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Internationally Coordinated Management Plan 2022 - 2027 for the International River Basin District of the Rhine

(Part A = Overriding Part)

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Introduction

The European Water Framework Directive (Directive 2000/60/EC, in the following WFD) has set new standards in water policy for EU Member States. Running waters, lakes, coastal and transitional waters as well as groundwater in a river basin (river basin district) have since been regarded as interconnected ecosystems.

The foremost target of the WFD is to achieve the good status of all surface waters and of the groundwater by 2015, or, with extensions, by 2027. To this end, inventories are to be conducted in all river basin districts (RBD) and monitoring programmes as well as coordinated management plans are to be drafted. The participation of the public in the process of implementation is an essential element of the WFD. International river basin commissions, such as the International Commission for the Protection of the Rhine (ICPR), serve as transboundary coordination platforms in this respect.

Since the ICPR does not cover the entire river basin district, the Coordination Committee was founded in 2001 to involve Liechtenstein, Austria and the Belgian region of Wallonia. Since the Italian share in the RBD Rhine comprises only a few square kilometres of mostly uninhabited territory, Italy does not in practice participate in the work of the ICPR. Switzerland is not bound by the WFD but does support the EU Member States in their coordination and harmonisation work within the framework of conventions under international law and their national law.

In 2004, the ICPR and the Coordination Committee presented a report on the delimitation of the Rhine river basin district, the network of waters part A and the competent authorities¹, in 2005 a report followed concerning the first joint inventory², in 2007 a report on the coordination of surveillance monitoring programmes³, and in 2009 the first internationally coordinated management plan⁴ (2010- 2015) for the International River Basin District (IRBD) Rhine.

So far, the coordination results on the implementation of the WFD in the Rhine catchment are composed of the overriding parts for the entire river basin district (part A) and of national or transboundary parts B. The B-parts either consist of coordination reports in some of the nine areas of operation established or of national reports coordinated at a transboundary level. These nine areas of operation have been delimited on the basis of natural features and are mostly international: Alpine Rhine / Lake Constance, High Rhine, Upper Rhine, Neckar, Main, Middle Rhine, Moselle and Sarre, Lower Rhine, Delta Rhine. In the areas of operation Alpine Rhine/Lake Constance and Moselle/Sarre the working structures of the already existing commissions (international water protection commissions for Lake Constance, International Commissions for the Protection of Moselle and Sarre) are used; these areas of operation continue to establish their own reports.

The WFD provides for a management plan every 6 years. The second management plan published in 2015 (2016-2021)⁵ will be evaluated by end 2021 and will be updated wherever required. The internationally coordinated third management plan (2022-2027) for the IRBD Rhine (Part A = overriding part) presented in this version – hereafter consistently referred to as "River Basin Management Plan 2022-2027 IRBD Rhine" – documents the updates.

The verification requirement also applies to some of the work steps. Thus, the ICPR reviews the inventory every six years, but without writing a new report. According to the WFD, this is only required for the first inventory.

¹ <u>Competent authorities</u>

² First inventory

³<u>Monitoring programmes</u>

⁴ Management plan 2010-2015

⁵ Management plan 2016-2021

The River Basin Management Plan 2022-2027 IRBD Rhine was prepared jointly by representatives of all states concerned. Due to the COVID 19 pandemic, which has also affected the entire Rhine river basin district since March 2020, there have been some delays in the processing and in the delivery of information and data by the states in the Rhine catchment. The present management plan for the IRBD Rhine was therefore published some months later than planned.

With respect to surface water bodies, the document again focusses on the main stream of the Rhine and major tributaries, such as Neckar, Main, Moselle with catchment areas above 2.500 km² (see K2). For the other surface waters reference is made to national or transboundary management plans (parts B) with links in Chapter 8 and on the ICPR website.

Statements on groundwater concern all groundwater bodies in the IRBD Rhine.

The River Basin Management Plan 2022-2027 IRBD Rhine (part A) describes monitoring results of the Measurement programmes Chemistry and Biology for the Rhine, the targets achieved and still to achieve and the programme of measures. The management plan thus serves on the one hand as an information tool for the public and the European Commission, and on the other hand it also documents the international coordination and cooperation of the states in the river basin district, which is also called for by the WFD in Article 3 (4) and Article 13 (3).

The four essential management issues for the IRBD Rhine continue to apply. They represent permanent tasks for the states in the Rhine catchment.

- "Restoration"⁶ of ecological river continuity, increased habitat diversity;
- Reduction of diffuse inputs interfering with surface waters and groundwater (nutrients, pesticides, metals and arsenic, dangerous substances from historical contamination and others);
- Further reduction of classical pollution of industrial and municipal point sources;
- Harmonisation of water uses (navigation, energy production, flood protection, regional land use planning and others) with environmental objectives.

These urgent issues are also reflected in the trend-setting programme "Rhine 2040"⁷, which the states in the Rhine catchment area and the EU adopted in February 2020 at the Rhine Ministerial Conference in Amsterdam.

The programme "Rhine 2040" also particularly supports the achievement of the objectives of the Water Framework Directive.

Climate change has an impact on all management issues. The effects of climate change, such as the changes of the discharge regime in the Rhine with, among others, more frequent flood events and longer lasting low water phases as well as the water temperature increases, were taken into account in the preparation of the third management plan (2022-2027) for the IRBD Rhine.

In the preparation of the River Basin Management Plan (2022-2027) IRBD Rhine, potential for improvement was also taken up, which the EU Commission had identified in its assessment of the international management plans 2016-2021⁸. Thus, the states in the Rhine catchment have achieved further standardisation in the area of methodology, among other things.

⁶ As far as possible, river continuity is to be restored.

⁷ <u>https://www.iksr.org/de/iksr/rhein-2040</u>

⁸ Commission Staff Working Document: International Cooperation under the Water Framework Directive (2000/60/EC) - Factsheets for International River Basins, page 158-188

1. Description of the international river basin district Rhine

1.1 General Description

The Rhine connects the Alps with the North Sea and, at 1,233 km long, is one of the most important rivers in Europe. The river catchment area covering some 200,000 km² spreads over nine states (see Table 1). The source area of the Rhine lies in the Swiss Alps. From there the Alpine Rhine flows into Lake Constance. Between Lake Constance and Basel, the High Rhine largely forms the frontier between Switzerland and Germany. North of Basel, the Franco-German Upper Rhine flows through the lowlands of the Upper Rhine. The Middle Rhine, into which the Moselle flows in Koblenz, starts at Bingen. In Bonn, the river leaves the low mountain regions and becomes the German Lower Rhine. Downstream of the German-Dutch border, the Rhine splits into several branches and, together with the R. Maas, it forms a wide river delta. The Wadden Sea adjacent to Lake IJssel fulfils an important function in the coastal ecosystem.

Surface	About 200.000 km ²
Length main stream Rhine	1.233 km
Mean annual discharge	338 m ³ /s (Konstanz), 1.253 m ³ /s (Karlsruhe-Maxau), 2.290 m ³ /s (Rees)
Important tributaries	Aare, Ill (FR), Neckar, Main (Regnitz, Fränkische Saale), Nahe, Lahn, Mosel (Saar, Meurthe, Sauer), Sieg, Ruhr, Lippe, Vechte
Important lakes	Lake Constance, Lake IJssel
States	EU Member States (7): Italy, Austria, France, Germany, Luxemburg, Belgium, Netherlands, other states (2): Liechtenstein, Switzerland
Inhabitants	More than 60 million
Major functional use/interests	Navigation, hydropower, industry and power plants (abstraction and discharge), municipal water management (handling wastewater and rainwater), agriculture, drinking water supply, flood protection, leisure , nature and mining

Table 1: Some characteristics of the International River Basin District Rhine

Further information on the boundaries of the IRBD, major tributaries and other features are found in the maps K1 (topography and soil cover according to Corine Land Cover), K2 (areas of operation with a water network > 2,500 km²) and K 3 (Situation and boundary of water bodies)⁹.

The area of the IRBD Rhine takes into account the previous Rhine catchment (188,715 km²), the Wadden Sea and the coastal waters within one nautical mile (3,034 km²), so that a total area of 191,749 km¹⁰ is assumed. For the chemical status survey only, territorial waters up to twelve nautical miles are additionally included (1-12 nautical mile zone: 5,534 km²), bringing the total area to 197,283 km².

⁹ For the Netherlands, the Prinses-Margriet-Canal has been included in the maps, but it is only assessed on Level B.

¹⁰ According to the EU WFD and confirmed in the EU working group meeting DIS (Data and Information sharing) in Brussels on 6 and 7 November 2019.

Half of the surface of the Rhine catchment area is used for agricultural purposes; about one third is forest area; approximately 10 % are built-up areas and some 3 % are covered by water (see Table 2). Lake Constance, Lake IJssel, smaller stagnant waters, the Rhine and its tributaries (but neither the Wadden Sea, nor the coastal waters) belong to these water bodies.

The Rhine is one of the most intensively used watercourses of the earth. In the past and with a view to reducing the associated pollution, extensive measures entailing extensive investment were introduced. Further efforts are still required.

		IRBD Rhine	IT	СН	LI	AT	DE	FR	LU	BE	NL
Surface	km²	197,283* 191,749** 188.715***	2	27.835	160	2.386	105.751	23.831	2.527	771	34,020* 28,486** 25 <i>,</i> 452***
Share in the total surface of the international river basin district Rhine	%		<1	14* 15**/***	<1	1	54* 55** 56***	12*/** 13***	1	<1	17* 15** 14***
Built-up area and settlement	km²	20,692	0	2,110	21	200	12,389	2,123	245	40	3,563
Open space	km²	3,777	2	2,940	10	265	296	63	4	1	195
Farmland	km²	46,129	0	5,257	22	38	29,791	6,944	439	41	3,596
Permanent crop	km²	3,007	0	46	34	<1	2,480	371	17	<1	58
Pasture land	km²	47,400	<1	7,915	29	896	19,376	4,987	883	398	12,915
Wood/forest	km²	62,246	<1	8,549	42	902	40,420	9,078	929	289	2,036
Wetlands	km²	572	0	44	2	22	59	21	<1	2	421
Water surfaces	km²	4,893	0	973	0	62	939	244	9	0	2,666
Inhabitants 2016		60.6 million	0	6.6 million	38,000	370,000	36.6 million	3.9 million	591,000	43,000	12.5 million
Share in the total number of inhabitants in the IRBD Rhine	%		0	11	<1	1	60	6	1	<1	21

Table 2: Major characteristic data of the IRBD Rhine (states) - rounded. Land use data according to Corine Land Cover 2018 and number of inhabitants in 2016 according to indications made by the delegations

Legend

IT Italy

- CH Switzerland LI Liechtenstein
- AT Austria
- Al Austria
- DE Germany

 \ast Including Wadden Sea and coastal waters until the 12 miles zone (8,568 km²)

** Including Wadden Sea and coastal waters until the 1 mile zone $(3,034 \text{ km}^2)$

*** Rhine catchment (without Wadden Sea and coastal waters)

All indications concerning surface uses without Wadden Sea and coastal waters (= Rhine catchment)

FR France

LU Luxembourg

BE Belgium

NL Netherlands

In order to improve water quality, so far (state 2016) 96 % of the about 60 million people living in the Rhine river basin district have been connected to a wastewater treatment plant. Many big industrial plants or chemical parks (a considerable part of the worldwide chemical production is located in the Rhine catchment area) have their own wastewater treatment plants which are, at the very least, state-of-the-art facilities. As a result of considerable investments into the construction of wastewater treatment plants in all states, point sources now contribute less often to classical pollutant contamination than in the past. The pollutant and nutrient contamination currently being observed is largely of diffuse origin. Agriculture, industry and municipalities have already made efforts to reduce these point and diffuse discharges. In addition, the "Rhine 2040" programme stipulates an overall reduction of micropollutant inputs by 30 %. The exact implementation of this reduction is currently being worked out.

The marked mining activities in the Rhine catchment area, particularly in the Moselle-Saar area, in the Ruhr area (until 2018) and the open-cast lignite mining areas along the left bank of the German Lower Rhine are equally relevant. While mining has declined sharply and will continue to decline with the phase-out of fossil fuels - for example, Germany intends to phase out coal-fired power generation by 2038 at the latest, ideally earlier, - the impacts are still visible in the data in many places, particularly in relation to the groundwater.

The climate is changing in Europe. Temperatures are expected to rise, the winters are expected to become more humid, while summers will presumably be drier. Regionally, the amount of precipitation falling in a short time may be greater than today. Among other things, for the Rhine this means that runoff levels and water temperature may change¹¹. Climate change impacts water balance, water ecology, flood protection, drinking water production, navigation, industrial activities, and agriculture. In the long run it is expected that the increase in temperature will lead to rising sea levels. In the Netherlands this among others leads to salt from sea water penetrating into the inland and threatening the freshwater supply for different uses such as drinking water, nature, agriculture and industry. This threat will increase during low flow of Rhine more often and for longer periods of time which may also be caused by climate change.

In 2015, the ICPR published its first climate adaptation strategy¹² to be updated by 2025. Since 2016, the ICPR has also been devoting more attention to the problem of low water and, one year after the 2018¹³ low water event, introduced an international monitoring system for low water¹⁴, which, according to "Rhine 2040", is to be further expanded in the coming years to support the development of interdisciplinary approaches to solutions.

Due to requirements concerning the quality of the marine environment, in particular that of coastal waters into which the Rhine flows, Rhine water quality is of particular importance.

Furthermore, the Rhine is the source for drinking water for some 30 million people. For drinking water purposes, several large water treatment plants abstract raw water directly (Lake Constance) or via riverbank filtration, or they abstract Rhine water filtered through the dunes.

The Rhine and a number of its tributaries contain sediments some of which are considerably contaminated by industrial and mining activities in the past. As a result, during strong flooding or dredging activities, for navigation purposes for instance, re-mobilised sediments may cause temporary pollution. The ICPR Sediment Management Plan adopted in 2009 treats this issue more in detail¹⁵.

¹¹ <u>ICPR technical report no. 188</u> (2011); <u>ICPR technical report no. 213</u> (2014); <u>ICPR technical report no. 214</u> (2014)

¹² <u>ICPR technical report no. 219</u> (2015)

¹³ <u>ICPR technical report no. 263</u> (2020)

¹⁴ ICPR technical report no. 261 (2019) and

https://www.iksr.org/de/themen/niedrigwasser/niedrigwassermonitoring

¹⁵ <u>ICPR technical report no. 175</u> (2009)

Hydro-morphological modifications for navigation purposes and the use of hydropower, flood protection, soil improvement from the perspective of that time for agricultural purposes (melioration) and land reclamations have resulted in a distinct decrease of the natural habitat of the Rhine and its tributaries, so that many ecological functions of this lifeline have been restricted. With the programme "Salmon 2020", the Lake Constance Lake Trout Programme, the "Biotope Network on the Rhine", and in particular the Master Plan Migratory Fish Rhine¹⁶ adopted in 2009 and updated in 2018, as well as the national eel management plans, the various national floodplain and migratory fish programmes in the Rhine catchment, important approaches to an improvement of the water ecology in the water system are already available, which are further substantiated by the stipulations of the programme "Rhine 2040", among others on fish passability.

For further details and information on the IRBD Rhine please consult the first inventory of 2005¹⁷.

¹⁶ ICPR technical report no. 247 (2018)

¹⁷ Inventory

1.2 Delimitation of water bodies

1.2.1 Surface water bodies in the IRBD Rhine

According to the WFD, water bodies represent the smallest unit for management planning. They either correspond to uniform and major sections of surface waters, e.g. part of a river or to delimited groundwater bodies (WFD, Article 2, no. 10 and 12). For water bodies, among others state and environmental targets are to be described.

The criteria to apply to the delimitation of water bodies are determined in WFD Annex II. In the first inventory of 2005 Chapter 2.1.1 described the approach in detail for surface water bodies, Chapter 2.2.1 gives a detailed description for groundwater bodies.

