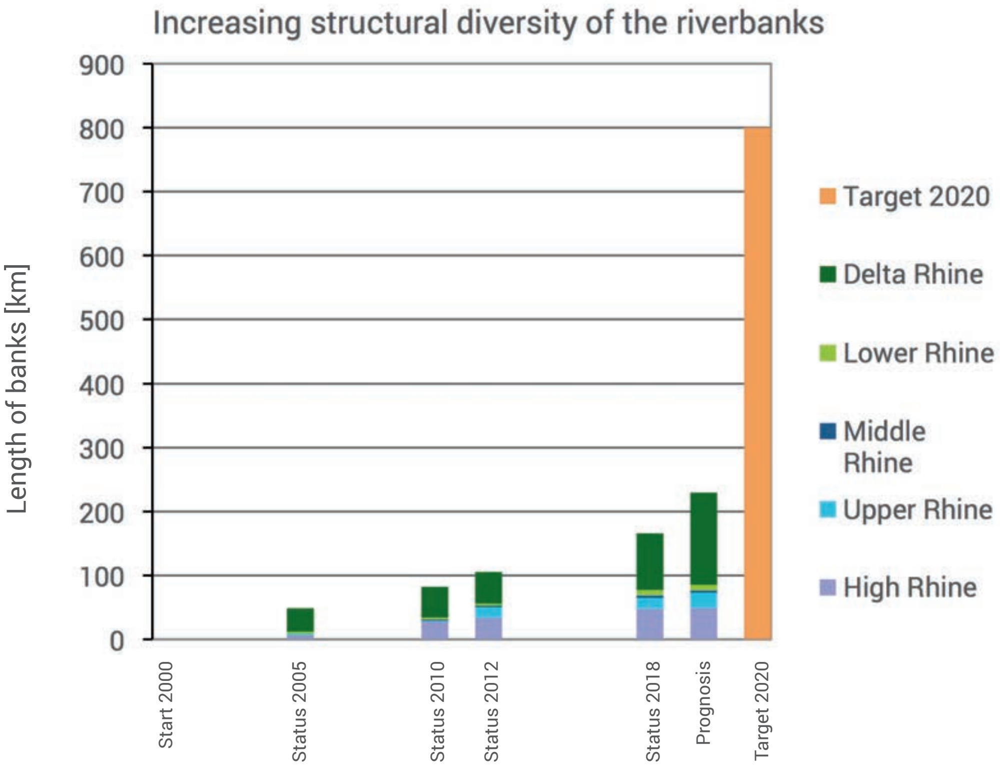
By the end of 2018, 166 km of measures had been implemented to increase structural diversity along the bank. More than 60 km of riverbanks are expected to be added by the end of 2020. The ambitious goal originally set of improving structural diversity up to 800 km along the Rhine and its arms by 2020 will thus clearly not be achieved. The implementation of these measures is made more difficult by the many uses along the main stream of the Rhine in many places.

### c. Reconnection of Rhine oxbow lakes and tributaries

The reconnection of oxbow lakes and lateral water bodies to the main stream of the Rhine restores the ecological link between the river and its floodplain. It creates valuable habitats for a large number of water-dependent animal and plant species. This lateral reconnection increases the water-dependent biodiversity to a particularly high degree. The connection of lateral waters also gives the Rhine more room. This has a positive effect on flood discharge.

Due to the natural conditions, numerous oxbow lakes and shallow water bays were reconnected to the Rhine, especially on the Delta Rhine and the Upper Rhine, and side channels through which water flows were created. The renaturation of the island of Rohrschollen near Strasbourg in the Upper Rhine is an example of this. Numerous measures are currently being implemented or planned. By the end of 2020, almost 30 further lateral waters are expected to be reconnected.






By the end of 2018, almost 600 migration obstacles in the Rhine and in the tributaries that are important for the reintroduction of migratory fish had been removed or equipped with fish passages. The goal of reopening the Rhine for fish migration from the North Sea to Switzerland has gradually become more tangible but has not yet been achieved. Many valuable spawning and juvenile fish habitats are still not accessible due to existing obstacles to migration.

### d. Increasing the structural diversity of the banks of the Rhine and its arms

Structural diversity promotes biological diversity. This is because a varied design of the banks and riverbed creates new habitats for typical Rhine flora and fauna. Naturally overgrown and shallow riverbank areas can also strengthen the self-purifying property of a water body and increase the attractiveness of a water landscape as a local recreation area.

In many places, concrete or monotonous rock-bed banks have been replaced by near-natural shallow and gravel-rich banks. Newly created gravel islands, areas protected from wave impact and the introduction of deadwood have created a variety of new habitats along the Rhine for young fish, aquatic plants and invertebrates such as crabs and insect larvae.

However, the implementation of this goal is progressing slowly, as it is both economically and socially challenging. Ambitious projects require the acquisition of large areas along the banks, and in some places users and residents are critical of measures. The transformation of the riverbank areas to a near-natural state is being prevented or at least delayed by the lack of clarity regarding responsibility for action and costs for large sections of the Rhine. In many places, it also conflicts with the use of the Rhine as a shipping lane.

The importance of increasing the diversity of bank structures has now been recognised and the framework conditions for implementing the corresponding measures are continually improving. The European Commission is providing financial support for projects to create a blue-green infrastructure.

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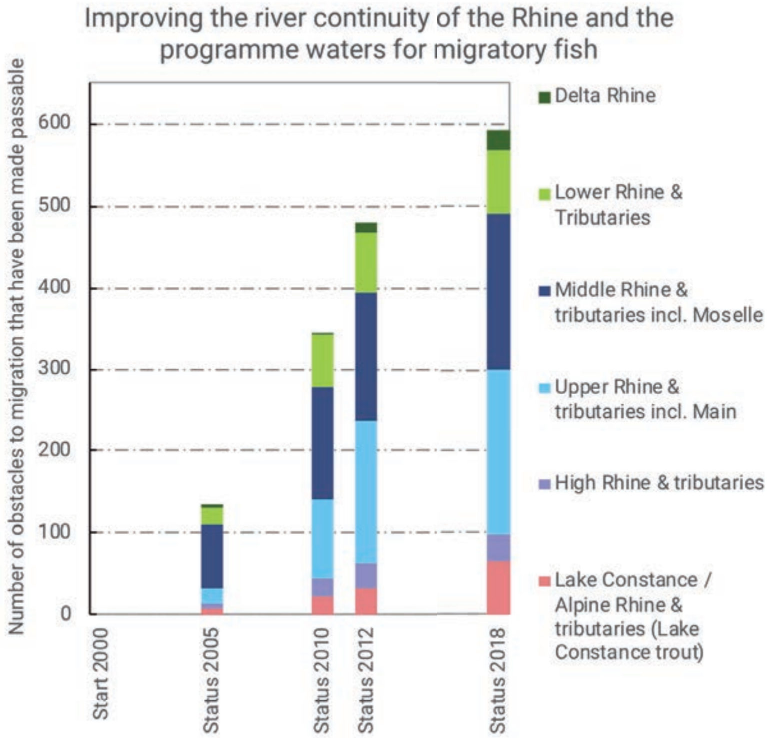
## e. Restoration of river continuity

Almost all fish make short migrations within rivers and streams in search of food, refuge areas or places to spawn. Some fish species, such as salmon and eel, also have to migrate long distances between the sea and watercourses to reproduce. Serious obstacles in the Rhine and its tributaries are transversal structures such as weirs and locks. The restoration of ecological continuity serves not only the fish, but also the distribution of many other aquatic animal and plant species and thus the important genetic interchange of populations.

592 weirs and thresholds in the Rhine and in the programme waters are once again passable, while there are still 160 large transverse structures with a drop height of more than 2 m that are impassable to fish. However, some milestones have already been reached towards restoring passability on the main stream of the Rhine. The Haringvliet dam south of Rotterdam was partially opened at the end of 2018. For the salmon migrating from the North Sea to the rivers Meuse and Rhine, the path is open again when there is sufficient discharge.

In addition, the construction of four fish passages at the large weirs on the Upper Rhine in Iffezheim (2000), Gambsheim (2006), Strasbourg (2016) and Gerstheim (2019) means that fish can now migrate through the Rhine main stream to below Rhinau. The fish passages in Strasbourg and Gerstheim provide migratory fish with access to potentially 59 ha of spawning habitats (salmon) in the Elz-Dreisam system in the Black Forest, if three fixed thresholds (drop height 1-2 m) in the old Rhine bed in the loops of Gerstheim and Rhinau allow the fish to pass so that they can ascend via the Leopold Canal.

However, the Upper Rhine section between Rhinau and Kembs near Basel remains an obstacle to fish migration. For example, salmon can only use the spawning grounds in the Basel tributaries of the Birs, Ergolz and Wiese and other High Rhine tributaries once the three remaining weirs in Rhinau, Marckolsheim and Vogelgrün on the Upper Rhine have been made passable.