Map K 3 represents the location and boundaries of the surface waters in the network of water bodies relevant for the overriding part A (basic network of water bodies). Apart from the main stream of the Rhine it also includes the tributaries with catchments larger than 2,500 km², lakes with a surface area of more than 100 km² and, as artificial waters, the most important navigation lanes (canals).

The establishment of a water body typology reflecting the different "settlement patterns" and natural conditions of waters is an important basis for the evaluation of the ecological status of waters mainly depending on biological components. Furthermore, the distinction between types of water bodies is an essential prerequisite for delimiting water bodies as partial element of an IRBD.

The Rhine catchment area spreads over five of the System A ecological regions listed in Annex XI WFD:

- Eco-region 4 (Alps, altitude > 800 m),
- Eco-regions 8 and 9 (western and central high hills, altitude 200 800 m) and
- Eco-regions 13 and 14 (western and central lowlands, altitude < 200 m).

All states in the IRBD Rhine have chosen System B according to WFD (see Annex II, No. 1.1 WFD) to describe the types of surface water bodies.

The typology of the main stream of the Rhine is extensively presented in a separate report which also includes the fact files of the different types of river sections¹⁸.

The types of water bodies in the IRBD Rhine are presented in Map K 4 (surface waters: types of water bodies). A harmonised representation of the national types of water bodies applicable to the IRBD Rhine is found in Chapter 2.1.1 of the inventory of 2005. The national water body types as well as possible adaptations of these types made in the meantime are described in the national management plans, to which reference is made here.

The type-specific reference conditions developed at a national level for the different types of water bodies are to be taken as reference conditions. Please refer to the national management plans.

According to the WFD, a water body may be classified as natural, heavily modified or artificial. The approach has been thoroughly described in chapter 4 of the inventory of 2005. This differentiation is important for the environmental targets to achieve for a water body. The classification was verified when drafting the River Basin Management Plan 2022-2027 IRBD Rhine.

For the sub-basins > 2,500 km², the result of this classification is presented in map K 6 (categories of water bodies - natural, artificial and heavily modified surface water bodies).

The training of the Rhine and of some of its major tributaries during the last centuries for the purposes of navigation, flood protection and use of hydro power have resulted in major morphological changes of the water bodies.

¹⁸ <u>ICPR technical report no. 147</u> (2005)

Of the 230 surface water bodies in the basic network of the IRBD Rhine (network of water bodies, catchment area > 2,500 km²), 36 % have been classified as natural, almost half as heavily modified and 14 % as artificial (Figure 1, left). If only the 28 water bodies of the main stream of the Rhine¹⁹ are considered, 93 % of them have been classified as "heavily modified"; the 7 % of natural water bodies are located on the High Rhine and correspond to the coastal waters (Figure 1, right; also, see Map K 6).



Figure 1: Categories of all surface water bodies in the baseline water network of the IRBD Rhine (catchment area > 2,500 km², left) and of water bodies in the main stream of the Rhine (right) based on the number of surface water bodies. State: March 2022; data without Switzerland²⁰, see text of Figure 12

1.2.2 Groundwater bodies in the IRBD Rhine

Groundwater protection is a major component of the WFD. In the Rhine catchment area, groundwater is important for nature conservation areas, among other things, and serves as a resource for drinking water production, which must be protected from pollution and overexploitation. Groundwater is delineated in the form of groundwater bodies; their delineation may differ from that of surface water bodies.

Map K 5 represents the location and delimitations of the groundwater bodies in the IRBD Rhine including the coordinated groundwater bodies (hatched) along the state frontiers.

Regarding the delimitation of the groundwater bodies, please refer to Chapter 2.2.1 of the survey of 2005 and to national adaptations since then (see parts B).

¹⁹ The data on the main stream of the Rhine cover the main stream from the Alpine Rhine at the border between Vorarlberg and Switzerland to the North Sea, including the three estuaries Waal, Nederrijn/Lek and IJssel, not including Lake Constance

²⁰ As a non-EU state, Switzerland neither delimitates water bodies nor carries out an evaluation according to the criteria of the water framework directive. In the context of an international data exchange, Switzerland reports "reporting units" to the European Environment Agency (EEA) (see maps). Swiss data was not included in the statistical analysis (see figures 1, 12, 14, 15, 16, 17, 18, 19).

2. Human activities and stresses

2.1 Hydromorphological changes

Numerous hydraulic measures have resulted in vast hydro-morphological modifications which have greatly impacted the ecological function of the Rhine. These effects include, among others, the almost complete restriction of river dynamics, the loss of alluvial areas, the impoverishment of biological diversity, and obstacles to fish migration.

Predominantly, the following descriptions refer to the main stream of the Rhine, but many statements also apply to other (lateral) water bodies within the IRBD Rhine.

2.1.1 Morphological changes

Straightening and bank stabilisation shortened the course of the river, which led to an increase in gradient as well as a lowering of the riverbed and of the alluvial groundwater, which is very pronounced in some places; over long stretches dyke construction cut off the floodplains from the river dynamics. As a result, structural diversity and important structural elements that are necessary for biodiversity and intact biotic communities have today become much rarer.

2.1.2 Changes in runoff and runoff dynamics

Eight hundred km of the Rhine between Rotterdam and Basel are navigable. From Iffezheim on the Upper Rhine to the North Sea estuary, the Rhine flows freely through the Waal, an arm of the Rhine and without obstacles. Further connections between the delta system of the Rhine and the North Sea such as the closure embankment of Lake IJssel and the sluices of the Haringvliet are, partly and occasionally, passable.

Extensive river engineering work was carried out in the 19th and 20th centuries to meet the needs of navigation, including water depth and stability of the navigation channel, hydropower generation and flood protection. The main stream of the Rhine is regulated and numerous hydraulic structures, for example a comprehensive system of dikes, groynes, barrages, locks and fixed sleepers have been built.

2.1.3 Impairments to the continuity

Between Lake Constance and Iffezheim, there are 21 impoundments for hydro power generation in the main stream or in bypass rivers. For many species, in particular fish species, and sediments several of these impoundments are not passable or only to a certain extent. In the upper reaches of the Rhine, in the Alps and their foothills, there are numerous reservoirs and barrages serving power generation; during power consumption peaks, the hydropower plants often regulate the water supply according to the need for power supply in "hydropeaking operation". That means that flora and fauna are not only impacted by morphological changes, backwater and interference with river continuity but also by the surge effects of hydropeaking operation.

There are more than 100 barrages, often combined with hydropower plants and shipping, with barrage locks in the Neckar, Main, Lahn and Moselle tributaries. Additionally, there are several important navigation channels in the Rhine river basin district connecting several river districts, e.g. the Main-Danube-Canal. For these artificial water bodies, the (good) ecological potential is to be achieved.

2.1.4 Water intakes

Surface water bodies

Water intakes for purposes of process water, drinking water or energy production may interfere with water bodies.

In the baseline water network of the IRBD Rhine, only in Luxembourg and Hesse (Germany), there are withdrawals of surface water classified as significant pressures in the sense of the WFD. In addition, major intakes for drinking water supply are located along Lake Constance and in the Rhine delta.

Groundwater intakes

Abstraction of groundwater for public drinking water supply is an important factor in large areas of the of the IRBD Rhine. Additionally, groundwater is used in mining, industry, trade and for irrigation purposes in agriculture.

In spite of numerous quantitative stresses, the quantitative state of groundwater in the Rhine catchment is largely good. Lowering of the groundwater level in the Rhenish lignite mining area is an exception. Intensive accompanying monitoring and locally effective measures (e.g. infiltration) prevent harmful impacts on groundwater-dependent terrestrial ecosystems.

2.1.5 Effects of hydromorphological changes on the status of water bodies

The hydromorphological changes considerably impact the ecological function of the Rhine:

- the straightening and embankment of the river in large sections and its subsequent canalisation have led to a significant shortening of the course, an increase in gradient and flow velocity, a considerable reduction in floodplains, the severance of oxbow lakes and floodplain forests, the unification of the riverbed and banks, the disappearance of habitats of fish and other aquatic organisms, the erosion of the riverbed and groundwater level, the reduction of groundwater level fluctuations, reduced groundwater/river exchange and the loss of the purifying filter that forests and meadows represent;
- the "tamed" riverbanks are used for industry and port activities, material extraction (gravel pits), urban development and for more intensive agriculture and forestry: as a result, the original alluvial areas have largely disappeared;
- the high number of barrages considerably restricts the ecological continuity of the Rhine system (cf. Maps K 7 and K 8, see below):
 - Only few of them are surmountable during upstream migration, since there are no upstream fish passages or those existing are not functioning sufficiently;
 - downstream, they are only passable for fish to a limited extent due to the lack of fish ladders. Particularly at obstacles with turbines, there is a risk of injury or even death to the migrating fish;
 - Migration obstacles of any kind mean an increased risk of predation and delay for the fish (as they stay longer at the foot of the obstacle) and represent a risk of disorientation after weir overtopping, as well as a risk of injury when hitting disturbance bodies in the stilling basin;
 - hydropower plants connected in series have a cumulative effect on migratory fish populations during upstream migration (fatigue, repeated failures, loss of time, predation). This is especially true for long-distance migratory fish such as salmon (anadromous) and eel (catadromous). For a species like the salmon this cumulative effect may be limiting, if all juvenile salmon of a sub-basin must pass by several hydro power plants during their downstream migration. For eel, injury or mortality occurs even when fishways are in place and/or mortality is considered low at each individual site.
- the solids transport system is severely impaired, what sometimes implies the almost complete loss of river dynamics, exacerbating the low morphological and biological diversity of the watercourses.

- each impoundment slows down the flow velocity and thus leads to unnatural sediment deposits in the impounded areas, promotes eutrophication, changes the species composition as well as their population size to a considerable extent and also increases the water temperature in summer; these influences also have a negative impact downstream;
- power generation specifically geared to demand through hydropeaking (peak power generation) has more or less harmful consequences, depending on the intensity (e.g. the repeated drying out and subsequent death of fish spawn, fry and fish feeders).

In the past, hydromorphological changes have led to an ecological impoverishment of habitats along the Rhine. More than 90 % of the floodplains have been lost, more than 80 % of the riparian forests and wetlands have disappeared and the function of the remaining natural habitats has changed profoundly.

Overview "Transverse structures"

The maps K 7 (Great transverse structures: Upstream fish migration and K 8 (Great transverse structures: Downstream fish migration) give an overview over great transverse structures in the network of water bodies in the international Rhine river basin district with sub-basins > 2,500 km². The additional programme waters for migratory fish with smaller sub-basins, as e.g. shown on the maps accompanying the "Master Plan Migratory Fish Rhine"²¹ are not included here. Due to the short distances between the transverse structures on the Upper Rhine between Basel and Strasbourg, the representation of the river section concerned is magnified in the map.

Map K 7 presents the passability of transverse structures for upstream migrating fish such as salmon or, in the Alpine Rhine for the Lake Constance lake trout, map K 8 presents downstream passability of transverse structures for downstream migrating fish, e.g. eel. Based on their knowledge and existing expert reports, national fish experts have assessed fish passability of the constructions. The assessment of passability of transverse structures in transboundary waters has been coordinated bilaterally.

For reasons of clarity in the scale of the river district, the representation has in Map K 7 been limited to transverse structures with a height of fall ≥ 2 m. But for most upstream moving fish species transverse structures with a lower height of fall also often present a migration obstacle. For downstream migrating fish, low transverse structures with hydropower plants, in particular, can be problematic. Therefore, in the interactive versions²² of Map K 7 and Map K 8, transverse structures with a height of fall of > 1 m and > 1 m with hydropower plants respectively have, therefore, additionally and optionally been depicted.

For transverse structures with hydropower generation, it must be taken into account that lead to a the mortality rate is evaluated as low (< 10 %) despite the generally expected damage to fish in the turbines, if only a small share of the discharge is used during phases of downstream migration.

²¹ ICPR technical report no. 247 (2018)

²² K7: <u>https://geoportal.bafg.de/karten/iksr_k7web/</u>

K8: <u>https://geoportal.bafg.de/karten/iksr_k8web/</u>

2.2 Chemical pollution from diffuse and point inputs

Chemical substances play an important role when evaluating the status of surface and groundwater bodies. The chemical load is due to various diffuse and point inputs, for which a scheme has been drawn up at EU level, which can be seen in Figure 2.



Emission path	Input pathway
no.	
P1	Atmospheric deposition, directly into surface water bodies
P2	Erosion
P3	Surface runoff from non-sealed surfaces
P4	Intermediate runoff, drainage runoff and groundwater
P5	Direct inputs and drift of agricultural origin
P6	Surface runoff from sealed surfaces
P7	Storm overflow, combined sewage inflow and wastewater pipelines not
	connected to a network
P8	Treated municipal wastewater
P9	Treated and untreated discharges from households
P10	Treated industrial wastewater
P11	Direct discharges from abandoned mines
P12	Direct discharges from navigation
P13	Natural background contamination

Figure 2: Scheme of input pathways into surface waters²³

²³ see Common Implementation Strategy for the Water Framework Directive (2000/60/EC), 2012, Technical Guidance on the Preparation of an Inventory of Emissions, Discharges and Losses of Priority and Priority Hazardous Substances, <u>Guidance Document No. 28</u>

2.2.1 General remarks

Point sources

In the international river basin district Rhine the wastewater from households and plants connected to the public sewage system, the so-called indirect industrial discharges are treated in approx. 5,000 wastewater treatment plants. This means that the majority of the population (96 %, see Chapter 6.1) is connected to a wastewater treatment plant.

Between 2010 and 2016, the treatment capacity of the municipal wastewater treatment plants in the IRBD Rhine was expanded from a total of just over 100 million population equivalents (p.e.) to about 106 million p.e..

Almost 200 of the municipal wastewater treatment plants have a capacity > 100,000 p.e.. Thus, they represent only about 4 % of the total of about 5,000 municipal wastewater treatment plants in the IRBD Rhine, which, however, corresponds to half of the total treatment capacity.

More than 3,400 of the municipal wastewater treatment plants in the IRBD Rhine, i.e. more than two thirds, have a design size \leq 10,000 p.e. and cover about 7 % of the total treatment capacity.

Figure 3 and Table 3 show a further differentiation between the different sizes of wastewater treatment plants.







²⁴ 3 WWTP without any indication of the design capacity were not taken into account

²⁵ ICPR technical report no. 278

Table 3:	Number and	design cap	acity (rou	unded) of	municipal	wastewater	treatment	plants
(WWTPs)	according to	size classe	s in Part	A and Pa	rt B waters	of the IRBD	Rhine* in	201626

Design capacity of	Waters pa	nrt A	Waters p	oart B	Share	Share
wastewater treatment plants In p.e.	Number of WWTP	Capacity in million inhabita nts	Numbe r of WWTP	Capacity in million inhabita nts	number of WWTP in % in the IRBD Rhine	design capacit y p.e. in % in the IRBD Rhine
> 500,000	11	10.6	8	8.7	0.4	18.2
> 250,000 - 500,000	26	9.0	12	4.3	0.8	12.5
> 150,000 - 250,000	28	5.7	37	7.1	1.3	12
> 100,000 - 150,000	29	3.5	40	5.1	1.4	8.2
> 50,000 - 100,000	90	6.8	161	11.6	5.1	17.3
> 10,000 - 50,000	307	7.8	752	18.3	21.3	24.6
> 2,000 - 10,000	333	1.7	889	4.7	24.6	6
≤ 2,000	376	0.3	1,867	1.1	45.2	1.4
Sum	1,200	45.4	3,766	60.9	100	100

* Part A with water bodies > 2,500 km² (Map 1), Part B: all other water bodies, not included: Water bodies without indication of water body section (68 KA)

Table 3shows that the treatment plants with a larger capacity are evenly distributed over Part A waters (sub-basin size > 2,500 km²) and Part B waters (all other waters). Most wastewater treatment plants with a smaller treatment capacity above all discharge into the smaller part B water bodies.