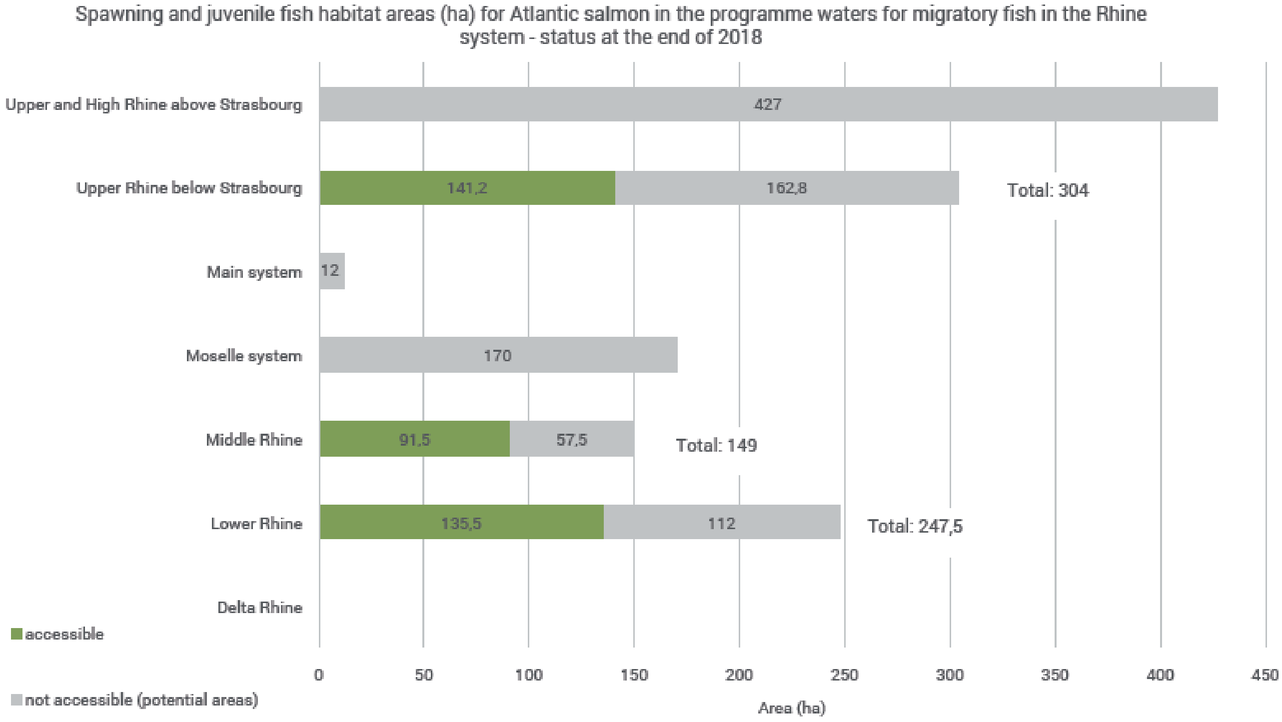

For this purpose, the ICPR has jointly worked out technically and ecologically feasible solutions for fish passages at the last not yet passable weirs on the Upper Rhine[9]; however, the discussions about the implementation are still underway.

In the course of the renewal of the concession for the Kembs hydroelectric power plant, the residual water volume in the Rhine was considerably increased and thus one of the objectives of the "Rhine 2020" programme was achieved. In addition to removing obstacles to migration, water bodies and floodplains in many places were redesigned to be more natural, thereby enhancing habitats for fish. The implementation of the WFD has promoted these measures.

Today, more than 28% of the potentially existing salmon habitats (more than 1,300 ha in total) are once again connected to the Rhine. However, many valuable spawning and juvenile fish habitats are still inaccessible to migratory fish due to existing migration barriers.
In addition to the continuous improvement of fish migration upstream since the beginning of the 1990s, the ICPR has devoted itself intensively to the joint determination of innovative descending techniques for transverse structures. The aim is to reduce the loss of young salmon or adult eels due to mortality and injuries during downward migration in the turbines of hydropower plants.

Today, there is sufficient experience with well-functioning descent aids for existing small hydropower plants where a maximum water volume of 50 m3/s is discharged through the turbines. In recent years, functioning descent systems have also been installed at some medium-sized power plants with an expanded water volume of up to 150 $m^3$/s. There is still no known satisfactory, feasible technology for existing larger plants. In some places, management measures are being implemented at hydroelectric power plants or catch and carry measures for eels in order to at least reduce fish mortality and injuries. In addition, lower injury rates can also be achieved with so-called „fish-friendly" turbines.

*[9] ICPR Technical Report No. 262 (2019): Report on the Results of the ICPR Project Group "Upper Rhine" 2015-2019*




## f. Positive effects of the measures on ecology

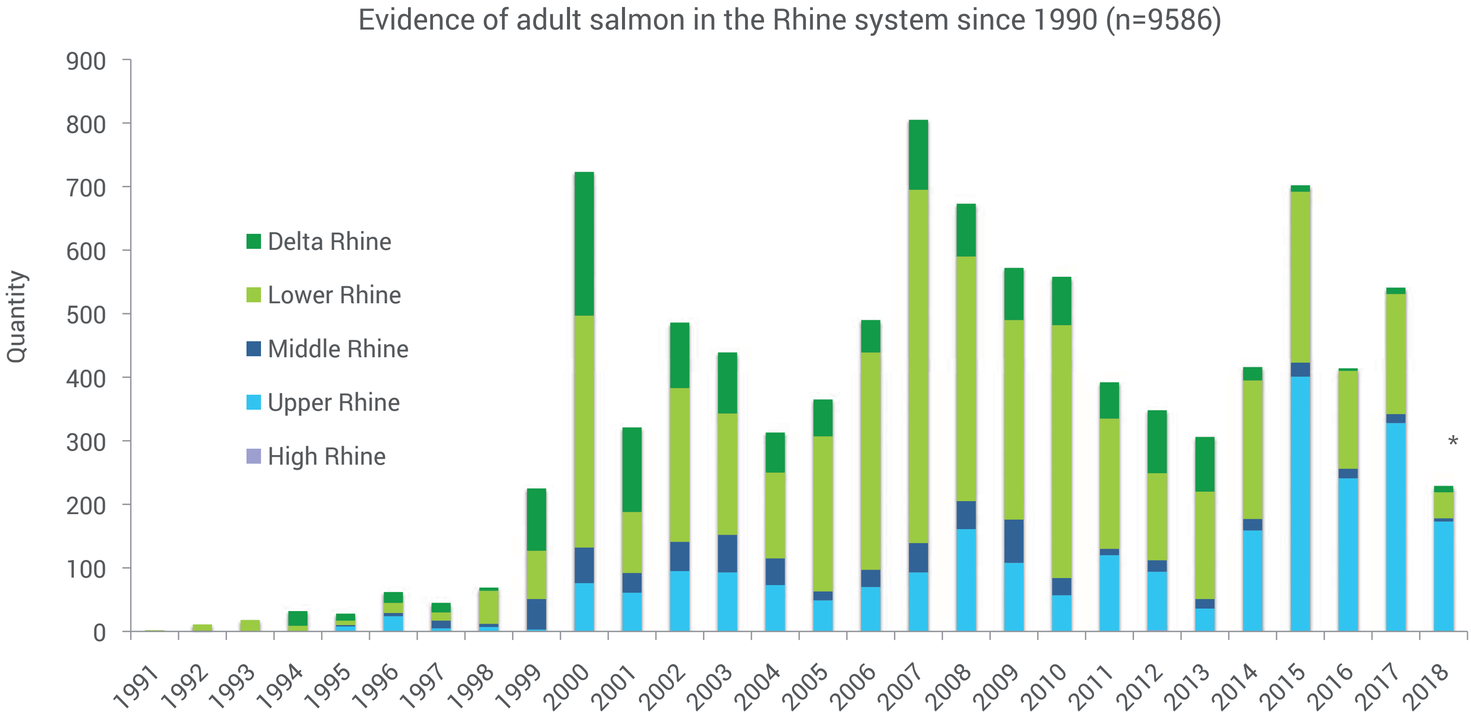
Since the beginning of the 1990s, the habitats of the main stream of the Rhine have regenerated themselves thanks to the now good water quality and the measures already implemented to reconnect tributaries and floodplains, to improve passability and to increase structural diversity. The construction of industrial and municipal sewage treatment plants has significantly improved the oxygen conditions in the Rhine. This has created the conditions for an increase in species diversity. In the case of fish fauna, the species spectrum is almost complete, although not in all sections and in the original dominant conditions. Since the water of the Rhine is cleaner today than it was 40 years ago, local aquatic plant communities typical of the Rhine were able to establish themselves again in the oxbow lakes and in protected groyne fields of the Rhine and form habitats for fish there.

Today's biological diversity in the Rhine is different from 40 years ago, because many new species that will continue to be part of the water system in the future have settled here. The renaturation of water bodies and the removal of obstacles to migration will favour species typical of the Rhine and strengthen the ecosystem. Some fish species (e.g. the eel) in the Rhine and its tributaries continue to be contaminated by historical pollutants such as mercury.

In addition to other typical Rhine animal and plant species, migratory fish such as salmon and lake trout in the Alpine Rhine region are particularly good indicators of the success of the „Rhine 2020“ programme. This is because they respond not only to the state of the main river, but also to the tributaries with their spawning grounds and juvenile fish habitats.

While the salmon was considered lost in the Rhine in 1958, today several hundred salmon from the North Sea return to the accessible tributaries of the Rhine every year and reproduce naturally there.