The EU Urban Wastewater Directive²⁷ stipulates that operators of wastewater treatment plants with more than 2,000 p.e. inland and more than 10,000 p.e. on the coast are generally obliged to treat wastewater with biological processes (= 2nd treatment stage, including partial nitrogen removal through nitrification). More extensive purification (= 3rd purification stage, i.e. the targeted elimination of phosphorus and/or nitrogen) is required for water bodies at risk of eutrophication ("sensitive areas" to be designated by the Member States). Member States have designated or consider waters in their part of the Rhine river basin as sensitive areas.

In addition to almost 100 % mechanical and biological treatment, targeted nitrogen and phosphorus reduction is also present in about 50 % of municipal wastewater treatment plants. More extensive treatment for the elimination of micropollutants, which is not required by the Urban Wastewater Directive, is installed (as of 2016 data) at a total of 26 municipal wastewater treatment plants, mainly in Switzerland and in the German federal states of Baden-Württemberg and North Rhine-Westphalia.

The load discharged by the wastewater treatment plants is of various origin. Sources are not only wastewater from households (including human excreta, consumer products) and indirect industrial discharges. They also include corrosion from construction material, atmospheric deposition and traffic which correspond to pollution discharged into wastewater treatment plants through combined sewer networks during rainfall.

For industrial discharges, the EU Industrial Emissions Directive (IE Directive)²⁸ applies, which contains regulations on the authorisation, operation, monitoring and decommissioning of particularly environmentally relevant industrial installations in the European Union.

²⁶ <u>ICPR technical report no. 278</u>

²⁷ Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment

²⁸ Directive 2010/75/EEC of 24 November 2010 concerning industrial emissions (Industrial Emissions Directive (IED))

The regular analysis of waters confirms that, during the past decades improvement of the water quality has been very successful. The nutrient and pollutant load has been considerably reduced. Among others, this success is due to the consequent state of the art improvement of industrial and urban wastewater treatment.

Diffuse inputs

In addition to point sources, diffuse inputs also significantly contribute to the pollution of surface waters and groundwater. Efficient reduction measures presuppose a consideration of input pathways (emission control)

The framework for reduction measures concerning the pollution of waters of agricultural origin is given by the following European regulations:

The Nitrates Directive (91/676/EEC) sets European standards for the reduction of nitrate discharges of agricultural origin. In some cases, the implementation in the states had to be adjusted in the last few years. Measures have been tightened and methods improved to achieve a more balanced fertiliser balance. These improvements, that partly also concern the discharge of phosphorus, are expected to contribute to reducing the nutrient load in the Rhine catchment.

In the past decades, improvements have already been achieved with regard to nitrate and phosphorus through the execution of partly new or revised national action programmes. However, significant pressures continue to be observed.

In the meantime, the Plant Protection Products Directive (Directive 91/414/EEC) repealed by the EC Regulation no. 1107/2009 concerning the placing of plant protection products on the market, the Directive establishing a framework for Community action to achieve the sustainable use of pesticides (Directive 2009/128/EU) and national regulations and recommendations on the proper use of plant protection products, for example the targeted implementation of measures on a cooperative basis in water protection areas have contributed to achieve improvements with respect to the discharge of plant protection products. Furthermore, based on the Directive 2009/128/EC, national action plans targeted at reducing the risks due to the application of plant protection products have been and continue to be implemented. However, plant protection products are still being recorded in the basic network of water bodies. In particular, during certain periods of the year and following heavy rainfall, pollution originating from these products is regularly determined in smaller water bodies.

The Rhine figures among the most important shipping lanes of the world and is the most important shipping lane in Europe. With a view to limiting emissions from navigation, the Convention on the Collection, Discharge and Reception of Waste arising from Rhine and Inland Navigation (CDNI) entered into force on 1st November 2009. This convention regulates the handling of oily and greasy ship waste (part A), cargo waste (part B) and other ship waste, such as wastewater and household waste of passenger and hotel ships (part C).

Since 2012 it is forbidden to discharge domestic wastewater from hotel and passenger ships for more than 50 persons into surface water bodies. Ships may only discharge treated wastewater or must securely dispose of untreated wastewater at the pier. Numerous countries have established collecting points since 2012. In June 2021, the conference of the CDNI contracting parties has decided to extend this ban to ships for 12 to 50 passengers. This ban enters into force as from 1 January 2025.

For recreational boating with a capacity of less than 50 persons in inland waters, there has also been a ban on disposing of toilet water in surface waters in the Netherlands since 2009. To facilitate the implementation, 350 collection sites have since been implemented in the Netherlands.

2.2.2 Relevant discharges into surface water bodies

Relevant discharges to surface waters can be divided into different substance groups:

- chemical-physical parameters, for example nutrients such as nitrogen and phosphorus;
- catchment-specific substances: within the ICPR, 15 Rhine-relevant substances were internationally agreed upon and Rhine environmental quality standards (EQS) were defined (see Annexes 2 and 3). If the EQS Rhine has not been adopted into national legislation, national assessment standards are applied. In addition, the states in the Rhine catchment have defined river basin-specific substances at national level, which are used for the ecological status assessment. These river basin-specific substances can vary from state to state and are not considered in detail here. For more information, please refer to the national management plans;
- priority (hazardous) substances of Directive 2008/105/EC, as amended by the Directive 2013/39/EU (see Annex 4 and 5). The priority (hazardous) substances are the basis of the chemical status assessment.

The list of 15 Rhine-relevant substances is to be reviewed in the coming planning period. Among other things, the list of Rhine substances, which is updated every 3 years, can form the basis for this.²⁹ The list of Rhine substances includes substances that have shown conspicuously high concentrations in tests and therefore have to be measured further on a regular basis. The substances are reviewed for relevance every 3 years.

At present, the data basis, which is the basis for the elaboration of the list of Rhine substances³⁰, is in parts different from the one provided for the management plan.

Nutrients

Excessive concentrations of nitrogen or phosphorous are problematic for the ecological state of inland waters. In addition to this, increased nitrogen loads have polluted the marine environment, in particular that of the Wadden Sea. This phenomenon is generally known as eutrophication. For the physical-chemical components national orientation values have been determined which are supposed to support the biological classification within the framework of the ecological state.

Compared to national guidance values, <u>phosphorous</u> concentrations show higher values at certain monitoring sites of the network of water bodies part A, as in many smaller waters in the catchment.

As far as eutrophication processes are concerned, <u>nitrogen</u> is not a limiting factor for inland waters on a local scale but it does play an important part at Level A, as it may be a source of coastal water pollution, in particular of the Wadden Sea.

The coastal water bodies off the Rhine estuary are particularly sensitive and, considering their species diversity, particularly deserving of protection.

Efforts going on since 1985 to reduce nitrogen in all the states of the international Rhine river basin district have already resulted in a reduction of nitrogen concentrations in the coastal waters. However, they are still above the Dutch guidance value of 0.46 mg DIN/I at a salinity of 30 (DIN = Dissolved Inorganic Nitrogen). Even though the total classification of the quality component phytoplankton along the Dutch coast is generally considered to be good to very good, the status in the Wadden Sea and its coast varies between poor, moderate and (very) good. In order to achieve a stable good status and to be able to continue to permanently comply with the value of 2.8 mg TN/I (= total nitrogen) agreed in the ICPR at least at the limnetic to marine boundary, the causes of pollution must be

²⁹ <u>ICPR technical reports no. 215 (2014)</u> and <u>no. 242 (2017)</u>

³⁰ http://iksr.bafg.de/iksr/auswahl.asp?S=0

monitored further and the measures initiated to reduce nitrogen in all states of the IRBD Rhine must be continued unabated.

Substances relevant for the Rhine

According to the current survey (cf. Chapter 4), of the 15 substances relevant to the Rhine, ammonium, arsenic, copper, zinc, dichlorvos and PCBs are a problem at several monitoring sites in Annex 2. For chromium (water phase), bentazone, chlorotoluron, dichlorprop, dimethoate, MCPA and mecoprop, the EQS Rhine/guidance values are currently undercut. For 4-Chloroaniline and dibutyltin-cation, the EQS-Rhine/orientation values are currently undercut, although only few measured values available.

Metals/Metalloids and PCBs

P5; 0% arsenic P3; 0%_P4; 0% P1 Atmospheric deposition, directly into surface P6; 0% P2;0% water bodies P7; 1%_ P9; 0% P1:1% P10; 1% P2 Erosion P11; 0% P12:4% = P3 Surface runoff from unsealed surfaces P4 Intermediate runoff, drainage runoff and groundwater P5 Direct discharges and drift of agricultural oriain P6 Surface runoff from sealed surfaces P7 Storm water overflow, combined mixed water inflows and sewer conducts not connected to the sewerage network • P8 Treated urban wastewater P9 Treated and untreated discharges from households P10 Treated industrial wastewater P13; 89% P11 Direct discharges from mining P12 Direct discharges from navigation

The main source of arsenic is natural background pollution (see Figure 4).

Figure 4: Distribution of arsenic discharges 2016 across the input pathways (total discharge 79 t)³¹.

There are several significant sources for copper. However, storm overflow, combined sewage inflow and wasterwater pipelines not connected to a network were the main sources in 2016, as already in 2010 (see Figure 5).

³¹ ICPR technical report no. 278



Figure 5: Distribution of copper discharges 2016 across the input pathways (total discharge 296 t)³².

The main sources of zinc are storm overflow, combined sewage inflow and wasterwater pipelines not connected to a network as well as treated municipal wastewater (see Figure 6).



Figure 6: Distribution of zinc discharges 2016 across the input pathways (total discharge 1,448 t)³¹.

³² ICPR technical report no. 278

t/a	1985 sum	1992*	1996*	2000*	2010 sum	2016 sum
		sum	sum	sum		
Total N	-	212,701	170,669	129,973	78,742	69,540
Total-P	50,938	21,918	15,981	12,143	-	5,722
Hg	2.8	1.5	0.9	0.7	0.2	0.2
Cd	21.8	4.1	1.8	1.7	0.8	0.7
Cr	651	106	63	46	18.9	16
Cu	469	150	114	105	89.7	65.5
Ni	394	102	62	63	69.4	39.8
Zn	2,199	811	650	465	419.4	338.6
Pb	303	90	65	43	11	6.2
As	-	21	17	11	5	3.9

Table 4: Overview of inputs of nutrients, metals, and arsenic from point sources (P8 and P10) from 1985 to 2016 (rounded).

- = not recorded

 \ast In 1992, 1996 and 2000, all entries were indicated with a "<" because all entries from Switzerland were made with "<".

Table 4 shows that emissions of priority and Rhine-relevant metals and arsenic from point sources have been significantly reduced since 1985, this is also true for the period 2000-2016 although the considered input area is larger than in the years until 2000.³³ The emissions of the substances lead (Pb), cadmium (Cd) and mercury (Hg) have been distinctly reduced in wastewater treatment plants as well as in industrial emissions (see also Figure 7).



Figure 7: Metal and arsenic emissions from municipal wastewater treatment plants and industry from 1985 to 2016 (indexed to 1985, As* indexed to 1992). * In 1992, 1996 and 2000, all entries were indicated with a "<" because all entries from Switzerland were made with "<".

Formerly, PCBs were used as softening agents in plastic materials, in transformers and as a compound of hydraulic fluids, for example in mining. They are persistent and accumulate in the food chain as well as in sediments. PCBs, which are widespread in the environment, today, stem primarily from past application processes and are redistributed between the various environmental compartments, again and again, due to remobilizing processes. No new direct discharges of PCBs are known.

³³ Contrary to 2010 and 2016 emissions from AT, LI, BE, and LU, as well as areas of the Wadden Sea, tidal flats, and coastal waters, were not recorded until 2000.

Ammonium-N

Ammonium nitrogen can be taken up as a nutrient by algae and higher plants. As a rule, the eutrophic effect does not play a decisive role in flowing waters. In contrast, ammonium in the form of ammonia is of considerable importance for the aquatic biocoenosis due to its toxic effect on aquatic organisms of all biological quality elements, especially on fish and fish feeding animals (benthic invertebrate fauna).

Ammonium-N exceeds the Rhine EQS/guidance value at some monitoring sites in the tributaries.

The pollution with ammonium-N at the monitoring station at the mouth of R. Emscher is due to the particular water conditions of R. Emscher draining an urban area. Mitigation measures are planned or implemented (including modern sewer infrastructure to relieve the river of wastewater and modernization of municipal wastewater treatment plants). The Emscher conversion is expected to be completed in 2022.

Plant protection products

Chlortoluron is the only plant protection product not regulated by the WFD that also remained on the 2014 and 2017 Rhine substance lists. In 2017, its concentration remained below the Rhine EQS at all monitoring sites.

The Rhine EQS for dichlorvos has been derived to $0.0006 \mu g/l$ which means that already low discharge quantities of agricultural origin may lead to values in excess of this standard. This was also the case in the area of the Delta Rhine and the coastal waters. Dichlorvos has been a priority substance since 2013. Therefore, it will be discussed again in the next section.

Priority substances and certain other pollutants of the Directive 2008/105/EC in the version of the Directive 2013/39/EU

Annex 4 gives a total overview over the substances und environmental quality standards (EQS) according to the Directive 2008/105/EC and above the adapted EQS for some of the substances concerned by the Directive 2013/39/EU.

Of the 45 priority substances or groups of substances and certain other pollutants or groups of pollutants in Directive 2008/105/EC as amended by Directive 2013/39/EU, some substances had exceeded the EQS in the IRBD Rhine or do still exceed them and have therefore been included in the 2014 and 2017 Rhine substance lists³⁴ (see Chapter 4.1.2 and Annex 5):

- brominated diphenyl ethers (PBDE)
- lead
- cadmium
- dioxines and dioxin-like compounds
- heptachlor/heptachlor epoxide
- hexachlorobenzene (HCB)
- hexachlorbutadiene
- isoproturon
- nickel
- PFOS (from the group of PFAS)
- polycyclic aromatic hydrocarbons (PAH), in particular benzo(a)pyrene
- mercury
- tributyltin

Since lead, cadmium, and isoproturon do not have exceedances of the EQS in the ICPR baseline water network (see Appendix 5) - as they did in the data analysis for the 2015-2021 International River Basin Management Plan - they are no longer considered in detail

³⁴ <u>ICPR technical reports no. 215</u> (2014) and <u>no. 242 (2017)</u>

here. The remaining on the Rhine substance list can be explained by the updating of the data series, partly local relevance and by exceedances in total contents. In addition, the data are used in individual cases to monitor success/check compliance with phase-out deadlines (e.g. isoproturon is no longer listed on the 2021-23 Rhine substance list, but remains in the mandatory measurement programme³⁵).

Other substances that are not on the 2014 and 2017 Rhine substance lists, but exceed the EQS (cf. Chap. 4.1.2), are:

- bifenox
- cypermethrin
- dichlorvos
- octylphenols

Cypermethrin is currently being evaluated for inclusion on the Rhine Substances List and may be included in the next revision. The other substances mentioned above are currently not on the Rhine Substances List, as their loads are locally restricted. However, some of these substances were included in the optional Rhine Measurement Program Chemistry.

The Directive 2013/39/EU characterises "persistent, bioaccumulating and toxic substances (PBT) and other substances behaving like PBT" as "ubiquitous" meaning that they can be found in the aquatic environment for decades – in amounts, that pose a significant risk, even when comprehensive measures to reduce or eliminate the emissions of such substances have been taken. The substances/groups of substances of brominated diphenylether (PBDE), mercury, polycyclic aromatic hydrocarbons (PAH), dioxins, hexabromocyclododecane, heptachlorine and tributyltin (TBT) belong to them. Some PAH-compounds, that is anthracen, fluoranthen and naphtaline have not been classified as ubiquitous substances.

With respect to the emission inventory³¹, the area considered for the priority substances extends to the 12-mile zone, in contrast to the physicochemical parameters and the Rhine-relevant substances, for which the area considered is limited to the 1-mile zone.