Other previously widespread migratory fish such as allis shad, sea trout and sea lamprey also swim in the Rhine once again. The populations of salmon, shad and sea trout are not yet self-sustaining and have to be supported by stocking measures in most of the programme waters and in the Rhine.  On the other hand, the houting, a migratory fish species originally native to the Lower Rhine and the Delta Rhine, which had become extinct in the meantime, has been reintroduced so successfully that the population has now established itself, even without stocking measures.




* Low ascent due to the low water level in the Rhine catchment area in 2018.

# 3. Water quality

## a. Introduction

In 2001, the ICPR set itself the goal of "making it possible to obtain drinking water using simple, near-natural treatment processes and ensuring that water constituents neither individually nor in their interaction have adverse effects on the biocoenoses of plants, animals and microorganisms".

In order to obtain the most comprehensive possible picture of the pollution situation, the monitoring, evaluation systems and measurement techniques in the states are being continuously adapted and further developed, e.g. with ICPR special measurement programmes and comparative studies on non-target analytics, etc. A major advantage of these new methods is the identification of previously unknown substances. These are often substances for which there are still no (legal) standards and findings on reduction, and which pose new challenges to the water authorities and drinking water suppliers when it comes to reduction measures. In the case of polar and persistent substances in particular, classic drinking water treatment and wastewater treatment processes often do not have a significant reduction effect. One representative of this group is, for example, trifluoroacetate (TFA), a salt of trifluoroacetic acid.

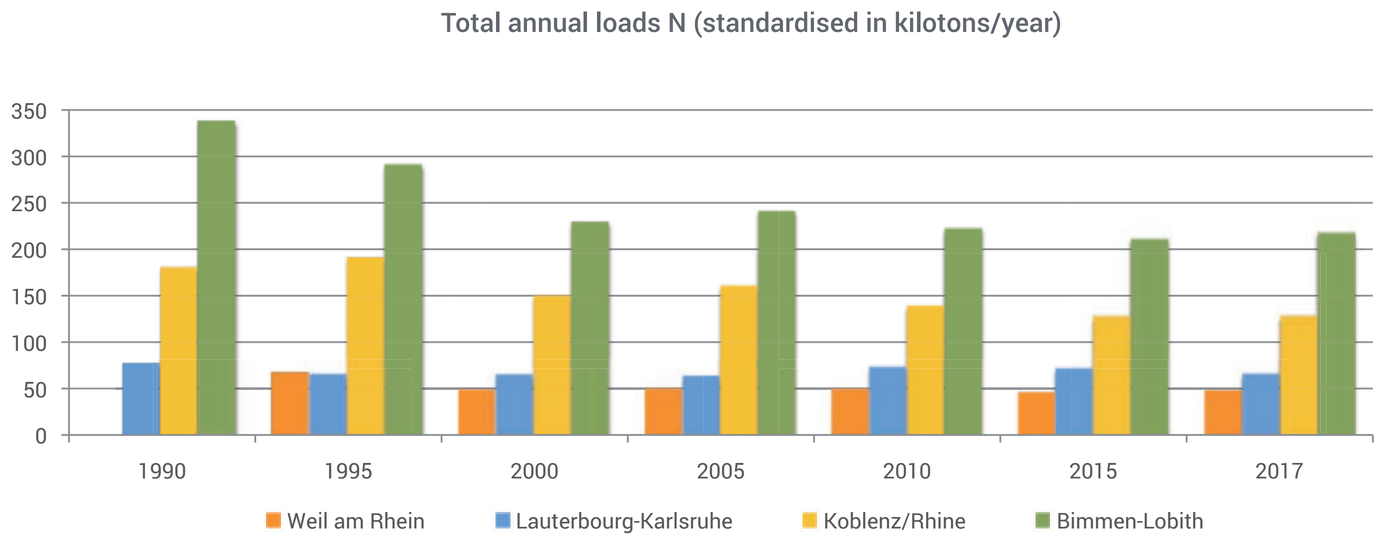
The monitoring stations along the Rhine, which are also included in the International Warning and Alarm Plan (IWAP), are good examples of a preventive approach to water protection. The new measurement techniques used at the international monitoring stations Weil am Rhein (downstream of Basel) and Bimmen/Lobith (border region Germany-Netherlands) are particularly worthy of mention. The measurement system in both stations enables, among other things, a comprehensive and timely analysis of the organic substances discharged into the river system and can also detect unknown substances. As a result, the sources of pollution can usually be located promptly, and the polluters informed by the authorities can immediately take countermeasures. In this respect, it also raises the environmental awareness of potential polluters of bodies of water.

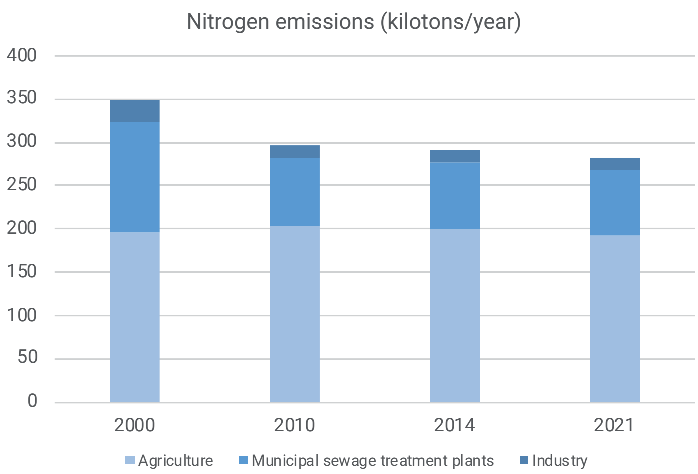
Since 2008, information on the relevance of various micropollutants in the Rhine catchment area and on approaches to reducing water pollution has been compiled and published in substance group-specific ICPR technical reports in addition to the existing substance groups, such as nutrients and metals.

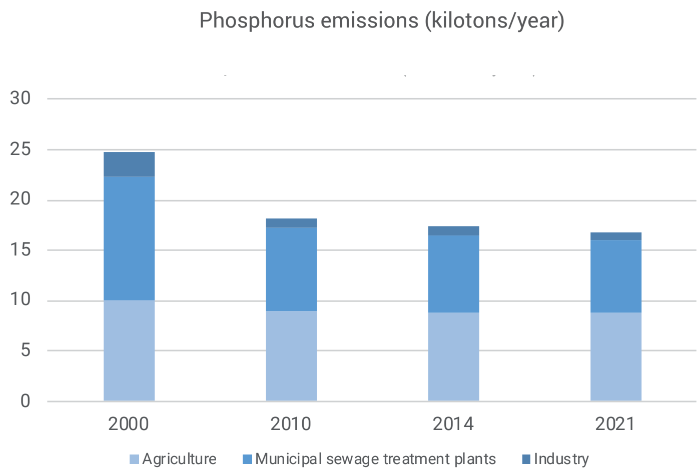
## b. Nutrients

**The agreed reduction of the nitrogen load of 15 - 20 % from the Rhine catchment area into the North Sea and the Wadden Sea by 2015 was just achieved (reference year 2000).**

However, it can be seen that the most significant reduction in the Rhine catchment area took place before the year 2000. Since 2010, the concentrations for P and N have remained at the same level. The phosphorus concentrations in the water still exceed the national requirements at some monitoring sites.




Since 1990, the total nitrogen loads on the Upper Rhine have remained at the same level and are declining slightly on the Middle and Lower Rhine. The reduction in nutrient loads is mainly due to the efforts made in the field of municipal and industrial wastewater discharges in recent decades. With regard to phosphorus and ammonium, however, there is still some potential for optimisation in municipal sewage treatment plants. A significant reduction in nutrient input from diffuse sources (with a focus on agriculture, but also on urban areas) has not yet been achieved. Further efforts will be needed in the coming years to reduce emissions even more.

To achieve and permanently maintain good nutrient status in coastal waters and inland areas, the causes of pollution must continue to be monitored and the measures introduced in all states in the Rhine catchment area must be continued undiminished, especially with regard to nitrogen pollution of groundwater.

The discharges of metals into flowing waters were already significantly reduced during the Rhine Action Programme in the years 1987 to 2000 and were further reduced by the construction, optimisation and modernisation of municipal and industrial sewage treatment plants after 2000.