Development since 2015

For the WFD priority substances / substance groups with EQS exceedances listed in the 2015 management plan, the EQS for hexachlorobenzene, hexachlorobutadiene and DEHP are now undercut at the monitoring sites of the basic water network (cf. Annex 5).

Exceedances that have been added compared to 2015 mainly concern substances that have been newly added by Directive 2013/39/EU and have not been assessed so far.

Nickel, for which the environmental quality standard was exceeded at one monitoring site (Erft), is discharged by different sources in 2016, mainly by interflow, drainage runoff and groundwater, and erosion (cf. Figure 8).

³⁵ ICPR technical report no. 266 (2020)



Figure 8: Distribution of nickel discharges 2016 across the input pathways (total discharge 173 t)³⁶.

Mercury was analysed almost comprehensively within the framework of the international Rhine monitoring programme Chemistry. Concentrations exceed the environmental quality standard set for levels in biota at almost all monitoring sites. The largest input pathways for mercury are atmospheric deposition as well as stormwater overflows, combined sewer inlets and unconnected sewer pipes, treated municipal wastewater and erosion (cf. Figure 9).



Figure 9: Distribution of mercury discharges 2016 across the input pathways (total discharge 0.9 t)³⁶.

The brominated diphenyl ethers (PBDE) were investigated almost area-wide within the framework of the international Rhine monitoring programme Chemistry. Their concentrations exceed the environmental quality standard set for biota at almost all

³⁶ ICPR technical report no. 278

monitoring sites. Atmospheric deposition and treated municipal wastewater were identified as the main input pathways.

Hexachlorobenzene (HCB) can be formed as a by-product in the synthesis of chlorinated hydrocarbons and was formerly used as a plasticiser and fungicide. In contrast to the investigations for the International Management Plan 2015, no quality standards were exceeded in biota at the monitoring sites of the basic water network (cf. Annex 5).

The ubiquitous PAH are not directly bound to a local emission source. These substance inputs are above all caused by diffuse emissions from combustion plants and motors, car tyres, old ship coatings and the use of coal tar and creosote primarily as wood protection agents in hydraulic engineering. Atmospheric deposition is the main pathway of emissions. These statements partly also apply to fluoranthene, which has not been classified as ubiquitous. Besides fluoranthene, an ongoing exceedance of the EQS has been detected for some other PAH (cf. Annex 5).

Perfluorooctyl sulfonate (PFOS, as a representative and particularly critical substance from a range of several dozen perfluorinated and polyfluorinated hydrocarbon compounds [PFAS, also PFC or PFT]) was already included in the Stockholm Convention's list of banned POPs (persistent organic pollutants) in 2010. The use of this substance is, with certain exceptions, prohibited worldwide. In the EU, the use of PFOS is now only permitted as a spray suppressant for non-decorative hard chrome plating (chromium VI) in closed loop systems (Regulation on Persistent Organic Pollutants (EU) 2019/2021)³⁷. Treated municipal wastewater, but also stormwater overflows, combined sewer inlets and wastewater pipes not connected to the network, as well as treated industrial wastewater, were identified as the main input pathways (cf. Figure 2). In addition, polluted areas due to damaging events can play a role. The EQS applicable to biota was exceeded at most of the main international monitoring sites (cf. Annex 5).

Tributyltin, which was no longer included in the list of Rhine substances in 2014, but was listed again in 2017, was incidentally found at a monitoring site with an average concentration above the EQS during the period under consideration. An influence via diffuse inputs, e.g. via previous use as a biocide, can be made responsible for this. However, it should be noted that only a few measured values are available for tributyltin.

2.2.3 Relevant discharges into groundwater

The most important groundwater contamination is due in particular to nitrate, ammonium, and pesticides and their metabolites, above all from diffuse agricultural sources.

For the most part, the diffuse influxes of micropollutants (cf. figure 2) comprise extensive influxes of substances that are not precisely localisable, and which generally enter bodies of water in an arbitrary manner. Among the diffuse input pathways, drainage, leaching and surface runoff are often the most relevant for plant protection products.³⁸

In addition, there is pollution with a range of substances from diffuse sources from builtup areas, from small sewage treatment plants and diffuse pollution from mining activities.

Relevant groundwater pollution from built-up areas can be caused, for example, by the release of pollutants from buildings, leaking pipes or sewers, groundwater damage, runoff from paved surfaces, deposition, uncontrolled dumping of materials containing pollutants and from contaminated sites or old industrial sites.

In the Rhenish lignite mining area, lignite is currently extracted from three open pits (Garzweiler, Inden, Hambach). As far as possible, the overburden is tipped back into the pit or deposited in mining waste tips (e.g. Sophienhöhe). Furthermore, there are still

³⁷ <u>https://www.umweltbundesamt.de/regulierung-von-pfc-unter-reach-clp-stockholm</u>

³⁸ ICPR technical report no. 240 (2016)

some old opencast mines (Fortuna-Garsdorf, Bergheim, Frechen, Ville) with the associated waste heaps. The lignite bedrock contains varying amounts of pyrite (iron disulphide), which is exposed to atmospheric oxygen during mining and oxidises. This can, with a correspondingly high pyrite content, release significant amounts of acid, iron and sulphate. Under certain conditions, heavy metals can also be mobilized. Locally, lignite residues in the waste heaps also lead to the formation of ammonium.

Point sources can be locally significant, e.g. point pollutant inputs from contaminated sites, old sites, industrial areas, waste heaps, mining heaps and landfills. Salinisation can also play a role locally. Taken as a whole, in a groundwater body, several point sources may impact the groundwater quality.

In addition, soil is expected to be used more and more intensively for energy production (e.g. geothermal energy), energy storage (e.g. heat and cold storage), water retention and storage, and for the storage of substances (e.g. CO_2). These activities can have direct or indirect effects on groundwater quality and, in the long term, amplify the contamination process down to the deeper groundwater layers.³⁹

³⁹ Nationale analyse waterkwaliteit. Onderdeel van de Delta-aanpak Waterkwaliteit | PBL Planbureau voor de Leefomgeving

2.3 Other human activities and their impact on the status of water bodies

Further loads which may in particular play a part in the Rhine downstream of Lake Constance originate from different uses of the water bodies. These include power generation (obstacles to ecological continuity, thermal stress), flood protection (little natural design in the area of technical flood protection facilities, abrupt flooding of areas used as technical flood retention areas) and navigation (wave impact, turbulences caused by ship propellers, spreading of neozoa or pollution as a result of accidents in navigation, illegal handling of residual cargo, cleaning and ballast water).

In addition, there are the consequences

- of historical uses in the Rhine catchment leading to contaminated sediments and the risk of re-suspension and re-mobilisation due to floods or dredging (historical contamination);
- of mining (hydraulic, thermal and/or chemical pollution due to mine water or percolating water;
- thermal pollution (cooling water discharge from power plants and industry).

As an example, the areas of sediment pollution and thermal pollution may be highlighted.

Sediment pollution

The build-up of sediments is for example favoured by lower flow velocity caused by the construction of barrages. This also applies to harbours and the North Sea. Sediments may still be heavily polluted by formerly discharged substances. That means, that floods or dredging bring about a risk of re-suspension or re-mobilization.

In 2009, the ICPR adopted a Sediment Management Plan⁴⁰ which is currently being implemented⁴¹. In most of the 22 areas at risk designated by the Sediment Management Plan (SMP) there are high PCB concentrations. Thirteen areas at risk are located in the Netherlands and are all polluted by high PCB contents. In the meantime, 10 sites have been cleaned up with success. The vastest cleaning up concerned the Ketelmeer-West. Of the 18 "areas of concern" identified in the SMP, remediation was successfully completed at six sites in the Netherlands. The remaining areas may be remediated.

For hexachlorobenzene (HCB), numerous investigations suggest that HCB contamination from the site of the original discharges near Rheinfelden (from the former PCP and chlorosilane production) has spread over the chain of barrages of the Upper Rhine over many years.

Thermal pollution

Between 1978 and 2011, Rhine water temperatures rose by about 1 °C to 1.5 °C. For the future, a further increase of water temperatures due to the impacts of climate change is to be expected.⁴² Apart from that, thermal discharges (e.g. due to the use of surface water for cooling purposes, among others in power plants and industry) contribute to rising water temperatures. Great thermal discharges permitted in 2018, i.e. those above 200 MW are listed in Table 5.

⁴⁰ ICPR technical report no. 175 (2009)

⁴¹ ICPR technical report no. 212 (2014) and ICPR technical report no. 269 (2020)

⁴² ICPR technical report no. 209 (2014)

		Permitted thermal	Permitted thermal
		discharges	discharges
	Rhine-	(> 200 MW)	(> 200 MW)
	km	31 December 2010	31 December 2018
Fessenheim nuclear power plant*	212.4	3,600	3,600
Rhine Steam Power Plant Karlsruhe	359.5	1,175	2,125
Philippsburg nuclear power plant**	389.5	4,265	2,810
Mannheim large power plant (June- Sept.)	416.5	1,014-2,027***	1,563.5
Mannheim large power plant (OctMay)	416.5	2,027	2,947
BASF Ludwigshafen, cooling water****	428.0	1,977	1,977
BASF Ludwigshafen, wastewater treatment plant****	433.0	280/380****	280/380****
Biblis nuclear power plant	455.0	1,674*****	1,674*****
Mainz-Wiesbaden power plants	502.0	1,035	785
GEW Köln AG, Cologne (2010) / GEW RheinEnergie AG, HKW Niehl (2018)	694.0	394	1,443
Bayer AG (2010) / Currenta (2018), Leverkusen	700.0	611	0
Bayer AG/EC (2010) / Currenta (2018), Dormagen	710.0	268	0
Lausward power plant, Düsseldorf	740.5	770	770
Bayer AG, Uerdingen power plant	766.0	461	Only temp. limit 30 °C
SW Duisburg power plant	777.0	720	Only temp. limit 28/ 30 °C
Herm. Wenzel power plant, Duisburg	781.0	545	545
STEAG Walsum	792.0	710	710
STEAG Voerde	799.0	820	0
Solvay, Rheinberg	808.0	208	208
Electrabel Nijmegen (Waal)	885.5	790	0
Electrabel Harculo (IJssel)	975	670	0
Sum		min. 22,833 MW max. 23,946 MW	min. 21,438 MW max. 21,538 MW

Table 5: Survey "Permitted thermal discharges (> 200 MW) into the Rhine in 2010 and 2018"

* In February 2020, the first reactor and in June 2020 the second and last reactor of the nuclear power plant in Fessenheim were shut down.

** On 31.12.2019, the Philippsburg NPP with unit II was decommissioned; the cooling towers were blown up. Residual heat input in the run-through due to the decay phase is currently approx. 20 MW. Further shutdowns are planned in Germany for the next few years.

*** Depending on the temperature of discharge

**** Thermal discharges and cooling water separately, since two different permissions and different discharge points.

***** 280 MW during 01.06.-30.09.; 380 MW during 01.10.-31.05.

****** Permitted thermal discharge during low water periods. Both power plant units have been shut down in the meantime.

Development since 2015

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As shown in Figure 10 and other studies⁴³, the shutdown of the nuclear power plants (Biblis A and B, Philippsburg unit I) from 2011 onwards has led to a reduction in the heat load on the northern Upper Rhine in Mainz in winter. However, newly approved heat discharges meant that the reduction remained roughly the same until 2018. In 2019, the remaining unit II of Philippsburg and in 2020 the French nuclear power plant Fessenheim were also shut down. Nuclear power plants were also shut down on tributaries not shown in the table (Grafenrheinfeld on the Main in 2015, Mühleberg on the Aare in 2019). Further shutdowns will follow in the coming years, but cooling water will still be needed in some cases after shutdown and thus discharges will take place. When interpreting the data, it must be taken into account that besides the effects of thermal discharges, the data is also influenced to an in detail unknown extent by the air temperature.



Figure 10: Extent of water temperature increase (winter = Jan-March, Oct-Dec; summer = Apr-Sept) in Kelvin between Karlsruhe and Mainz (Graph: FGG Rhein) Nota bene: The data comprises both the effects of thermal discharges and the warming effect caused by the air temperature.

During particularly warm summers with extremely low discharges the combined effect of air temperatures and cooling water discharges may make water temperatures rise to such an extent that a negative impact on the aquatic ecosystem is to be expected. Due to water law limitations, the dischargeable waste heat is reduced with rising water temperatures, and when temperatures rise above 28 °C, normally, no additional temperature discharges are permissible.

The extent to which the apparently increasing degree of temperature rise between Karlsruhe and Mainz in summer (cf. Figure 10) is related to weather phenomena and possibly climate change would have to be investigated separately. The consideration of climate change in the programme "Rhine 2040" and in the management plans of the

https://www.researchgate.net/publication/344929776 Anthropogenic influence on the Rhine water tempera tures
federal states and countries is a sign that the problem is recognised and addressed (cf. Chapter 2.4).

2.4 Effects of climate change

This chapter presents available research results on climate change, on changes in runoff, and water temperatures, on impacts on water quality and ecology, and on changes in water uses in the Rhine catchment. The measures taken by the states in the Rhine catchment to counter the impacts of climate change are described in chapter 7.5.

In the Rhine catchment, considerable knowledge is available on the impacts of climate change already observed during the 20th century on the discharge pattern of the Rhine and the development of water temperatures since 1978⁴⁴. Furthermore, during the last years, and based on climate projections, gauge-related simulations of the development of the water balance⁴⁵ and the water temperature⁴⁶ in the Rhine river basin have been drafted for the near future (until 2050) and the distant future (2100).

According to these projections, the development until 2050 is characterized by a continuous rise in air temperature which, for the period 2021 to 2050 compared to the period 1961- 1990 will amount to an average of +1 to +2°C for the entire Rhine catchment.

Simulations for the near future (NF, see Figure 11) indicate that, compared to the reference period (2001-2010), the number of days with **water temperatures** above 25 °C which are critical for certain fish communities will increase, during periods of low flow (Qmin) up to the double. In the distant future (df), the number of days with exceedances of 25°C will strongly increase (maximum value for good status in the barbel region, e.g. Middle Rhine). Similar statements also apply to the distant future for temperatures above 28°C. Many invasive species and the ubiquists among the invertebrates are supported by the higher water temperatures. The effects of these changes on the biocoenosis in the Rhine, in particular on target species of the programme for migratory fish should be further observed. The thermal load of the Rhine, which has already decreased in winter in recent years (cf. figure 10), should be kept within limits.

⁴⁴ <u>https://www.iksr.org/de/themen/klimaaenderung/</u>

⁴⁵ ICPR technical report no. 188 (2011)

⁴⁶ ICPR technical report no. 213 (2014); ICPR technical report no. 214 (2014)



Figure 11: The average number of days per year with a water temperature above 25 °C in the course of the Rhine determined by means of LARSIM (Basel-Worms) and SOBEK (Worms-Werkendam). The bandwidth in the figure is given for different scenarios. The y-axis (vertical) shows the number of days, on which the water temperature of 25°C is exceeded. The x-axis (horizontal) shows different locations with their river kilometre. Among them, different scenarios are indicated: NF = near future, FF = far future, Qmin = low runoff, Qmax = high runoff, \pm = standard deviation (band with of maximum single values) for Ref50 (with 50% of the approved thermal discharges), NF+Qmin and FF+Qmin. For further explanations please see the ICPR technical report no. 214 (2014) and ICPR technical report no. 219 (2015).

For the winter, a moderate increase in precipitation is projected until 2050. Increased precipitation during the winter which, due to higher temperatures, will more often occur as rainfall than as snowfall, may lead to a moderate increase of medium and low flows and, downstream of Kaub, of flood runoff.

Projections for the summer do not indicate any clear trend for precipitation until 2050.

Due to rising air temperatures, the results of the model chains considered seem to indicate that floods and extreme events will occur more often in the river basin district, that is, that the water balance will distinctly change, and this development might become more marked towards the end of the 21st century. Also, higher air temperatures (a rise by $+2^{\circ}$ C to $+4^{\circ}$ C is projected for 2100) will lead to higher water temperatures.

The direction of change for the **water balance**, which, in the near future (until 2050) will partly still be moderate, becomes clear when considering what is expected for the end of this century:

a. during the hydrological winter:

- Increased precipitation in winter
- Increased discharge
- Early melting of snow/ice/permafrost, shift of the line of snowfall

b. during the hydrological summer:

- Less precipitation (but possibly more often heavy rainfall in summer)
- Decreasing discharges
- Increasing periods of low flow.
- c. More smaller to medium floods, increase of peak flows of rare floods seem to be possible, but their extent cannot be quantified beyond doubt.

A study published by the international water protection commission for Lake Constance looks into the possible consequences of climate change on Lake Constance⁴⁷ According to this study, the climate change will increase water temperatures which will entail a modification in stratification and lead to less mixing of water layers. Less oxygen will reach the deeper layers of the lake. Thanks to the distinct reduction of nutrients discharged into Lake Constance and the low phosphorous content, there are no pronounced oxygen deficits.

Further elements related to flood prevention can be found in the first and the second International Flood Risk Management Plan of the IRBD Rhine (IFRMP)⁴⁸.

Particularly in connection with higher water temperatures, low water can have negative consequences for the ecosystem, the water quality and the uses of the Rhine. As far as the issue of low water is concerned, in 2018 the ICPR inventoried and analysed existing knowledge on low water events in the Rhine basin⁴⁹. According to the analysis of historical discharge series, low water levels on the Rhine were much more pronounced in the first half of the last century and occurred with lower discharges and longer shortfall periods than in the last 50 years, this in particular as a consequence of the construction of many dams during the second half of the 20th century. However, water users are more concerned, e.g. navigation, energy production, industry and agriculture.

Furthermore, the characteristics of the low water event on the Rhine of 2018, its consequences and the measures taken have been presented in a report⁵⁰.

It is necessary to adapt water management to the possible effects of climate change. These measures must be considered in connection with climate change adaptation measures of other sectors and their possible interactions.

⁴⁷<u>Climate Change on Lake Constance, IGKB report no. 60 (2015)</u>

^{48 2}nd IFRMP

⁴⁹ ICPR technical report no. 248 (2018)

⁵⁰ ICPR technical report no. 263 (2020)

3. Register of protection areas

As required by the WFD, a register of all areas has been drafted for the IRBD Rhine, for which according to the specific community legislation aimed at protecting surface waters and the groundwater or to preserve biocoenosis and species directly depending on water a particular need of protection has been stated. As in the Management Plan 2015 three maps represent the relevant areas of protection depending on water for part A:

- Map K 9: Water abstraction for human consumption;
- Map K 10: Fauna-flora-habitat areas dependent on water Natura 2000 (Directive 92/43/EEC);
- Map K 11: Bird protection areas dependent on water Natura 2000 (Directive 79/409/EEC).

For Switzerland, these three maps indicate the corresponding areas based on national legislation.

- In K 9: Cantonal groundwater protection zones according to the Water Protection Act⁵¹
- In K 10: Natura 2000 areas: Areas from the federal inventory of low moorlands⁵² and the federal inventory of alluvial areas; ⁵³
- In K 11: Bird protection areas according to the federal inventory of reserves for water fowl and migratory birds.⁵⁴

Measures concerning transboundary protection areas have been coordinated. Concerning the other protection areas, please refer to the Part B reports.

Development since 2015

(Figures without Switzerland)

The number of water protection areas has increased again since the 2015 management plan and their total area has also increased by $1,390 \text{ km}^2$ (Table 6).

The number of recreational and bathing waters, just as the number and surface of bird protection areas, have slightly sunk.

The number of FFH sites has more than doubled to 3,250, which can be attributed to restructuring in site designations (designation of smaller sites). The surface has also increased by 245 km^2 .

The total area of Natura 2000 areas depending on waters in the IRBD has diminished by 60 km² and is now 35.438 km². (This corresponds to17.9% of the total surface of the IRBD Rhine including 12-miles-zone and 18.5% with 1-miles-zone, respectively. This is only little less than in 2015).

The total surface of water protection areas amounts to 24,890 km². This surface does not include the groundwater bodies in the Netherlands from which water is abstracted for human consumption; this surface amounts to further 18.420 km².

⁵¹ Drinking water

⁵² Moorlands

⁵³ Floodplains

⁵⁴ Reserves for water fowl and migratory birds

	22 March 2010 (Management Plan 2010- 2015)	12 October 2015 (Management Plan 2016- 2021)	21 January 2021 (BWP 2022-2027)
Water protection areas - number	27,680	9,020	14,780
Total surface of water protection areas (km ²)		23,500	24,890
Surface of groundwater bodies in the Netherlands from which water is abstracted for human consumption (km ²)		19,580	18,420
Recreational and bathing waters - number	985	1,080	1,000
Bird protection areas - number	380	390	360
Natura 2000 areas - number	1,410	1,335	3,250
Bird protection areas - surface (km ²)	17,330	18,340	18,040
Natura 2000 areas - surface (km ²)	14,910	17,100	17,345
Total surface of Natura 2000 areas depending on water (km ²)	32,240	35,440	35,385
in % of the total surface of the IRBD Rhine	17.1 (base area IRBD Rhine) or 16.3 (12-miles- zone)	18.8 (base area IRBD Rhine) or 18.0 (12-miles- zone)	18.8 (base area IRBD Rhine) or 17.9 (12-miles- zone)

Table 6: Development of the number and surface of protection areas in the IRBD Rhine *Figures without Switzerland.*

In the Rhine catchment, waterbird populations are monitored independently of the WFD, amongst others, according to the EU Birds Directive. The results of the last report⁵⁵ are shortly presented in Annex 11.

All measures retaining water in the entire catchment and along the Rhine, and which locally enhance natural seepage, that is, the renaturing of rivers, the reactivation of floodplains, the extensification of agriculture, nature development, afforestation and depaving of urban areas serve flood prevention and improve the quality and quantity of groundwater and surface waters. At the same time, these measures will contribute towards improving the habitats for the flora and fauna living in the water, on its banks and in the floodplains.

⁵⁵ ICPR technical report no. 277 (2020)

4. Surveillance networks and results of surveillance programmes

Water bodies must be controlled regularly in order to check their condition. Furthermore, this surveillance shows whether improvement measures are proving successful in respect to the most important management questions.

As far as the basic water body network of the Rhine is concerned, the ICPR, International Commissions for the Protection of the Moselle and the Saar (ICPMS), the International Commission for the Protection of Lake Constance (IGKB) and the German Commission for Keeping the Rhine Clean (since 2011 the river basin community (FGG) Rhine) have agreed upon and been implementing an international chemical monitoring programme since 1953 and a biological monitoring programme since 1990. Within the Rhine Monitoring Programme Chemistry and Biology⁵⁶ 2018/2019 according to the WFD, the chemical and physical parameters as well as the biological quality components have been analysed.

The internationally coordinated surveillance monitoring programme has been presented in a joint summary report on the coordination of the surveillance monitoring programmes (part A)⁵⁷. The surveillance monitoring programme has again been conducted for the period 2022-2027 of the WFD during 2018 and 2019.

4.1 Surface water bodies

The networks monitoring the ecological and chemical status were established on schedule by 22 December 2006.

Map K 12 presents the location of the monitoring stations for the biological surveillance monitoring of the basic network of water bodies (catchment area > 2,500 km²). Map K 18 presents the location of the 56 monitoring stations for the chemical and physicalchemical surveillance monitoring, that is for the physical-chemical components, the substances relevant for the Rhine, the priority substances according to the Directive 2008/105/EC in the version of the Directive 2013/39/EU for the basic network of waters (catchment area > 2.500 km²). The criteria for the choice of these monitoring stations represented in the maps K 12 and K18 and which are taken into account in the River Basin Management Plan 2022-2027 IRBD Rhine were a) monitoring stations in the main stream, b) outlets of big Rhine tributaries and c) a survey over the ramified delta area. In salt water, control of the ecological state is limited to the coastal waters, i.e. to the 1mile-zone. The determination of the chemical status extends as far as the 12-mile-zone.

4.1.1 Ecological status / ecological potential

Mainly, the ecological state resp. the ecological potential is determined by the biological quality components (phytoplankton, macrophytes, phytobenthos, macrozoobenthos, fish). Furthermore, hydromorphological and general physical-chemical components must be taken into account.

⁵⁶ ICPR technical report no. 241 (2017)

⁵⁷ Surveillance programme (2007)

4.1.1.1 Overall ecological assessment

Figure 12 shows the present ecological status / the ecological potential expressed in per cent based on the number of water bodies for the entire network of water bodies on level A (left) and for the main stream of the Rhine (right; data basis: biological monitoring programmes 2018 / 2019). Thus, at present, 10% of the water bodies are in a good state; a bit less than half of the water bodies were classified as moderate, the rest of them as below moderate. For 4% of the water bodies there is no information available. In the main stream of the Rhine, 79% of the water bodies were classified as moderate, 21% as poor.

Switzerland as non-EU member state does not delimit water bodies and does not classify them according to the WFD criteria. Within international data exchange, Switzerland reports "reporting units" to the European Environment Agency (EAA) (see maps) These Swiss data were not taken into account during the statistical evaluation (see figures 1, 12, 14, 15, 16, 17, 18, 19).



Figure 12: Ecological state / ecological potential of 230 surface water bodies in the basic network of waters of the IRBD Rhine (catchment area > 2.500 km², left) and of the 28 surface water bodies in the main stream of the Rhine (right) based on the number of surface water bodies. State: March 2022; data excluding Switzerland, see above

Map K 17 presents the national assessment of the present ecological status or potential of surface water bodies in the IRBD Rhine (basic network of water bodies, catchment area > 2 500 km²). Further information is available in the corresponding parts of the B-reports. The classification must identify values in excess of the environmental quality standards for river basin specific pollutants if these are decisive for not achieving the good status/potential (representation on the map: black dot in the water body). This means that if all four biological quality elements are rated as "good", but the nationally defined river basin-specific substances are not good, the overall rating becomes "moderate". This case does not apply to any of the surface water bodies of the basic network of waterbodies in the IRBD Rhine.

Annex 1 shows the present comprehensive ecological classification of the water bodies where monitoring stations of the ecology surveillance network are located as compared to the Management Plans for 2009 and 2015.

Due to different invasive species, the biocoenosis of the Rhine and of many of its tributaries is again and again distinctly changing and dominance proportions vary. These changes also impact the current ecological status assessment and make it difficult to assess the achievement of objectives. The effects of the programmes of measure on the biocoenosis achieved since 2009 cannot always be clearly distinguished from natural biological interactions. The improvements that can be observed in individual biological quality elements (see Chapter 4.1.1.2 and Appendix 11) do not manifest themselves in the overall assessment if the assessment of one of the other elements is worse, due to the one-out-all-out principle.

4.1.1.2 Assessment of the individual biological quality elements

All Member States, the federal states or the regions have determined the criteria for the classification of the ecological status resp. potential according to WFD Annex V for each type of water body/water and for each relevant quality component (see Annex 1).

Map K 13 represents the results of the present national classification of <u>phytoplankton</u> in the IRBD Rhine (basic network of water bodies, catchment area > 2,500 km²) according to the WFD.

The species composition of the phytoplankton and increasing biomass indicate the nutrient contamination of a water body. In the river section between Lake Constance and Karlsruhe the biomass of the phytoplankton measured as chlorophyll a content and biovolume is very low. The phytoplankton in Lake Constance is in a "good" status. With respect to phytoplankton, the status of the entire **High Rhine** and of parts of the **Upper Rhine** is "high". Downstream of the Karlsruhe monitoring station the biomass gradually increases. Nevertheless, the Rhine can be rated as "good" as far as Worms. From the mouth of the Main, over the **Middle Rhine** to the **Lower Rhine** at the German-Dutch border, the Rhine is in a "moderate" condition. The maximum concentration of phytoplankton biomass was achieved on the Lower Rhine at the **Delta Rhine**, the phytoplankton biomass slightly decreases. Here, the rivers were not classified with respect to their phytoplankton concentrations. The stillwaters **IJsselmeer and Wadden Sea** are assessed as "moderate", whereas the **coastal waters** in the Delta Rhine are in a "good" condition.

Map K 14 presents the results of the latest national classification of the biological component <u>macrophytes/phytobenthos</u> in the IRBD Rhine according to the WFD (basic network of water bodies, catchment area > 2,500 km²).

In 2018/2019, **Lake Constance** is rated as "good" in all parts, as is the **High Rhine** up to upstream of the mouth of the Aare. Downstream of the mouth of the Aare, the High Rhine is rated as "moderate". The **southern Upper Rhine** up to Breisach is rated "good" by the German side and "moderate" by the French side. The southern Upper Rhine from Breisach to Strasbourg is rated "moderate" by the German side and "good" by the French side. Without exception, the further course of the Rhine (**northern Upper Rhine**, **Middle Rhine**) until the German-Dutch border is classified as "moderate" with two "good" water bodies in the Upper Rhine (mouth of R. Lauter to mouth of Neckar) and in the Middle Rhine. The section in the 2015 (mouth of Wupper to mouth of Ruhr) has improved from "bad" to "moderate" compared to 2015. In the **Delta Rhine**, numerous water bodies have achieved the "good" ecological potential with respect to the quality component macrophytes/phytobenthos. See below for the classification of the coastal and transitional waters and for the Wadden Sea (Annex 11).

Map K 15 shows the latest national assessment of the benthic invertebrate fauna (<u>macrozoobenthos</u>) in the IRBD Rhine according to WFD (basic network of water bodies, catchment area $> 2500 \text{ km}^2$).

The national assessment of the benthic fauna according to the WFD resulted in a good rating for the **Alpine Rhine**. The Austrian assessment method for macrozoobenthos does not cover the effects of stressors that change mainly quantitative aspects of a biocoenosis (e.g. effects of hydropeaking). Thus, the assessment in the Alpine Rhine reflects the material and not the hydromorphological load.

Over long stretches, the **High Rhine** is marked by reduced flow velocities due to the impoundments of the 11 Rhine water power plants. In addition, the share of invasive species rises in the further **High Rhine** until Basel. The assessment in the High Rhine

only results in a "moderate" state. For the navigable part of the Rhine downstream of Basel the environmental target is to achieve a good ecological potential. The assessment of the potential for the benthic fauna is "moderate" in the entire **Upper Rhine** as far as Bingen. In the **Middle Rhine** up to the **Lower Rhine** near Duisburg, the "good" ecological potential is achieved. From Duisburg to the Dutch border, the potential is classified as "moderate", which is an improvement from previously "poor" potential compared to 2015. The Rhine arms Boven Rijn and Waal were assessed as "moderate", but most other water bodies in the **Delta Rhine** as "good".

Map K 16 presents the current national assessment of the <u>fish fauna</u> in the IRBD Rhine (basic network of water bodies, catchment area > 2 500 km²) according to the WFD.

The national classification of the fish fauna according to WFD resulted in a "bad" classification of the potential in the Austrian **Alpine Rhine**. This is primarily due to structural poverty as a result of massive regulations and the surge-sunk operation of hydroelectric power plants. The improvement in comparison to 2015 is merely du to a modification of the assessment scale. From the point of view of fish ecology, the state of **Lake Constance** is good. The fish fauna of the impounded **High Rhine** was assessed to be "moderate". In the southern Upper Rhine, the fish fauna was evaluated to be "moderate" by Germany/Baden-Württemberg and includes a "poor" section between Breisach and Strasbourg. These sections were not assessed by France, as in France the biological quality element fish fauna is not considered in the assessment of the ecological potential in heavily modified water bodies. The assessment of the northern Upper **Rhine** as far as the mouth of the Main is equally "moderate". The further course of the northern Upper Rhine and the **Middle Rhine** is assessed to be "good", which means an improvement by one classification (from "moderate" potential). The potential of the Lower Rhine until the mouth of the Ruhr is "moderate". Downstream the mouth of the Ruhr until and including the first water body in the **Delta Rhine** (Boven Rijn / Waal), the Rhine is evaluated as "poor". Apart from further water bodies, the Nieuwe Waterweg, the Hartel-, Caland- and Beerkanaal and Lake IJssel have been assessed as "moderate". According to the Directive, no evaluation of the fish fauna is required for the coastal waters and the Wadden Sea.