## c. Metals

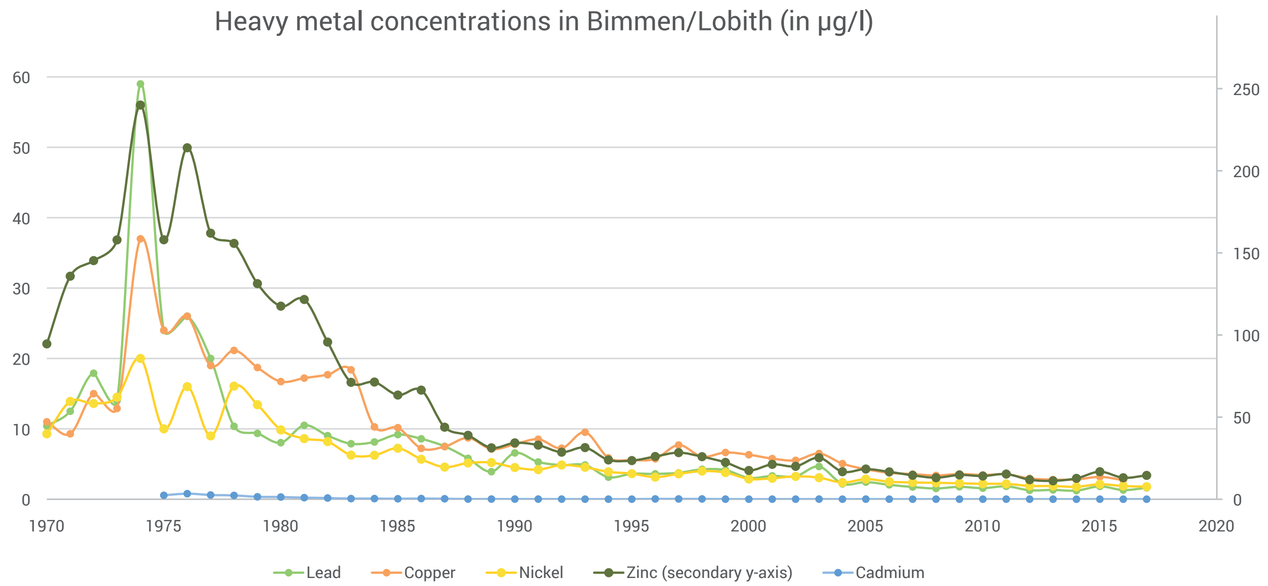
For the most part, industrial sewage treatment plants have achieved the highest reduction rates. Due to the diminishing importance of point sources, the pollution of water by metals today is mostly dominated by contamination from diffuse sources. Key diffuse contamination routes include erosion, groundwater inflow and surface runoff.

Here, too, the causes of pollution must continue to be observed and the measures introduced in all states in the Rhine catchment area must be continued undiminished.

## d. Pesticides

In the case of pesticides, there are some positive examples where significant reductions in emissions have been achieved thanks to new legal regulations in substance legislation (plant protection product and biocide legislation), bans on use and approvals, new application technologies and international cooperation.

For example, the atrazine concentrations in the Rhine at the Bimmen measuring station have generally been below the detection limit for years and - with the exception of the year 2000 with a maximum value of 0.2 µg/l - are always well below the drinking water target value of 0.1 µg/l. Atrazine has been banned from use in the EU since 2005 and 2007 respectively, and since 2009 in Switzerland. A similar positive example is isoproturon. Thanks to a variety of measures, particularly in agriculture, it has been possible to significantly reduce the contamination and thus the IWAP warning notifications for isoproturon on the Rhine. No isoproturon has been reported since 2016. This is also due to the fact that isoproturon has no longer been approved as an active substance throughout the EU since June 2016, even though it could still be used until October 2017.



However, pesticides and their degradation products are still being detected in the Rhine and its tributaries - in some cases even exceeding environmental quality standards (EQS) or drinking water-relevant assessment values. This is particularly true when there is heavy rainfall shortly after they have been applied in agriculture. Particularly in smaller, regional surface bodies of water, peak loads can occur if there is an unfavourable temporal correlation between the use of pesticides and precipitation.

Peak loads in the Rhine are also reported via the International Warning and Alarm Plan for the Rhine (IWAP). The frequency of the reports can also be influenced by the measurement methods, which have improved continuously over the years, so that significantly more substances can be measured.

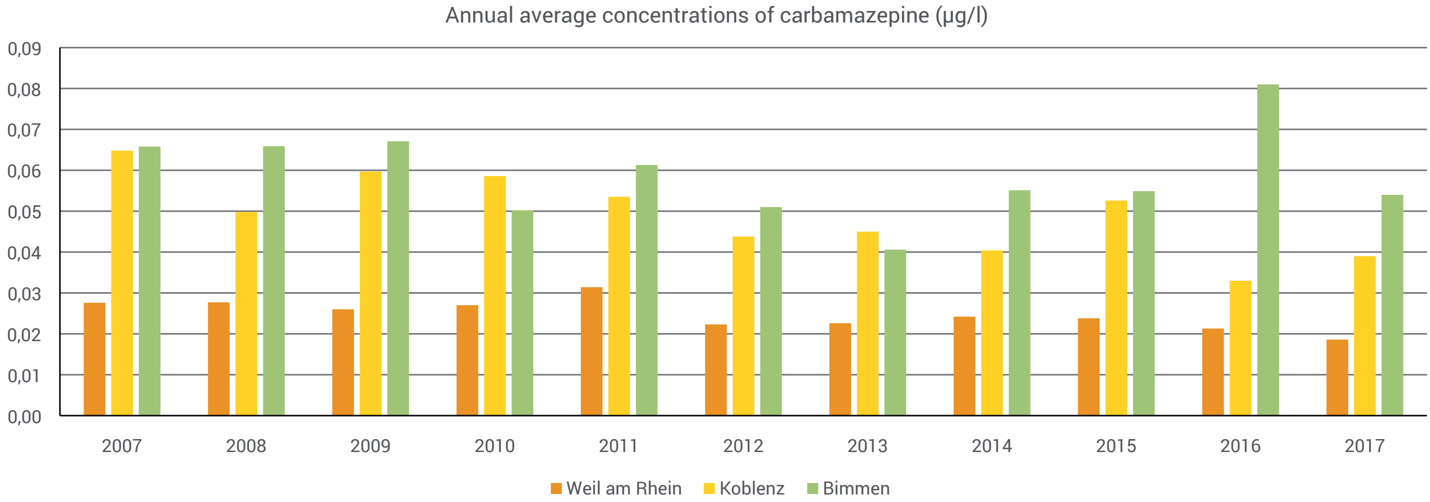
Thus, contamination due to pesticides continues to be a problem for the ecosystem as well as for drinking water production. Accordingly, the measures that have been initiated in all states in the Rhine catchment area must be continued undiminished.

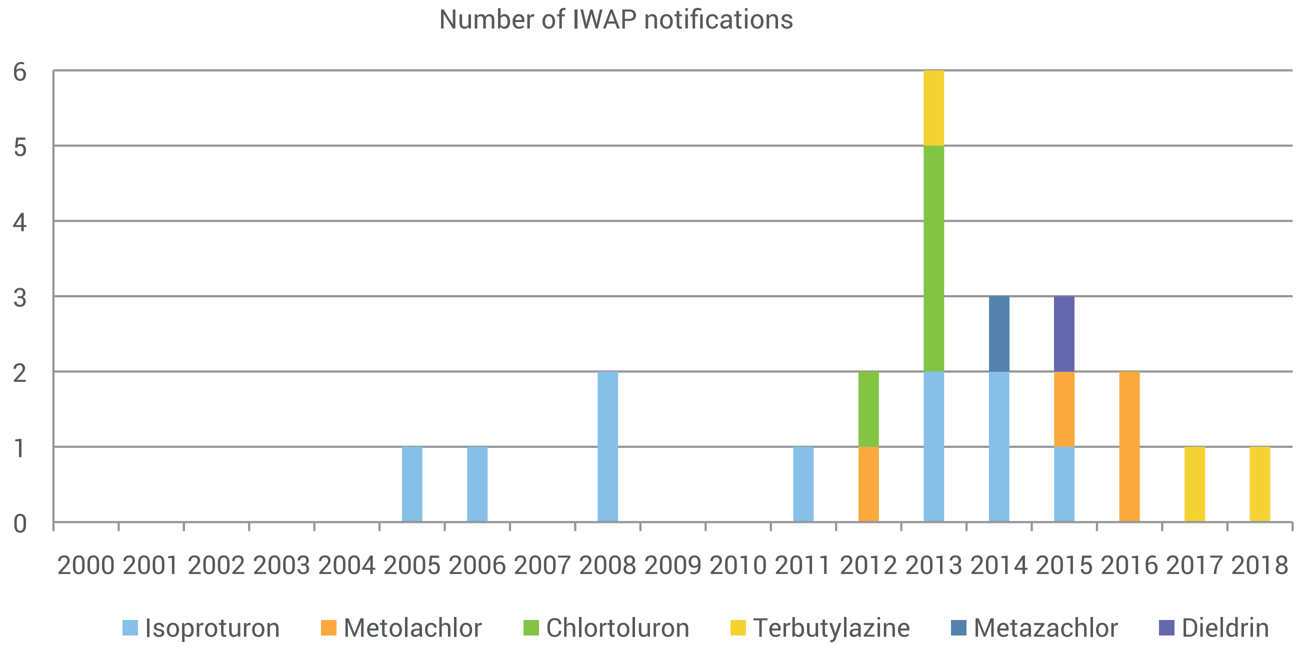
### e. Active pharmaceutical ingredients, biocides and other micropollutants

It is already clear today that micropollutants have a negative impact on water quality and can be relevant for both ecology and drinking water production. Active pharmaceutical ingredients such as carbamazepine and their degradation and transformation products can be detected in the entire catchment area of the Rhine. The highest concentrations were found in the lower reaches of the Rhine and in tributaries with a high proportion of municipal wastewater. Active pharmaceutical ingredients are also found in raw water from drinking water extraction plants and partly in drinking water.

**In 2019, the ICPR issued recommendations on how to further reduce discharges of micropollutants into water bodies.[10]**

[10] *ICPR Technical Report No. 253 (2019): ICPR recommendations for reducing micropollutants in waters*






[11] *ICPR Technical Report No. 183 (2010): Evaluation report on biocidal products and anti-corrosive agents*

Biocides and corrosion inhibitors are still found in strongly fluctuating concentrations in the Rhine catchment area[11]. A reduction of the maximum concentrations can be observed for some substances (e.g. diethyltoluamide; DEET). Biocide concentrations may be in the order of ecotoxicologically relevant values (e.g. this was the case with cybutryn in 2016). In some cases, insufficient data and complex contamination patterns were found for biocides and corrosion inhibitors.