4.1.1.3 Investigation results for biological quality elements

The qualitative and quantitative inventory of the biological quality elements fish, small invertebrates (macrozoobenthos), planktonic algae (phytoplankton) as well as aquatic plants (macrophytes/phytobenthos [here: benthic diatoms]) within the framework of the Rhine monitoring programme Biology⁵⁸ form the data basis for the assessments of the ecological status/potential (cf. Chapters 4.1.1.1 and 4.1.1.2). The most important investigation results for each biological quality element are given in Annex 11.

4.1.1.4 Physical-chemical elements and river-specific/substances relevant for the Rhine supporting the assessment of the ecological state/potential

The general **physical-chemical elements** such as the nutrients nitrogen and phosphorous and the substances the states have defined as river basin-specific are part of the assessment of the **ecological status / potential**. Annex V of the WFD requires an assessment of these quality components together with the biological quality components. These river basin-specific substances can vary from state to state and are not considered in detail here. For more information, please refer to the national management plans.

Concerning the general physical-chemical elements, the measurements at some locations do not comply with the national orientation values for dissolved oxygen,

⁵⁸ ICPR technical report no. 241 (2017)

water temperature, chloride, total nitrogen, Orthophosphate-phosphorus and total phosphorus (see Annex 2).

However, internationally agreed substances relevant to the Rhine have also been defined for the Rhine river basin district. Annex 2 provides an overview of the assessment of the physico-chemical components and the Rhine-relevant substances for the year 2017, unless otherwise stated.

The selection of **substances relevant to the Rhine** is based on the environmental relevance of the respective substances.

For the 15 substances relevant for to the Rhine the ICPR has derived environmental quality standards (EQS Rhine) (see Annex 3). These are partly also applied as national standards, otherwise the EQS-Rhine are applied if no national standard is available.

The classification of substance concentrations determined in the Rhine is based on a comparison of measured annual average values with the individual national determination taking into account the Rhine, as well as other river basins and may thus differ from the EQS Rhine.

Based on national evaluation criteria, Annex 2 gives the results for the physical-chemical components and for the 15 substances relevant for the Rhine at 56 monitoring stations:

- At some monitoring stations, the values are in excess of the (national) environmental quality standards for ammonium, arsenic, copper, zinc, dichlorvos and PCB (annual mean value);
- There are exceedances for PCBs at a few monitoring sites (dissolved: NL monitoring sites on the Delta Rhine; suspended matter: Schwarzbach and Regnitz).
- the standards for chromium, bentazone, chlortoluron, dichlorprop, dimethoate, MCPA and mecorpop are respected at all monitoring sites;
- at some monitoring sites, the national norm values for 4-chloroaniline and dibutyltin cation are complied with, although only few measured values available.

The values of the metals **copper and zinc** in the water phase at Dutch monitoring stations and at several monitoring stations in tributaries exceed the EQS. In suspended matter, exceedances of the national standards are also measured for these metals (in 7 cases for zinc, in 3 cases for copper) on tributaries, namely on the Schwarzbach (Trebur-Astheim), on the Lahn and on the Sieg, Wupper, Erft, Ruhr and Emscher.

For the group of **PCBs**, there are exceedances of the water environmental quality standards only in the Dutch Rhine and in one coastal water body. At three Rhine tributaries in Germany (Schwarzbach (Trebur-Astheim), Main, Regnitz) exceedances in suspended matter were detected, especially for the higher chlorinated PCBs.

As is shown in Annex 2, analysis data permitting a check of the EQS for **dichlorvos** are only available for some of the monitoring stations. Often, the analysis procedure was not sufficiently sensitive. Exceedances were detected at 5 Dutch monitoring sites. With the entry into force of Directive 2013/39/EU, dichlorvos will be a priority substance in the future, which is why this substance is also considered again in Chapter 4.1.2 (cf. also Annex 5).

Apart from known substances, "**new**" **substances** may be determined as relevant for the Rhine following innovations in industry, altered uses by consumers, new environmental analysis possibilities or increasing knowledge concerning the ecotoxicological effects of substances. Thanks to improved or new analytical methods such as non-target analytics, "new" substances, often not regulated under water law, are now also being discovered time and again. For example, the substance fexofenadine was identified through non-target analytics and included in the facultative Rhine measurement programme Chemistry. Fexofenadine is an antihistamine and, as a pharmaceutical product, it shows background exposure of municipal origin. However, it is mainly discharged into the Main through a point source. This point source dominates the development of the load flow below.

For other substances, the concentrations decrease due to appropriate measures, so that these substances are no longer relevant to the Rhine. Therefore, the lists of substances are regularly updated.

The Rhine substance lists 2014 and 2017 were applied for the Rhine monitoring programme Chemistry between 2014⁵⁹ and 2017⁶⁰.

The evaluation of annual mean values does not show, whether the pollution of the Rhine with other substances getting into the waters accidentally or within targeted intermittent emissions originate from ships, for example or from irregular agricultural practice. In order to record such discharges, the Rhine is continuously being monitored an reports or alerts are shared via the International Warning and Alarm Plan (IWAP) Rhine (see also chapter 7.2.8). Pollution events recorded in this context are described in the annual IWAP compendium of the ICPR⁶¹. The corresponding **warnings and alarms** are investigated by the water police or within water management measures.

Also, the analysis of data of the surveillance monitoring stations of the A-level do not always show pollution events leading to an excess of the environmental quality standards in smaller waters in the catchment. Further information is to be found in the B-parts (management plans of states and federal states).

Since the 1950s, the **physical-chemical components** in the main stream of the Rhine are under intensive, internationally coordinated surveillance.

Intensive farming, amongst other factors, can result in elevated **nitrogen** values in water. The nitrogen values in the Rhine catchment are regularly monitored. Within the framework of the ICPR, in the River Basin Management Plan 2010-2015 IRBD Rhine, a load reduction for nitrogen in the amount of 17% was agreed on. This will be reached if in the Rhine in Bimmen / Lobith and in the area of the estuary into the North Sea a target value of 2.8 mg N-total is complied with as an annual average.

⁵⁹ ICPR technical report no. 215 (2014)

⁶⁰ ICPR technical report no. 242 (2017)

⁶¹ The annual IWAP compendiums are published on the ICPR website in the "Technical Reports" section: <u>https://www.iksr.org/de/oeffentliches/dokumente/archiv/fachberichte</u>

Year	Lobith		Maassluis*		Kampen		Vrouweza	nd
	Summer	Year	Summer	Year	Summer	Year	Summer	Year
Standard	2.5	2.8	2.5	2.8	2.5	2.8	1	-
1985	5.3	6.5	5.1	5.6	5.5	6.4	4.2	4.1
1990	5.0	5.6	4.2	4.8	5.0	5.8	3.5	4.0
1995	3.6	4.3	3.8	4.3	3.6	4.8	3.0	3.6
2000	3.1	3.3	2.9	3.3	3.4	3.9	3.0	3.2
2005	2.6	3.4	2.5	3.0	2.7	3.6	2.1	2.5
2010	2.3	2.9	2.3	3.0	2.6	3.1	2.5	2.7
2011	2.6	3.0	2.2	2.7	2.5	3.1	2.5	2.7
2012	2.3	2.8	2.1	2.6	2.3	2.8	2.2	2.3
2013	2.6	2.9	2.4	2.7	2.6	3.0	2.2	2.6
2014	2.4	2.9	2.1	2.6	2.5	3.0	1.8	2.1
2015	2.5	3.0	2.2	2.6	2.4	3.0	2.2	2.6
2016	2.8	3.8	2.3	2.8	2.6	3.4	2.2	2.3
2017	2.5	3.2	2.1	2.8	2.6	3.6	1.4	2.0
2018	2.7	3.2	1.8	2.4	2.3	3.0	2.2	2.4
2019	2.6	3.2			2.3		2.4	

Table 7: Nitrogen concentrations (calculated values in summer and mean annual value and standard in mg total N/I) at Lobith, Maassluis, Kampen and Vrouwezand

* Maassluis is located on a transitional water body, which is why the standard should actually be converted to 0.46 mg DIN/l with a salinity of 30.

For the calculated annual mean values at Lobith, Table 7 shows that nitrogen concentrations in the Rhine decreased until 2010 and subsequently remained relatively stable with both slight increases and decreases. From 2015 onwards, there is a slight increase in the annual mean values at Lobith with a spike of 3.8 mg N-total/l in 2016.

2020 has shown that from 2015 onwards greater differences have arisen between the calculated and the measured values for N-total. Table 8 contains the measured values for N-total for Bimmen and Lobith for the period 2010-2019.

Table 8: Nitrogen concentrations (summer and annual mean value in mg N-total/I) at Lobith and
 Bimmen, by the Netherlands (calculated) and Germany (measured)

Year	Nethe	rlands	Germany		
	Lobith calculated		Lobith	Bimmen	
			measured	measured	
	Summer	Annual average	Annual average	Annual average	
2010	2.3	2.9	3.1	3.1	
2011	2.6	3.0	2.8	2.8	
2012	2.3	2.8	2.7	2.6	
2013	2.6	2.9	2.9	2.9	
2014	2.4	2.9	2.8	2.6	
2015	2.5	3.0	2.6	2.7	
2016	2.8	3.8	2.8	2.7	
2017	2.5	3.2	2.6	2.7	
2018	2.7	3.2	2.3	2.3	
2019	2.6	3.2			

Table 8 shows that the values for N-total of the calculated annual mean values of the Netherlands (column 3) and the measured values of Germany (columns 4 and 5) differ more strongly from 2015 onwards, i.e. > 0.2 mg/l. The annual mean values

calculated for the Netherlands are above the German measured values as of that year.

Germany complies with the target value of 2.8 mg N-total/I as an annual average for Bimmen as of 2014 as a result of the German measured values (table 8, column 5 in). Based on the values calculated by the Netherlands for total N (table 8, column 2), the Netherlands do not comply with the target value of 2.5 mg total N/I mean value of the summer half-year at Lobith.

The different measured values can be explained by measurement uncertainties (e.g. due to different handling of limits of determination) and different methods. The scattering between the observations of Kiehldahl-N is noticeable, here. It is elevated at Lobith after 2015. As this parameter is a part of the calculation of the total nitrogen, there is an influence on the annual average value for total nitrogen at Lobith.

Since November 2020, the Netherlands (Rijkswaterstaat) have started to measure N-total at the Lobith monitoring station (and all the other RWS monitoring stations), instead of calculating the value via Kjeldahl-N, nitrate and nitrite. This is to further harmonise the methods used by the Netherlands and Germany. A first analysis indicates that this can (partly) explain the differences. Further reconciliations between the Netherlands and Germany in this regard will take place. This is important because it is part of the task of determining whether further reduction efforts are needed.

Exceedances of the target value for total nitrogen were measured at the other surveillance monitoring stations Kampen, Vechte, IJsselmeer, Wadden Sea and Dutch Coast (cf. Annex 2).





Figure 13 shows the freight development from 1985 up to and including 2018 from the river basin district into the North Sea and the Wadden Sea, while the freight from 2015 onwards may show an overestimation.

The Dutch coastal waters are significantly - but not only - influenced by the discharge of the Rhine via the Nieuwe Waterweg and the Haringvliet to the coast. There is a direct correlation between the river load in the delta and concentrations in the coastal area. It is estimated that runoff from the Rhine and Meuse rivers together account for 77% of the total coastal nitrogen load in the 1-mile coastal zone, about 13% comes from the English Channel, 6% from the Scheldt in Belgium,

2% from France and 1% each from the UK and Germany⁶². In the eastern part of the Wadden Sea (in the German coastal waters), about 80% come from river loads, with the German rivers (Ems, Weser, Elbe) contributing about 50% and the Rhine/Meuse about $30\%^{63}$.

Development since 2015

Since 2015, total nitrogen loads in coastal waters and the Wadden Sea appear to be slightly increasing. However, this increase may be due to an overestimation of total nitrogen loads. The calculation of the load takes place on the basis of the calculated total nitrogen. From January 2021 on, this will take place on the basis of the measured total nitrogen. Closer investigation is going on (see also text accompanying table 8).

In 2014 (Management Plan 2016-2021) and 2019, around 292 and 255 kt of nitrogen were emitted, respectively (cf. Table 12 in Chapter 7.1.2). The forecast for 2027 shows a further decrease (to about 244 kt) which is due in particular to the decrease in emissions from agriculture in Germany and the Netherlands.

Since nitrogen concentrations are expected to be further reduced, concentrations and loads will continue to fall. In spite of this development, nitrogen continues to be a relevant substance with negative impact on the status, as concentrations are too high in some surface waters (see Annex 2) as well as in the groundwater (see Map 25). If all water bodies are to achieve or maintain a stable, good status, efforts towards reducing nitrogen must be continued.

For **total phosphorus** and **ortho-phosphate-phosphorus**, respectively, the national assessment standards are exceeded at many of the 56 monitoring sites of the Rhine monitoring programme Chemistry (cf. Annex 2). This exclusively concerns measuring stations at the tributaries of the Rhine. At the following monitoring stations, no exceeding values were determined: Bregenz/Bregenzerach, Fussach/Alpine Rhine, Öhningen, Weil am Rhein, Lauterbourg/Karlsruhe, Worms, Mainz, Koblenz (Rhein), Bad Honnef, Düsseldorf, Bimmen/Lobith, Kampen (IJssel), Maassluis, Vrouwezand (Lake IJssel), Deizisau (Neckar), Weschnitz, Erpeldingen (Sauer), Sieg, Wupper, Ruhr and Vecht.

The **temperature** is a critical parameter for plants and animals in water bodies. High water temperatures ($\geq 25^{\circ}$ C) may be a stress factor for migratory fish and may imply an increased risk of infections and a temporary interruption of upstream migration⁶⁴.

Also due to the hot summers of the last years, the national assessment standards for temperature are not met in the entire High, Upper, Middle and Lower Rhine (cf. also Chapter 2.3), furthermore in the Neckar, the Schwarzbach, the Main, the Kinzig and the Nidda, in the upper reaches of the Lahn, in the upper reaches of the Sauer and at the mouths of the Rhine tributaries in the Lower Rhine.

The assessment standards for dissolved **oxygen** or oxygen saturation are not met at the monitoring sites of the northern Upper Rhine and the Middle Rhine as well as at 20 tributary monitoring sites (cf. Annex 2). The annual mean **pH value** is outside the recommended value range at 13 tributary monitoring sites and Lake IJssel.

Exceeding values of the **chloride** parameter are registered at the Palzem monitoring station on the Moselle, in the mouth of R. Lippe at Wesel and in the mouth of R. Emscher.

In Lake Constance, the national classification scales and recommendations are respected at the surveillance monitoring station.

⁶² Blauw et al. 2006

⁶³ OSPAR/HASEC, Bonn, 28 March - 1st April 2011

⁶⁴ ICPR technical report no. 167 (2009)

4.1.2 Chemical status

The chemical status of a surface water body is classified according to the concentrations measured for priority substances and priority hazardous substances.

The basis for the monitoring programme assessed in this report is the list of substances determined in the EU Directive on Priority Substances (Directive 2008/105/EC). In the meantime, this directive has been updated by the Directive 2013/39/EU implemented in national law by 14 September 2015. The EQS have been revised for seven substances which had already been regulated. These revised EQS were to be applied as of 22 December 2015 in order to achieve these more demanding targets within the new programmes of measures of the second management plan by 22 December 2021.

Due to changes in the substances to be assessed and due to different types of measurements, e.g. measurements in water and biota, the assessment and in particular the comparability of assessments over time and between monitoring sites is made more difficult.

Annex 5, the Maps no. 19 and 20 and Figure 14 include the classifications of the average annual value based on classification standards valid in the entire EU.

Since the "ubiquitous" substances / substance groups occur in almost all European waters and thus remain in the environment in the long term, they lead to a "not good status" in the overall assessment of the chemical status almost everywhere in Europe, including in the Rhine catchment. The following substances have been defined as "ubiquitous" (Directive 2013/39/EU): Mercury, PBDE, heptachlor/heptachlor epoxide, PAH, TBT, PFOS, dioxines and dioxin-like compounds and HBCDD.

Annex 5 and Map K 19 show exceedances of the EQS for the ubiquitous substances **mercury**, **PBDE**, **heptachlor/heptachlor epoxide**, the partly ubiquitous **PAH compounds** (especially for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(g,h,i)perylene) and **PFOS** at almost all monitoring sites and for almost all water bodies in the basic network of waters in the Rhine catchment. The national management plans include a detailed pollution analysis.

In contrast, the ubiquitous substances **dioxins** were only detected at two monitoring sites and **HBCDD** at none.

Too few measured values are available for **tributyltin** in the water phase for a final assessment to be possible. However, the data from the suspended matter analysis (cf. Annex 4, bottom part of the table) indicate that the tributyltin problem no longer reaches the proportions it did at the time during its authorisation⁶⁵.

The PAH compound **fluoranthene** which is not classified as ubiquitous exceeds the EQS at a great number of monitoring stations.

The other substances not classified as ubiquitous are less exceeding the EQS (see Annex 5):

At one monitoring station: **Nickel** (Erft); at two monitoring stations: **Octylphenols** (Dutch coast), **cypermethrin** (Kahl a. Main, Syr), **anthracene** (Alzette);

at five monitoring stations: **Dichlorvos** (Maassluis, Waddenzee (2), Dutch coast (2)) and **Bifenox** (Neckar (2), Kinzig, Nidda, Lahn (1)).

Furthermore, the impounded Upper Rhine has a section in which hexachlorobenzene is in excess of the EQS which is not shown in the monitoring stations Weil (upstream the impounded section) and Karlsruhe (downstream the impounded section) in Annex 5. For further information please refer to the B-reports.

⁶⁵ <u>http://iksr.bafg.de/iksr/auswahl.asp?S=0</u>

Other priority substances, such as lead, cadmium and many pesticides, currently show no exceedances of the EQS at the monitoring sites in the basic network of waters on an annual average (cf. Annex 5). Nevertheless, they are analysed in detail as, in the past, they exceeded the target values and the EQS⁶⁶.

In addition, for a number of substances with extremely low EQS, the limits of determination in the laboratories are above the EQS at many monitoring sites, so that no reliable statements can be made (examples: dichlorvos, cypermethrin, cybutryn). For isoproturon, waves of pollutants were also measured at agricultural application time until the ban on use in 2017⁶⁷. These did not lead to annual mean values exceeding the EQS, but the maximum values were in excess of the fixed quality standards (PMC-EQS). In addition, several reports on elevated isoproturon concentrations have been made in recent years via the International Warning and Alarm Plan Rhine, which have led to the cessation or restriction of Rhine water abstraction for drinking water treatment. The last restriction on drinking water production due to isoproturon contamination.

Map K 19 is summarized in Figure 14 (left). Figure 14 shows the assessment of the chemical status based on the number of water bodies for all water bodies in the basic network of water bodies in the IRBD Rhine (top) and for the main stream of the Rhine (bottom). 100% of all surface water bodies in the basic network and in the main stream of the Rhine have been classified as not good.

Due to the extensive occurrence of one or more ubiquitous substances, a differentiated analysis of the pollution with the rest of the substances is required. Therefore, the Directive 2013/39/EU gives the possibility to additionally present the chemical state **without the ubiquitous substances**. These presentations are given in Annex 5, Map 20 and Figure 14 (right).

Figure 14 (right) and Map 20 illustrate that, in the Rhine tributaries in the Rhine catchment the EQS are exceeded with respect to one or more non-ubiquitous priority substances. For more than half of the surface water bodies in the IRBD Rhine (graph above right, 59%) and of the main stream (graph below right, 53%) the EQS of "non ubiquitous substances" are not exceeded. Concerning differentiated representations, please refer to the Part B reports.

⁶⁶ ICPR technical report no. 215 (2014)

⁶⁷ https://ec.europa.eu/food/plant/pesticides/eu-pesticides-db_en



Figure 14: Current chemical status of the 231 surface water bodies in the basic water network of the IRBD Rhine (catchment area 2500 km², above) and the 28 surface water bodies in the main stream of the Rhine (bottom), with (left) and without ubiquitous substances (right). Up-to-date national classification according to Directive 2013/39/EU. State: March 2022; data without Switzerland, see text of Figure 12

4.2 Groundwater

Groundwater has at least been controlled according to WFD since 2007, normally in the upper main aquifer, in some states also in the lower main aquifer on the level of delimited groundwater bodies or groups of groundwater bodies.

Data collection varies both between countries and between management plans, as some countries have made fundamental changes in data collection.

As a matter of principle, surveillance monitoring of the chemical status is done in all groundwater bodies and serves to determine and monitor the status and the trend of pollutant concentrations resp. to identify a trend reversal. Operative surveillance is only done for those groundwater bodies which, according to the survey and / or surveillance monitoring were classified as "achievement of target unlikely" or "achievement of target uncertain" and serves to determine the status of these groundwater bodies, their trend and the development of the effects of measures taken to achieve the target.

Guidance on the classification of the chemical groundwater status is given above all in the WFD daughter directive groundwater (2006/118/EC) as well as in the "Guidance Document: Groundwater Status and Trend Assessment EC 2009". For the present management plan, the amendment of Annex II of Directive 2006/118/EC by Directive 2014/80/EU of 20 June 2014 is also applied.

Quantitative status

According to WFD Annex V, the quantitative status of groundwater is good if there is no excessive use of groundwater and no significant interference with terrestrial ecosystems or connected surface water bodies. Furthermore, there should be no signs of intrusion of salt and other substances.

The yardstick for the quantitative status of groundwater is primarily the groundwater level or the pressure height of groundwater in cases of non-confined aquifers. Furthermore, discharges from springs are considered. The analysis of groundwater levels is e.g. carried out with the help of trend calculations based on long-time well hydrographs.

If the groundwater table cannot be monitored, e.g. in solid rocks or if the number of suitable monitoring stations is insufficient, supplementary or alternative water balances will be established in order to determine the groundwater status.

Another criterion used for the assessment of the quantitative groundwater status is the impairment of terrestrial ecosystems depending on groundwater. For the survey, those terrestrial ecosystems depending on groundwater were chosen for which a risk of impairment exists. If required, the groundwater table will be monitored in these areas.

According to the WFD and the Groundwater Daughter Directive, any existing adverse impacts on surface waters connected to groundwater must also be examined as a further criterion for assessing groundwater status (for both quantitative and chemical status).

Chemical status

According to the WFD and its Groundwater Daughter Directive (Directive 2006/118/EC), groundwater is in a good chemical status if EU-wide quality standards are met (nitrate⁶⁸ 50 mg/l, total pesticides 0.5 μ g/l and individual pesticides 0.1 μ g/l) and there is no impairment of groundwater-dependent terrestrial ecosystems or associated surface waters. Furthermore, there shall be no signs of intrusion of salt and other substances of anthropogenic origin. According to the Groundwater Daughter Directive, a groundwater body has a good chemical status, if - besides other criteria– the above-mentioned quality standards and national threshold values (see Annex 6: groundwater threshold values determined at a national level) are respected at all monitoring stations.

If the quality standard or threshold value is exceeded at one or more monitoring stations, the groundwater status is good if the excess values are not significant for the groundwater body. The daughter directive does not give precise information concerning the assessment of significance. The "Guidance Document Groundwater Status and Trend Assessment EC 2009" indicates how the assessment of significance can be carried out:

This assessment includes different tests to determine whether values in excess may lead to not achieving the good chemical status. These tests take into account environmental criteria and criteria of use. All in all, the classification procedure for the chemical groundwater status includes 5 different tests:

Test 1: General quality classification (total surface resp. total volume of the groundwater body in which exceeding values have been determined amounts to less than 20% compared to the entire groundwater body);

Test 2: Salt or other intrusions;

Test 3: Surface water bodies;

Test 4: Terrestrial ecosystems depending on groundwater;

Test 5: Drinking water protection areas according to WFD, Article 7.

Another significant element of surveillance monitoring is the determination of trends in cases of significantly increasing pollutant concentrations. The starting point for trend reversal is defined as 75% of the quality standard or of the threshold value. Measures may be required for a groundwater body with good status if a significantly increasing pollutant trend is registered. When the starting point for trend reversal is achieved, measures must be taken.

With a view to assessing the effects of relevant point sources, additional trends must be determined for certain pollutants and it must be ensured that pollutant plumes will not spread and deteriorate the chemical status.

4.2.1 Quantitative groundwater status

On the whole, and just as in the Management Plan 2015, the quantitative groundwater status in the Rhine catchment can be characterised as good (see Figure 15). Map K 22 shows that, compared to the Management Plan 2015, largely the same groundwater bodies (3%) are in a bad quantitative status, but at present, less groundwater bodies are concerned.

There are individual cases of extensive falls in groundwater level, for example due to coal mining and which are of regional importance. In this connection, the open-cast lignite mines on the left banks of the Lower Rhine are to be mentioned. As a result of the pumping measures of the opencast lignite mines Hambach, Garzweiler and their predecessor opencast mines, some groundwater bodies show a "poor" status and significant negative trends in groundwater levels. The "poor" quantitative condition in

⁶⁸ According to Nitrates Directive + Groundwater Daughter Directive

the groundwater bodies affected by pumping will persist in the long term because extensive groundwater abstraction in the opencast mines themselves and in their surroundings is still necessary to keep the opencast lignite mines dry. Also, due to the large extraction depth, the extraction funnel and thus the extraction influence of the opencast mines radiates far into the neighbouring groundwater bodies and will thus continue to influence groundwater conditions for decades. There are exemptions to the quantitative influences of lignite mining.

Further reasons for a bad quantitative status are impacts on land ecosystems depending on groundwater due to the phenomenon of the lowering of the river bottom on some sections of the Rhine and due to the effects of climate change. Climate change can influence the quantitative status of groundwater, particularly through the increase and intensification of dry periods.

In the Netherlands, in general, almost all groundwater bodies have good quantitative status. However, the interaction between groundwater and terrestrial ecosystems is assessed as poor for most Dutch groundwater bodies in the Rhine catchment.



Figure 15: Present quantitative status of all 585 groundwater bodies in the IRBD Rhine (catchment > 2500 km²). State: March 2022; data without Switzerland, see text of Figure 12

4.2.2 Chemical groundwater status

The result of the classification of the chemical groundwater status in Figure 16 and Map K 24 (total classification) and in Map K 25 (nitrate) shows a comparable situation as that of the Management Plan 2015-2021. All over the Rhine catchment, the status of several groundwater bodies was again classified as bad (25%). However, the number of these groundwater bodies is declining and the majority of groundwater bodies (75%) is in a good chemical status.



Figure 16: Present chemical status of all 585 groundwater bodies in the IRBD Rhine (catchment > 2500 km²). State: March 2022; data without Switzerland, see text of Figure 12

In Map K 24 of the overall classification, groundwater bodies with significantly increasing pollutant trends are highlighted by a black dot. Due to insufficient long-term data sets, some states or federal states have not indicated any trend while, in individual cases, even a trend reversal is being reported.

Compared to the Management Plan 2015-2021, the chemical state of groundwater bodies has hardly changed in the Rhine catchment. The main contamination of groundwater bodies presenting a bad state is due to nitrate, to a lesser extent due to plant protection agents.

In the Rhine catchment area, too high nitrogen inputs (nitrate and ammonium) of the upper main aquifer continue to be the main problem. Therefore, a separate map has been established for the groundwater contamination with nitrates (Map K 25). It is only slightly different from the map showing the overall pollution, as, due to the nitrate pollution, most of the groundwater bodies have a bad chemical status. The causes are, above all, fertilization in agriculture and intensive livestock farming.

Furthermore, inputs of pesticides (and their degradation products / metabolic products) lead to a bad chemical status of certain groundwater bodies. Also, due to national threshold values for plant protection agents (Annex 6), the chemical status of certain groundwater bodies is bad, which is caused by these substances. The same applies to national threshold values for ammonium, heavy metals and salts, volatile chlorinated hydrocarbons (VCHCs), perfluorinated and polyfluorinated alkyl substances (PFAS). Some groundwater bodies also fail to achieve the good chemical status due to:

- pollution from mining activities
- pollution from historical contamination
- difficulties for drinking water production
- effects on surface waters or
- effects on land ecosystems depending on groundwater.

In Germany, despite the measures introduced, the nitrate contamination of groundwater has not yet decreased significantly due to the unfavourable hydrogeological (with karst and fissured aquifers and often thin surface layers) and climatic conditions (low amounts of precipitation).

The implementation of the amended Fertiliser Ordinance 2020 in Germany and the corresponding Fertiliser Ordinances 2021 of the Länder are expected to contribute to achieving the objectives of the Nitrates Directive in Germany and thus to reducing nutrient problems in ground and surface waters. With the extended area-wide requirements for agricultural fertilisation, it is currently assumed that there will generally be no significant surpluses of nitrate in the future that will lead to exceedances or rising trends in groundwater.

This will also have corresponding positive effects on the IRBD Rhine.

In the German federal state Baden-Württemberg the chemical status of groundwater bodies in the Rhine catchment has further improved. A direct comparison with 2015 is not possible due to extensive redefinition of the groundwater bodies. With regard to nitrate, 7 out of a total of 117 groundwater bodies now fail to achieve the "good chemical status". Nevertheless, existing measures will be carried on also in these cases in order to secure the status achieved. Apart from the nitrate pollution, the chloride pollution originating from potash mining at Fessenheim is responsible for the classification of one of these seven groundwater bodies as bad.

In the German federal state Rhineland-Palatinate the chemical status of groundwater bodies in the Rhine catchment has slightly improved. With respect to nitrate, 11 out of so far 42 red groundwater bodies at risk have been classified as "good status" in 2020. At the same time, however, four previously green groundwater bodies had to be classified as having "poor status". Overall, the number of red groundwater bodies thus decreases from 42 to 35 compared to the 2015 Management Plan.

In 2020, the chemical status of the groundwater bodies in the parts of the German Rhine catchment located in Bavaria, Hesse and Lower Saxony has hardly changed as compared to the Management Plan 2015. The main contamination of groundwater bodies presenting a bad state is due to nitrate, to a lesser extent due to plant protection agents. So far, measures taken do not show any measurable modification of the groundwater quality. This is for example due to the residence times of seeping water and groundwater.

In the North Rhine-Westphalian part of the German Rhine catchment, the chemical status has slightly improved. In the meantime, almost 70% of groundwater bodies are in good chemical status, which corresponds to an area share of approx. 65%. Compared to the second Management Plan, the number of groundwater bodies with poor chemical status in the North Rhine-Westphalian Rhine catchment has decreased from 41.3% to 30.2%. The surface share has decreased from 46.7% to 34.7%. The main pollutant is still nitrate, followed by ammonium, which leads to poor chemical status, especially in agricultural areas.

In the French Rhine catchment area, the number of groundwater bodies presenting a bad chemical status has increased. However, this is due to the improved analytical detection of metabolites.