Relatively high and sometimes increasing concentrations (e.g. for iopromide) are found especially for X-ray contrast media. They are developed in the form of biologically inactive substances, are scarcely degraded in sewage treatment plants due to their stability and can pose a problem in the production of drinking water.

For active pharmaceutical ingredients and other micropollutants, contamination from wastewater treatment plant effluents (municipal and industrial) usually represents the most important contamination path into surface waters. The use of advanced methods to eliminate micropollutants from wastewater is therefore an option if further measures, e.g. at the source and in the production process, are not sufficient.

### f. IWAP Rhine

**Communication via the International Warning and Alarm Plan for the Rhine (IWAP Rhine) functions well and reliably across countries and federal states.**

The IWAP Rhine[12] is a core task of the ICPR. If, despite all precautionary measures, an incident occurs or considerable quantities of pollutants flow into the Rhine, the IWAP Rhine comes into play and warns all Rhine riparian states and, above all, the downstream states as well as the drinking water works of an incident. In addition to warning messages, which are only triggered in the event of far-reaching serious water pollution, the IWAP is also increasingly being used for the exchange of reliable information on water pollution measured by measuring stations in the Rhine, Neckar, Main and smaller tributaries. In the event that the polluters are unknown, those responsible for the pollution are sought via the IWAP.

[12] *ICPR Technical Report No. 177 (2009): International Warning and Alarm Plan Rhine*

In the course of time, it has been repeatedly updated to modern means of communication and now operates via an Internet exchange platform.

The total number of notifications decreased overall in the period from the end of the 1980s to the beginning of the 2000s and has increased again since 2003. This can be attributed to the fact that more and more notifications are triggered by the constantly intensified monitoring, the improved equipment at the measuring stations and the increasing emphasis on timely water monitoring[13]. In addition, the orientation values for the triggering of a notification have been significantly lower since 2009.

[13] *ICPR Technical Report No. 255 (2019): International Warning and Alarm Plan Rhine (IWAP)- Releases 2018*

## g. Sediment management

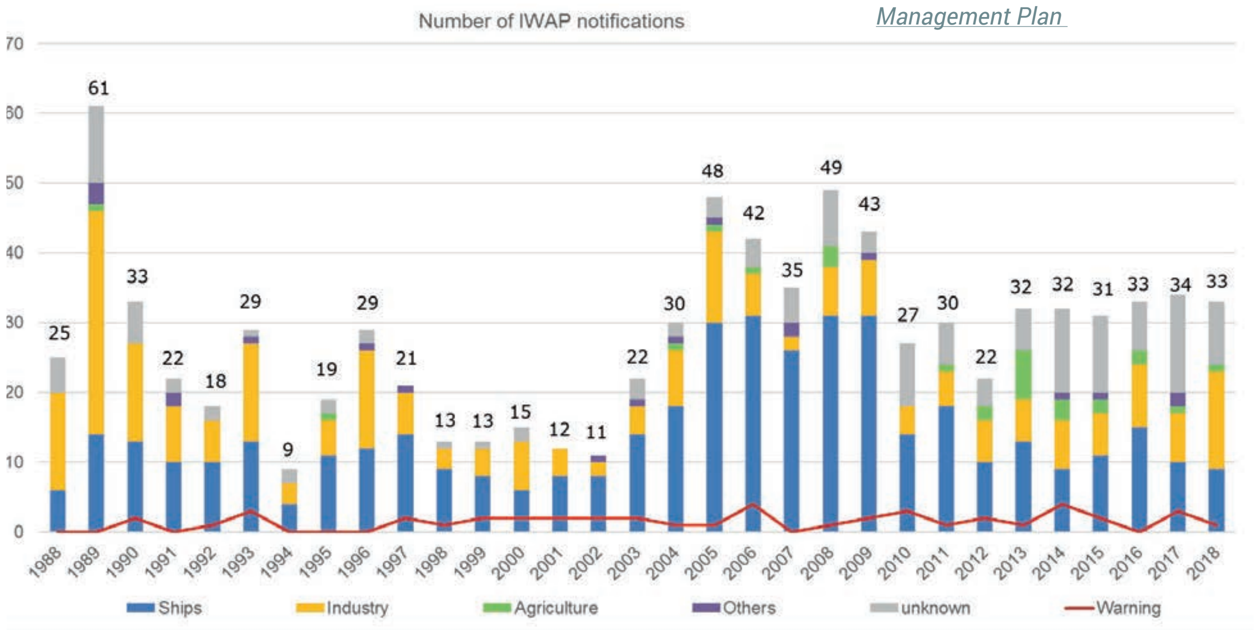
**Out of the 22 risk areas identified in the Sediment Management Plan 2009[14], the remediations were successfully completed for ten sites[15].**

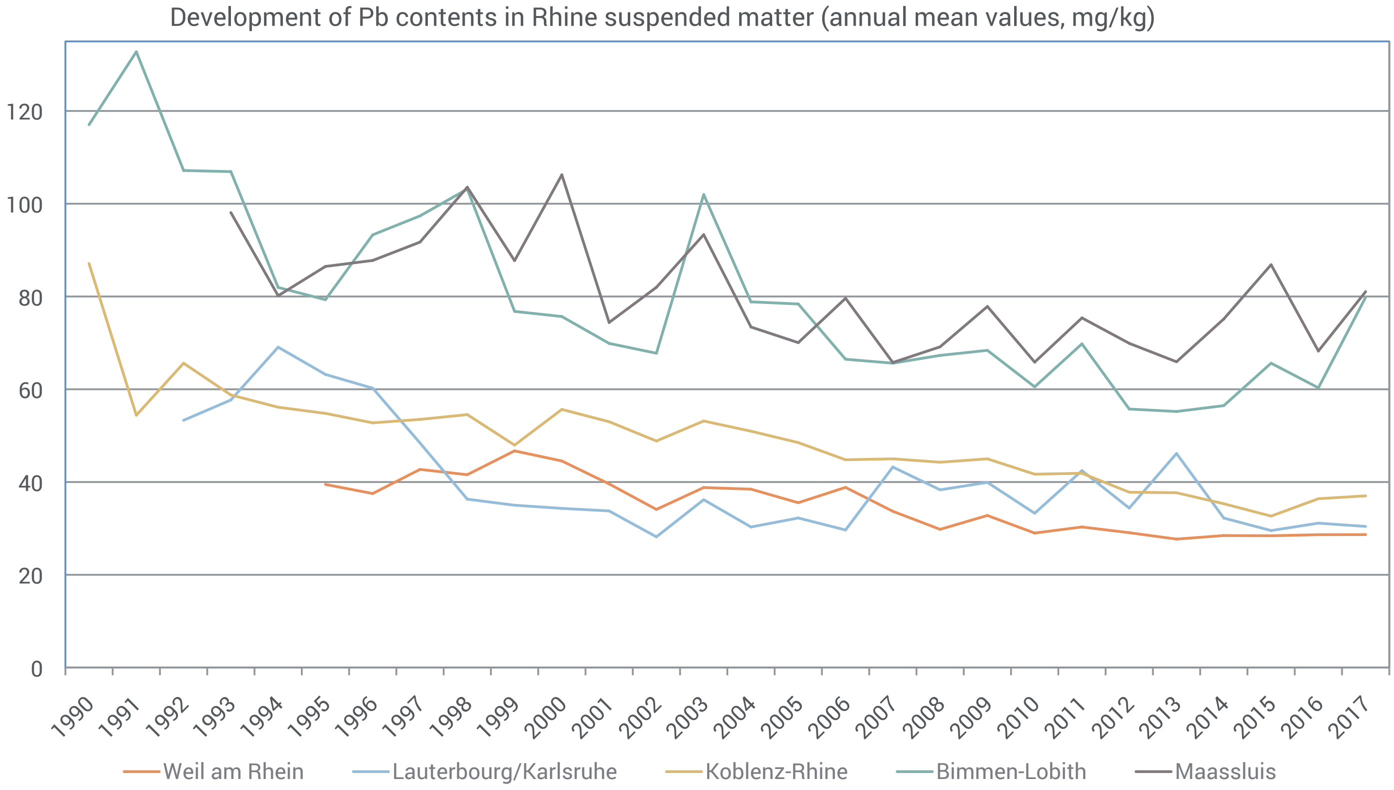
Since the establishment of the sediment management plan, further sediment investigations have been carried out or completed in all countries, as have remediation measures in some countries.

The quality of the recent sediments normally corresponds to that of the current suspended sediments. For example, the long-term trends for lead in suspended matter show a steady decrease due to the decrease of lead discharges into water bodies. In order to avoid the resuspension of contaminated sediment, further implementation of the sediment management plan is necessary.

[14] *ICPR Technical Report No. 175 (2009): Sediment Management Plan Rhine*

[15] *ICPR Technical Report No. 212 (2014): Implementation of the Sediment Management Plan*






**The analytical methods have been further developed, among other things thanks to the possibilities of non-target analysis.**

## h. Analysis / newly occurring substances

As a result, freight-relevant substances emitted from municipal and industrial discharges can be better identified and assessed. The cooperation of the laboratories, the standardisation of analysis and the evaluation along the Rhine have been significantly improved.

The exchange of information has been intensified with regard to the handling of “new” substances or those that are not regulated under water law in all states, their evaluation and the assessment of their relevance for drinking water production and aquatic communities.

### i. Biota studies

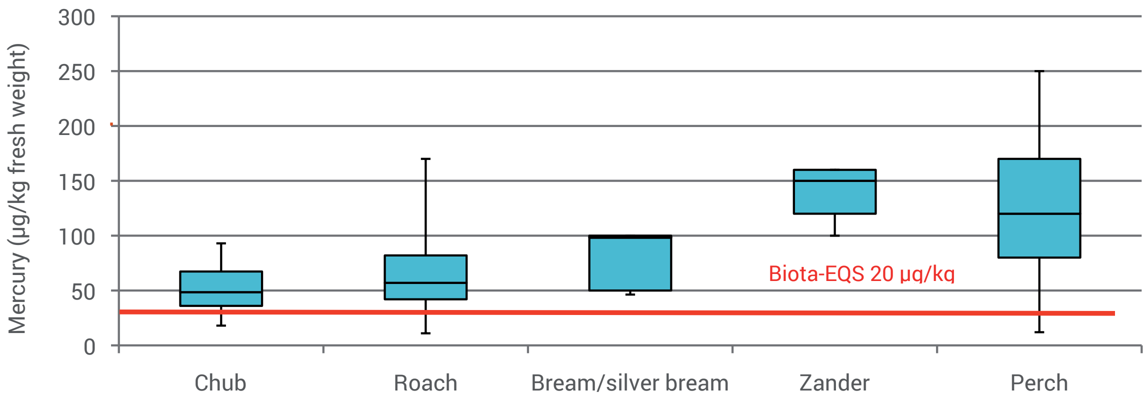
In 2014 and 2015, the ICPR carried out a joint programme for investigation into the contamination of biota (fish) with pollutants in the Rhine catchment area[16]. The aim was to obtain comparable data, as the investigations of the states were previously very different, and a joint evaluation was hardly possible. For this pilot programme, selected fish species were analysed at 37 measuring points in the Rhine catchment area.

The EQS for mercury and polybrominated diphenyl ethers (PBDE) were exceeded almost everywhere. Perfluorooctanoic acid (PFOS), hexachlorobenzene (HCB) as well as heptachlor and heptachlorepoxide were found to exceed the EQS in some cases. This also applies to dioxins, furans and dioxin-like polychlorinated biphenyls, if the results are normalised to body fat. Differences in the contamination situation were visible in the longitudinal course of the Rhine and between fish species.

In the future, too, biota studies in the Rhine catchment area are to be harmonised as far as possible and thus carried out in a comparable manner. According to the WFD, the EQS must be complied with by 2027. The states are obliged to implement measures to this end.

[16] *ICPR Technical Report No. 252 (2018): Statistical evaluation of measurements on the contamination of biota/fish with pollutants in the Rhine catchment area in 2014/2015*

Exceedance of the biota environmental quality standard for mercury for various fish species




### j. (Micro)plastics

The topic of (micro)plastics continues to be the focus of public interest, especially because of marine waste. It is the subject of numerous research projects and investigation programmes. Since 2013, also on the basis of the Marine Strategy Framework Directive[17], an annual exchange of information has been taking place in the ICPR. This exchange of information and the studies available so far show that there are still considerable gaps in knowledge regarding the environmental behaviour and consequences of (micro)plastics and that the state of data needs to be improved. Irrespective of this, however, plastic discharges into water bodies must be minimised and appropriate measures taken as directly as possible at source. This is not primarily a task of water management, but encompasses a large number of sectors, in particular waste management and industry.
For this reason, decisions have already been made at various levels outside the ICPR to reduce (macro)plastics in the environment, including the development and implementation of joint European measures to reduce and avoid plastic waste, the identification of research needs and priorities, and the examination of measures to reduce the impact on the environment.

[17] *Directive 2008/56/EC*

## k. Temperature change

Heat pollution in the Rhine catchment area is increasing due to climate change. Average water temperatures have already risen by around 1° C to 1.5° C between 1978 and 2011[18]. In addition, anthropogenic heat discharges are contributing to the increase in temperature. The shutdown of nuclear power plants in Switzerland, Germany and France has led to a reduction in heat pollution due to the reduction in cooling water discharges.

[18] ICPR Technical Report No. 209 (2013): Development of Rhine water temperatures based on validated temperature measurements between 1978 and 2011

## l. Groundwater state

Quantitative and qualitative groundwater monitoring in the Rhine catchment area has been carried out in six-year cycles since 2000 as part of the implementation of the WFD. Accordingly, the quantitative state of groundwater in 2015 was largely described as good. Only 4 % of the groundwater bodies are in a poor quantitative state, e.g. due to large regional groundwater lowerings as a result of coal mining. The situation is different for groundwater quality. Here, 67 % of the groundwater bodies are in a good chemical state and 33 % are in a poor state, in particular due to excessive nitrogen discharges (nitrate and ammonium).

# 4. Floods

## a. Introduction

Due to the major flooding of the Rhine in 1993 and 1995, the ICPR was given the task of drawing up an „Action Plan on Floods (APF)“ in Arles (France) on 4 February 1995. The 12th Conference of Rhine Ministers in 1998 decided to implement this action plan by 2020 with costs of 12.3 billion euros. The reference year was set at 1995.

Since then, flood protection and prevention have developed into comprehensive flood risk management, which was formalised with the entry into force of the European Flood Risk Management Directive 2007 (FD).

Flood risk management takes into account the effects of climate change and seeks synergy effects with the restoration of the water ecosystem and is holistically and sustainably oriented, i.e. the safety level to be achieved should be ecologically, economically and socially acceptable. The reduction of flood risks and their negative consequences is the focus of past and future objectives and activities.

The concrete and ambitious APF targets adopted in 1998 for 2020 were as follows:

1. Reduce flood damage risks by 25 % by 2020
2. Reduction of flood levels - reduction of extreme flood levels by up to 70 cm by 2020 below the impounded section (60 cm due to water retention along the Rhine and approximately 10 cm due to water retention in the Rhine catchment)
3. Increasing flood awareness by drafting and disseminating flood risk maps for 100 % of the areas at risk of flooding
4. Improving the flood announcement system - short-term improvement of flood announcement systems through international cooperation. Prolonging forecasting periods by 100 % by 2005.

These objectives were incorporated in 2015 into the objectives of the 1st Flood Risk Management Plan (FRMP):

1. Avoidance of new unacceptable risks
2. Reduction of existing risks to an acceptable level
3. Reduction of negative consequences during floods
4. Reduction of negative consequences after a flood.

The objective of "reducing flood damage risks by 25 % in the period 1995 to 2020" will have been achieved for economic flood risks by 2020 if the protection and prevention measures agreed in the APF are implemented. Risk reductions have also been established for the other risk objects “human health”, “cultural heritage” and “environment” listed in the FRMP.

## b. Reduction of flood damage risks

Flood risk is the combination of the extent and the probability of possible damage. The possible damage depends on the persons and material assets affected as well as their vulnerability and can be reduced by measures such as keeping flood prone areas open and precautionary building. Technical protective measures such as the construction or strengthening of dykes, retention measures or riverbed expansion measures influence the probability of flooding.
The reduction of flood damage risks has been achieved through a variety of measures. The ICPR has regularly evaluated the implementation of the measures and the achievement of the objectives in quantitative terms, most recently with the special ICPR tool „FloRiAn“ and has published the key results in the ICPR technical reports.[19]

## c. Overview of implemented measures

The table shows that many measures that can have a local, regional and/or supra-regional impact have been implemented on the Rhine or in the catchment area: Improvement of water retention on the Rhine and in the entire catchment area, maintenance and/or expansion of flood plains on Rhine tributaries, dyke relocation, renaturation, extensification of agriculture, nature development and afforestation, and also local protection, etc.

A large part of the measures can be regarded as no-regret and win-win measures. This means that they not only have a positive effect on flood prevention, but also on water quality and ecology (see Chapter 2 “Ecology”). They also mitigate the effects of climate change.

Chapters d to f explain some important measures in more detail.

[19] *ICPR Technical Report No. 200 (2012): Flood Action Plan 1995-2010: Action objectives, implementation and results and ICPR Technical Report No. 236 (2016): Assessment of Flood Risk Reduction (Action Plan on Floods, Action Target 1) with Due Regard to Types of Measures and Receptors of the Directive 2007/60/EC (FD)*

The table contains the information compiled by the ICPR on the measures implemented between 1995 and 2020. The Action Plan on Floods contained ambitious concrete objectives. Not all measures could be implemented by 2020 as planned, as their implementation proved to be more complicated than planned. However, the 14.1 billion euro expenditure shows that even higher investments were made than had been estimated in 1998.

| Rhine Action Plan on Floods: Overview of measures and implementation from 1995 - 2020 | |
|---|---|
| Water retention | |
| On the Rhine | |
| Reactivation of floodplains | 140 $km^2$ |
| Technical flood retention | 340 Mio $m^3$ |
| In the Rhine catchment | |
| Renaturations (river kilometres) | > 5650 km |
| Reactivation of floodplains | > 1230 $km^2$ |
| Extensification of agriculture | 14690 $km^2$ |
| Nature development, afforestation | > 1040 $km^2$ |
| Technical flood retention | 55 Mio $m^3$ |
| Promotion of rainwater infiltration | Improvements, but difficulty in data acquisition |
| Technical flood protection | |
| Maintenance and strengthening of dykes, adaptation to the protection level, local flood protection on the Rhine and in the catchment area (river kilometres) | > 2290 km |
| Preventive planning measures | |
| Sensitisation | Improvements through the creation of websites, brochures, the organisation of events and flood exercises |
| Creation of hazard and risk maps | 100 % |
| Flood forecasting | |
| Improvement of flood forecasting and announcement systems | Improvements to systems, databases and public information |
| Prolonging of forecasting periods | 100 % |

The APF target of "reducing extreme flood levels by up to 70 cm below the impounded Upper Rhine by 2020 (60 cm due to water retention along the Rhine and approximately 10 cm due to water retention in the Rhine catchment)" was not achieved. However, the measures taken so far have already led to a considerable reduction in water levels and thus contribute significantly to reducing the flood risk. In 2020, a retention volume of around 340 million m³ will be available on the Rhine. According to the FRMP, additional retention measures - some of which were planned for the APF for 2020 - will be implemented by 2030, so that the total retention volume will amount to around 540 million m³ from that date. This will allow further reductions to be achieved at extreme flood levels.

### d. Reduction of flood levels

Retention measures and riverbed extensions reduce the water level and consequently the probability of flooding. The effect of measures such as retention basins on lowering water levels depends on the location and is not equally effective for all extreme flood events: It is greater near the measure than further away from it. In addition, a retention basin can be designed in such a way that it is frequently flooded or that it only has to be used in much rarer and more extreme situations.

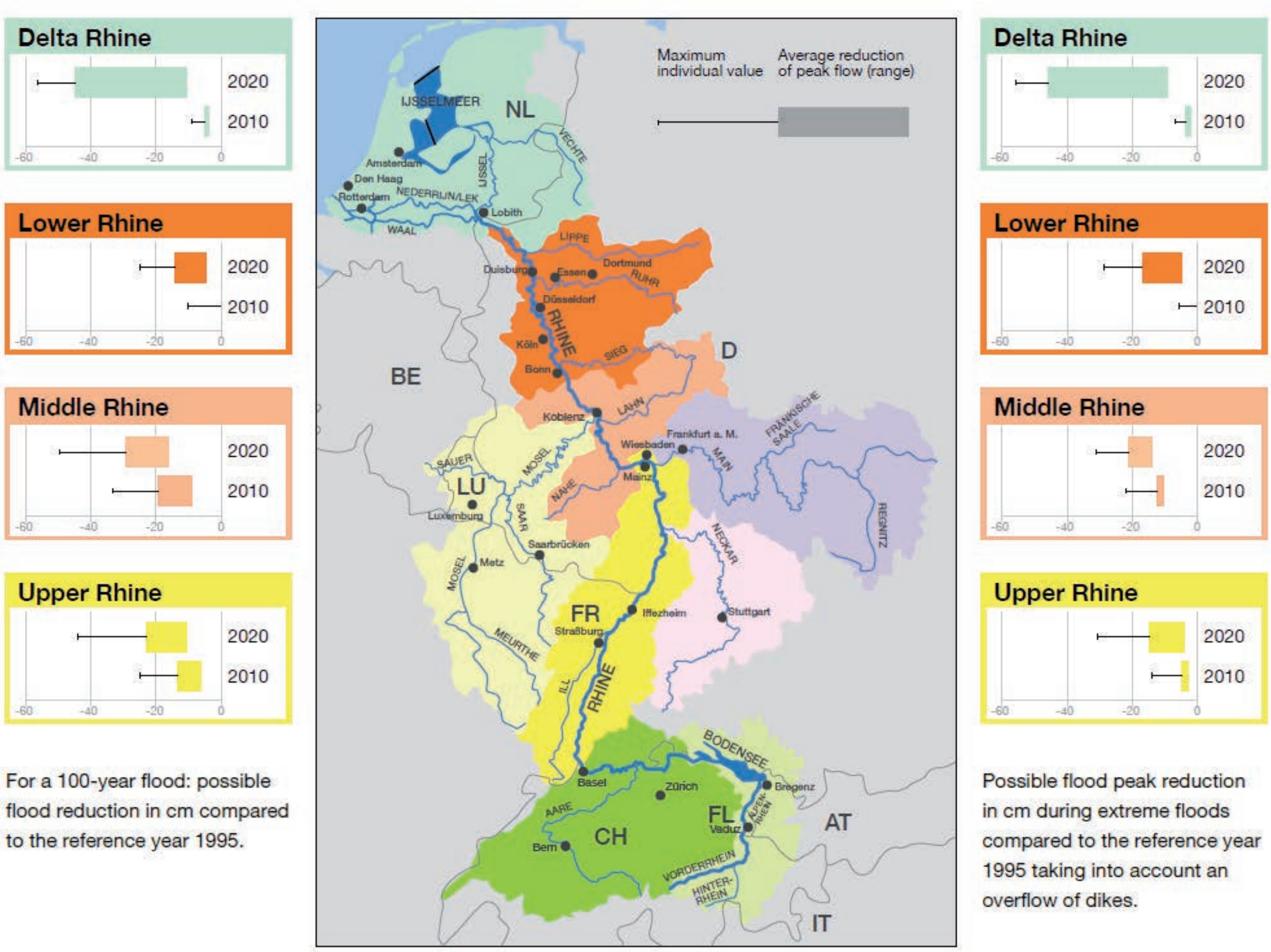
Many of the measures to reduce water levels have been implemented in the states in the Rhine catchment area over the last 25 years to meet the APF target. It must be borne in mind that some of the measures originally planned by 2020 will probably not be implemented until 2030. A reduction of 70 cm is only being achieved selectively and for only a few flood events. The targeted reduction of 70 cm water level in the event of flooding will only be possible with additional retention areas or with measures to improve discharge - provided that no downstream areas are endangered. To achieve this goal completely, further major efforts are required in the states, countries and regions in the Rhine catchment area.

There are many reasons why not all measures planned for 2020 have been implemented: technical, administrative and legal obstacles/ restrictions delaying implementation.

The calculation results show possible flood peak reductions due to water level lowering measures for the development states of the Rhine in 2010 and 2020 at the sections of the Upper, Middle and Lower Rhine for an approximately hundred-year flood and an extreme flood. In the Netherlands, the measures of the „Room for the River“ programme, which runs until 2020, will further reduce water levels. These have different effects on the three Rhine arms:

The greatest reductions in water levels in the Delta Rhine will be in the IJssel; in Waal and Lek they will be lower. The figure shows the range of mean reductions across all three arms for the Delta Rhine. The range of the most relevant mean values for some Rhine levels in the respective Rhine sections is shown for the other Rhine sections.[29]

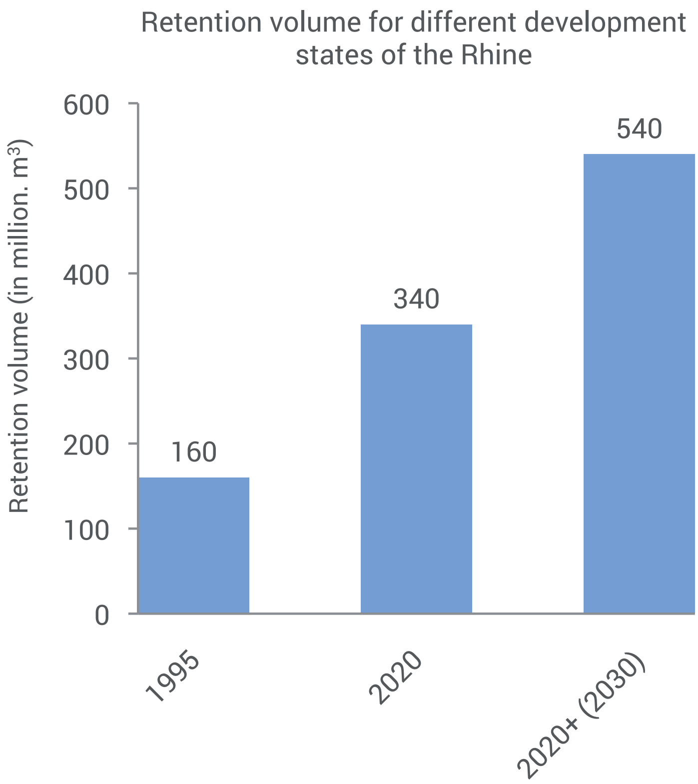
[20] *ICPR Technical Report No. 199 (2012): Identification of the effectiveness of measures to reduce flood levels in the Rhine*




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.

*The figure shows retention volumes for different development states of the Rhine, especially in 2020 (around 340 million m³) and 2030 (planning, 540 million m³).*




**Increasing flood awareness by drafting and disseminating flood risk maps for 100% of flood-prone areas and areas at risk of flooding by 2005 plays a major and important role and the objective has been achieved.**

## e. Increasing flood awareness

Using the web-based „Rhine Atlas“ with flood hazard and risk maps for the Rhine main stream from the Lake Constance outlet to the North Sea estuary, which was produced in 2001 and updated in 2015 in the course of the FD, it is possible to comprehensively inform and sensitise the population about the flood risks on the Rhine. In addition, there have been many different national and regional sensitisation measures (websites, information campaigns, brochures, etc.). Since the end of the 1990s, NGOs have been intensively involved as ICPR observers in ICPR work related to flood, critically monitoring it and making significant contributions to the dissemination of information. The same applies to the municipal flood partnerships on the Rhine and Moselle that have been established in recent years.

*Rhine Atlas*

## f. Improvement of the flood announcement system

The necessary exchange of data (flood announcements, forecasts, measurement data) and information between the participating and responsible persons from the flood forecasting centres on the Rhine from Switzerland to the Netherlands is now institutionalised and, in parallel with the implementation of the FD, is a matter of course. New developments are presented, and technical and communicative optimisations are tested so that the system functions well in the event of an incident and is always up to date.

**The objective of improving the flood announcement system, including the prolonging of the forecast periods by 100% by 2005, has been fully achieved. The close cooperation and data exchange between the flood forecasting centres on the Rhine as well as technical and communicative improvements have been accomplished.**

The following table shows the prolonging of flood forecasts between 1995 and 2020

| Rhine section / Gauge | Forecasting horizon for floods | | Additional estimation period (partly internal, partly published) |
|---|---|---|---|
| | Year 1995 | Year 2020 | Year 2020 |
| High Rhine/Basle | 72 h | 72 h[1] | up to 10 days |
| Upper Rhine/Maxau | 24 h | 48 h[2] | up to 7 days |
| Middle Rhine/Andernach | 24 h | 48 h[2] | up to 4 days |
| Lower Rhine/Lobith | 48 h | 96 h | up to 15 days |

[1] For the High Rhine, there was no need for action to extend the forecast period for the period 1995 - 2005
[2] The forecast hours 25-48 are marked as "estimation"


Rhine arm near Koblenz (Middle Rhein)

# 5. Low water

## a. Introduction

Low water is part of the natural discharge behaviour of rivers, but can cause ecological and economic problems. While flood events occur quickly and can lead to major damage within a short period of time, low water phases develop over a longer period of time and initially appear less spectacular. Reducing the size of habitats can have negative consequences for aquatic biocoenoses, especially if low water levels occur together with high water temperatures and low oxygen levels in the water body, as in the extreme summer of 2003. Particularly in the case of long-lasting events, considerable financial losses may result from low water levels, for example due to restrictions in navigation, load restrictions due to shallow water depths or reduced electricity generation. Water supply and agriculture are also affected. The occurrence and extent of low water events can vary as a result of climate change.

## b. Inventory of low water events

Existing knowledge on low water periods in the Rhine basin was brought together and hydrological measurement data from the beginning of the last century were analysed. Future potential changes in low water discharges due to climate change were also investigated.

Measurement data since the beginning of the 20th century show that low water periods on the Rhine were much more pronounced in the first half of the last century. Discharges were lower and low flow periods lasted longer than in the last 50 years. Low water therefore occurs no more frequently than in the past. This hydrological finding is mainly attributable to the regulating influence of many lake reservoirs in the Alpine region. However, the vulnerability of the users of the Rhine, such as shipping, energy production, industry and agriculture, has increased.

**The ICPR Inventory of the Low Water Conditions on the Rhine published in 2018[21] provides a common basis and a common understanding of low water situations and their cross-border effects for the Rhine riparian states.**

[21] *ICPR Technical Report No. 248 (2018): Inventory of the low water conditions on the Rhine*

Since low water has a direct impact on water quality, ecology and uses, the ICPR has set up its own low water monitoring system, which ran in test operation during the low water event of 2018 and has been available on www.iksr.org since summer 2019[22].

[22] *ICPR Technical Report No. 261 (2019): ICPR low water monitoring for the Rhine and its basin*

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## c. Low water monitoring

The ICPR has established common discharge thresholds and classifications for the intensity of low water - after prior consultation with the International Commissions for the Protection of the Moselle and the Saar (ICPMS) and the International Meuse Commission (IMC): The discharge threshold NM7Q corresponds to the lowest arithmetic mean (sum of the values divided by their number) on seven consecutive days of the preceding week. It is a good early warning value. To illustrate the intensity of the low water, the states have agreed on a 5-stage classification (see table below).

An ICPR report on the extreme Rhine low water from July to November 2018 was published.[23]

[23] *ICPR Technical Report No. 263 (2020): Report on the low water event July-November 2018*

## d. Sharing information on low water events

The low water event 2018 can be classified as a 40-year "very rare" event in relation to the low water discharges, and as a good 100-year "extreme" event in relation to the low water duration. In addition to ecological damage, the economy was particularly affected by production reductions and greatly reduced transport possibilities on the waterway.

Mäuseturm at Middle Rhine in October 2018

Prolonging of flood forecasts between 1995 and 2020 (coordinated with ICPMS and IMC)

| Colour | Class | Severity | Designation |
|---|---|---|---|
| green | 0 | >= NM7Q(T2) | normal = no LW |
| yellow | 1 | < NM7Q(T2) | frequent LW |
| orange | 2 | < NM7Q(T5) | less frequent LW |
| red | 3 | < NM7Q(T10) | rare LW |
| purple | 4 | < NM7Q(T20) | very rare LW |
| black | 5 | < NM7Q(T50) | extremely rare LW |

# 6. Climate change: Effects and adaptation strategy

In the Rhine catchment area, extensive knowledge is available on the effects of climate change on discharges in the Rhine, which were already observed in the 20th century, and on the development of water temperatures since 1978. Furthermore, gauge-related simulations for the development of the water regime and the water temperature in the Rhine river basin district for the near future (up to 2050) and the remote future (up to 2100) have been developed in recent years on the basis of climate projections.

### a. Introduction

The relevance of climate change has increased since the end of the 1990s. The 14th Conference of Rhine Ministers in 2007 stated that the effects of climate change in the water sector are clearly recognisable and instructed the ICPR to deal with this issue.

### b. Effects of climate change

More frequent flood events, longer low water levels and higher surface water temperatures as well as a change in groundwater recharging, to varying regional degrees, must be expected in north-western Europe[24].

[24] *ICPR Technical Report No. 188 (2011): Study of scenarios for the discharge regime of the Rhine*

By 2050 (near future), moderate changes in air temperature, water regime and water temperature are expected for the entire Rhine river basin. By 2100 the trend will be clearer compared to the reference period 1961-1990:

| | |
|---|---|
| a. | Air temperature: increase from +2 °C to +4 °C by 2100, with +1 °C to +2 °C expected by 2050 |
| b. | Changes in the water regime in the hydrological winter half-year: |
| | Increase in precipitation in winter |
| | Increase in discharges |
| | Early melting of snow/ice/permafrost, shifting of the snowfall line |
| c. | Changes in the water regime in the hydrological summer half-year: |
| | Decrease in precipitation (but possibly more frequent heavy rainfall events in summer) |
| | Decrease in discharges |
| | Increase in low water periods |
| d. | Increase in small to medium floods, increases in peak discharges of rare floods appear possible, but their dimension cannot be quantified beyond doubt |
| e. | Water temperature: higher air temperatures lead to higher water temperatures (especially with low discharge): strong increase in the number of days exceeding 25 °C as well as 28 °C by 2050 or 2100 respectively. |

### c. Adaptation to climate change

The possible impacts of climate change require the adaptation of water management. The necessary measures must be seen in the context of measures taken in other sectors to adapt to climate change and its interactions. Adaptation measures in water management should aim at ensuring the basic functions of water protection and use even in an altered climate; this is possible with no-regret and win-win measures. In the case of measures on the land surface, spatial planning and urban land use planning are also addressed.

The main messages of the ICPR climate change adaptation strategy published in 2015 continue to apply:

1. Continue and reinforce measures within the framework of avoidance, prevention, crisis management, and based on measures of the APF so far, and which are provided for in national and regional flood risk management plans to reduce present flood risks. Due to the expected increase of flood events and possible more often extreme events, the planned measures to create more space for (temporary) flood retention will, in future, be even more important, as would be flood prevention and comprehensively raising the awareness of the general public for flood issues;
2. Securing and keeping flood-prone areas in settlement areas free from further uses and decentralized water retention in the surface of the entire catchment area;
3. Taking into account the aforementioned measures when drafting future flood risk management plans according to the FD and management plans on the basis of the WFD;
4. Drafting and providing for preventive water management measures for critical periods of low flow (taking into account the problems related to water quantity and water temperature) including a transboundary coordination of such measures;
5. Restoring/enhancing as near-natural water bodies as possible and creating a network of habitats according to the environment targets of the WFD. Mutual synergy effects must be used beneficially and strengthened.
6. Integrating the socio-economic developments into water management measures and coordinating them with corresponding measures in other fields (drinking water supply, water abstraction, power generation, navigation, agriculture, fisheries and recreation).

In addition, knowledge of the effects of climate change on biocoenoses and river ecosystems needs to be further developed through studies and monitoring.

**In 2015 the ICPR published the first ICPR climate change adaptation strategy for the Rhine river basin[25]. It contains a compilation of the knowledge and provides a framework for action for adaptation options.**

[25] *ICPR Technical Report No. 219 (2015): Strategy for the IRBD Rhine for adapting to climate change*

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