In Luxemburg, 3 out of 6 groundwater bodies with pesticide metabolic products present a bad chemical state. The poor rating is mainly due to the degradation products metolachlor-ESA and metazachlor-ESA. It should be noted here that the application of the substances S-metolachlor (nationwide) and metazachlor (in drinking water protection zones) has been prohibited since February 2015. In addition, the application of metazachlor outside drinking water protection zones has been restricted to 750 g/ha/4 years. Furthermore, the quality standard for nitrate was exceeded in one of the three groundwater bodies. In spite of measures taken aimed at groundwater bodies, no significant reduction of the contamination has been recorded, yet. Due to the long retention times caused by the natural inertia of groundwater, it can probably take years to decades, depending on the groundwater monitoring site, before the quality standards are reached again.

For the groundwater bodies in the Dutch part of the Rhine arms, the general chemical status for almost all (9 out of 11) groundwater bodies meets the objectives for substances with a European standard and nationally agreed threshold values. There are five groundwater bodies whose status is poor for drinking water abstraction and, in addition, the status is inadequate for some natural areas.

The water body Sand Rhine-East presents an increasing trend for arsenic in the deep groundwater aquifer. In the tidal flat Rhine-North, the upper and lower groundwater aquifer presents an increasing trend for chlorides. In Salt Rhine-North, phosphorous is increasing in the upper groundwater aquifer. The trend analysis is based on two monitoring years. Nothing indicates that these negative trends are caused by human activities. New monitoring campaigns will result in additional information on this point.

Compared to 2009, the chemical status of Dune Rhine-West was classified as bad. This is a result of lowering the threshold value for phosphorous from 6 to 2 mg/l. The concentration of total phosphorus in this groundwater body is exceeded at more than 20% of the monitoring points, but there is no negative trend for the concentration and thus no question of deterioration.

5. Environmental objectives and adjustments⁶⁹

Article 4 of the WFD defines the environmental objectives to be achieved in principle for each water body category. These objectives are summarised in Table 9. If it proves to be impossible to achieve the objectives by 2015, deadlines may be extended to 2021 or 2027 or other dates and relevant reasons must be submitted.

r						
		Overriding objective				
Category: Water body			Good sta	potential 2015		
			Qualitative objectives		Quantitative objectives	
Natural	Groundwater	No deterioration		Good chemical status	Good quantitative status	
	Surface waters	No deterioration	Good ecological status	Good chemical status		
Heavily modified	Surface waters	No deterioration	Good ecological potential	Good chemical status		
Artificial	Surface waters	No deterioration	Good ecological potential	Good chemical status		

Table 9: Environmental targets for water bodies according to WFD

5.1 Environmental targets for surface water bodies

5.1.1 Ecological status / ecological potential

Figure 17 (left) illustrates the present assessment of the states in the IRBD Rhine with respect to achieving the targets for the good ecological status / good ecological potential of surface water bodies in 2027. Accordingly, it is expected that in a further 22% of the surface water bodies in the basic water network of the IRBD Rhine (catchment > 2,500 km²) the objectives will be achieved by the end of 2027. For 65%, target achievement is expected after 2027. For 3% of the water bodies there is no information on the achievement of targets available. In the main stream of the Rhine, 21% are expected to achieve their objectives by 2027 and 72% of the water bodies are expected to achieve their objectives after 2027. For 7% of the water bodies there is no information on the achievement of targets available.

⁶⁹ In Germany, "adjustments" are identical with "Exemptions and extensions of deadlines". In the Netherlands, the notion "exception" is used according to WFD, Article 4 Par. 4 to 7.



Figure 17: Timeframes for the achievement of the objectives of good ecological status / good ecological potential for all 230 surface water bodies in the basic water network of the IRBD Rhine (catchment > 2,500 km², left) and for the 28 surface water bodies in the main stream of the Rhine (right). State: March 2022; data without Switzerland, see text of Figure 12

Stresses due to the use functions of flood protection, navigation, water regulation and hydropower lead to less favourable living conditions, causing lower values for the biological quality elements than required for the good ecological status/potential:

- the quality component phytoplankton indicates the trophic state of a river. Both biomass and the composition of species are important indicators, here. The growth of the phytoplankton in a river section is influenced by the concentration of nutrients, the turbidity and light conditions, the runoff dynamics and the river morphology. High nutrient concentrations, low runoffs with long flow times, e. g. through stowage regulation, and high water temperatures favour mass developments of phytoplankton.
- lower values are achieved for the quality component macrophytes/phytobenthos (aquatic plants) if the water body only has few shallow water areas, as shallow waters are preferably colonised by macrophytes. Wave action and the suction and surge caused by shipping also impair the growth of aquatic plants;
- the quality element benthic invertebrates (macrozoobenthos) is impaired by lower variation and dynamics of the bed substrate (stones, gravel and sand), by a higher proportion of substrate that is poor in organic matter, and by the strong current and constant shifting of substrate in the navigation channel (partly caused by development and shipping). In the impoundments, on the other hand, the increased fine sediment deposits with increased organic content cause a blockage of the gap system and thus possible oxygen deficits. In addition, benthic colonization in the navigation lane is clearly dominated by invasive species. The reasons may in particular be: spreading due to ships (among others attached to the hulks) and immigration through the canals interconnecting different catchments (in particular Main-Danube-Canal);
- the quality component fish fauna is mainly affected by the presence and availability of food sources and habitats (in particular spawning grounds). This situation is further aggravated by (heavily) restricted access to spawning waters and diversified habitats and the still restricted continuity of the water body (in particular along the coast, in the main stream of the Rhine, towards tributaries, between the high-water channel and the low-water channel).

Even if the "good ecological status" for natural water bodies or the "good ecological potential" for heavily modified waters is possibly not achieved for all water bodies in 2027, the aquatic ecosystem of the basic network of waters of the Rhine will be considerably and sustainably improved by the implementation of measures. In this connection, the improvement of river continuity is one of the basic requirements for heavily modified water bodies.

According to Annex V WFD, the "river continuity" is a "hydromorphological quality element supporting the biological elements". Electrofishing near the riverbank is the normal method for fish inventories in large rivers to which the national classification systems refer (IPR in France, fiBS in Germany). With this method, (anadromous) migratory fish that are only temporarily present in the water body are seldom recorded and are therefore only included in the respective index result with little computational influence. This may lead to the fish fauna in individual water bodies already being assessed as "good" in 2021, although the river system's continuity has not yet been restored and possibly planned improvements to spawning habitats have not been implemented.

As an important management issue in the IRBD Rhine and essential objective of the "Master Plan Migratory Fish Rhine" ⁷⁰ the restoration of the ecological continuity of the Rhine for migratory fish from its mouth to the Rhine Falls (including thresholds in the Rhine loops) as well as in its major tributaries, in particular the Moselle (up to its mouth at the river Sûre) as an international tributary, including the programme waters of the Master Plan Migratory Fish has been identified - independent of the assessment of individual water bodies. This was confirmed by the Conference of Rhine Ministers in Amsterdam on 13 February 2020.

The lake trout of Lake Constance as the indicator fish species for the Alpine Rhine / Lake Constance area of operation is also considered within the management plans for this area.

For the eel, maturing in fresh water and spawning in the sea, the environmental objective set by the EC Eel Regulation is to ensure that 40 % of the silver eel reach the sea.

By the end of 2008, all EU Member States with natural stocks of eel submitted eel management plans intended to secure a 40% minimum survival rate of downstream migrating eel. A survey of national measures in the Rhine catchment 2014– 2016 according to the Eel Regulation is included in an ICPR technical report.⁷¹

Reduction objectives for physical-chemical components and for inputs of substances relevant for the Rhine supporting the achievement of the good ecological status /good ecological potential

Chemical-physical components supporting biological findings are e.g. oxygen, the nutrients nitrogen and phosphorous as well as chloride and temperature. In most water bodies in the basic network of waters in the IRBD Rhine (Level A) impairments due to a lack of oxygen and increased chloride contents are no longer relevant. However, increased phosphorous contents continue to play a role. Regarding questions of temperature, please refer to Chapters 2.3, 2.4 and 7.1.2. As described below, the reduction target for nitrogen is based on the protection of the marine environment.

The schedule for reducing the discharge of substances relevant for the Rhine will be determined locally in coordination with the Rhine-bordering countries. A reduction at the source is striven for. As far as required, the management reports (Level B) address further specific pollutants or groups of pollutants that must meet national standards or must be taken into account as a matter of precaution.

⁷⁰ ICPR technical report no. 247 (2018)

⁷¹ ICPR technical report no. 264 (2019)

Reduction targets aimed at marine protection

The average annual total nitrogen load discharged into the estuary of the Rhine, the coastal waters and the Wadden Sea between 2014 and 2013 amounts to about 204 kilotons (see Chapter 4.1.1.4). This is about 30 kt less than in the previous period (2007-2013) and about 70 kt less than in the period 2000-2006.

In order to achieve the good status for the phytoplankton quality element, especially in the Wadden Sea, the maximum load of 192 kt total nitrogen per year on average from the Rhine catchment into the North Sea and the Wadden Sea for the period 2014-2018 was not to be exceeded. Since the average annual load of 204 kt may be an overestimate, no conclusive statement can be made at present.

Development since 2009

This convened load reduction of 17% will be achieved when the annual average value for total N in the Rhine at Bimmen/Lobith and in the North Sea estuary is not greater than 2.8 mg/l (target value). In the past years, the mean annual values of total N at Lobith were in the range of the target value 2.8 mg/l (see Table 7 in Chapter 4.1). Since 2015, the average annual concentrations at Bimmen/Lobith have been inconclusive. But also for this period the values were in the range of the target value of 2.8 mg/l (see also Chapter 4.1.1.4).

The long stated in reduction in total N has led to a stable, good status of the phytoplankton on the Dutch coast. For the coast of the Wadden Sea and the Wadden Sea this status is not yet as stable as along the Dutch coast. In the eastern part of the Wadden Sea the state is worse than in the western part.

Due to the prognosis for N emissions in 2027 (see section 7.1.2) it is assumed that the concentration will continue to fall during the coming years. The effect of measures only takes effect with a time delay.

5.1.2 Chemical status

Figure 18 and Map K 27 illustrate the present assessment (2020) of the states in the IRBD Rhine with respect to achieving the targets for the ecological status / ecological potential of surface water bodies in 2027. Accordingly, the objectives for the chemical status will be achieved by 2027 in presumably 10 % of the surface water bodies in the basic water network of the IFGE Rhine (catchment > 2500 km²). For 88%, target achievement is expected after 2027. For 2% of the water bodies there is no information on the achievement of targets available. In the main stream of the Rhine, 36% are expected to achieve their objectives by 2027 and 64% of the water bodies are expected to achieve their objectives after 2027.



Figure 18: Timeframes for the achievement of the objectives of chemical status for the 231 surface water bodies in the basic water network of the IRBD Rhine (catchment > 2,500 km², left) and for the 28 surface water bodies in the main stream of the Rhine (right). State: March 2022; data without Switzerland, see text of Figure 12

The low degree of target achievement expected by 2027 is correlating with the ubiquitous PAH and mercury contamination in numerous surface water bodies of the Rhine catchment for which improvements are only gradually expected. Furthermore, the EQS for the substance fluoranthene not classified as ubiquitous is largely neither achieved in the main stream, nor in the catchment (see Chapter 4). Due to the one-out-all-out principle the improvements that can be observed for individual substances (see Chapter 4.1.2 and Annex 5) do not show in the overall assessment.

5.2 Groundwater

As far as groundwater is concerned, noxious modifications of the quantitative and chemical condition must be avoided and the environmental objectives "good quantitative status" and "good chemical status" (Chapter 4.2) must be reached.

The general wording of the targets will be specified by the states or federal states/regions. Sometimes, hydraulic links to groundwater bodies exist at the borders between federal states and between states. In these cases, the classifications and the measures required to achieve the targets are coordinated bilaterally, e.g. between the Netherlands and the German federal state North Rhine Westphalia.

Therefore, a coordination of objectives for groundwater is limited to neighbouring states (on Level B). A more detailed description of the targets for groundwater and the corresponding coordination is given in the relevant reports on level B.

Moreover, the WFD stipulates the requirement that the "Member States implement the required measures, in order to reverse the trend in all cases of sustained upward trends of pollutant concentrations due to human activities".



Figure 19: Timeframes for the achievement of the quantitative status (left) and the chemical status (right) objectives for all 585 groundwater bodies in the Rhine IFGE. State: March 2022; data without Switzerland, see text of Figure12

Figure 19 (left) and Map K 28 show today's assessment of the states in the IRBD Rhine with respect to the target achievement for the quantitative status of the groundwater; Figure 19 (right) and Map K 29 represent the corresponding data for the chemical status of the groundwater bodies.

Accordingly, it is expected that in addition to the 97% of groundwater bodies in the Rhine IFGE that have already achieved the objective of good quantitative status, another 0.2% will achieve the objective in the period 2022-2027.For 3% of the groundwater bodies there is no data on the target achievement of the objectives with regard to the year 2027 available.

For the chemical status, in addition to the 74% of groundwater bodies that have already achieved the objective of the good chemical status, a further 3% are expected to achieve the objective in the period 2022-2027 and a further 22% only after 2027. For 1% of the groundwater bodies there is no data on the target achievement of the objectives with regard to the year 2027 available.

5.3 Protection areas

Article 4, Par. 1, c WFD determines the targets for protection areas: Member States shall "achieve compliance with any standards and objectives at the latest 15 years after the date of entry into force of this directive unless otherwise specified in the Community legislation under which the individual protected areas have been established". For these targets mainly the adaptation possibilities offered by the WFD apply.

Thus, two kinds of objectives must be achieved for protected areas: i.e. specific objectives of the directive concerned and which are decisive for the designation of an area (see WFD Annex IV) and the individual national standards of implementation and objectives of the WFD. The protected areas to consider are listed in WFD Annex IV. They correspond to:

- On the one hand, (present and future) water bodies for human use and to be designated according to Article 7, par. 1 WFD. On a daily basis, these water bodies deliver more than 10 m³ of water for human consumption or deliver such water to more than 50 people;
- On the other hand, water bodies used for bathing and water sports.

The other protected areas do not exclusively consist of water bodies:

- "Sensitive" areas in the sense of Directive 91/271/EEC on the treatment of municipal wastewater;
- "Areas at risk" in the sense of Nitrates Directive 91/676/EEC concerning the

protection of waters against pollution caused by nitrates of agricultural origin;

Habitat and species protection areas if, according to Habitats Directive 92/43/EEC of 21 May 1992 concerning the protection of natural habitats and wildlife fauna and flora and the Bird Protection Directive 79/409/EEC of 2 April 1979 concerning the preservation of bird wildlife, conservation or improvement of the state of the water is an important protection factor.

In the meantime, the Directive 2006/44/EC of 6 September 2006 on the quality of fresh waters needing protection or improvement in order to support fish life and the Directive 2006/113/EC of 12 December 2006 on the required quality of shellfish waters quoted in the WFD and mentioned in the Management Plan 2009 have been repealed.

Please refer to explanations given in Chapter 3 and relevant maps.

5.4 Adapting environment objectives for surface waters and groundwater, reasons

The implementation of the WFD is a complex process that is fraught with some uncertainties in terms of measure selection, measure implementation and target achievement.

The states in the Rhine catchment will make every effort to bring as many water bodies as possible to the good status by 2027 and to take as many measures as possible.

The WFD's timeframes for achieving good water status or target status are very ambitious. They also increasingly collide with global, anthropogenic changes (e.g. the effects of climate change).

The WFD basically provides that 15 years after its entry into force, i.e. by the end of 2015, good status should be achieved in all water bodies. Under certain circumstances, an extension of the deadline is possible (Art. 4 para. 4).

The WFD allows for less stringent objectives to be set if there is sufficient justification (Art. 4 para. 5). An exception is also possible in certain cases in the event of a failure to achieve the objective or deterioration of the status as a result of unforeseen circumstances (Art. 4 para. 6) or new interventions of overriding public interest (Art. 4 para. 7).

All these exemptions may only be used if they do not lead to a permanent failure to achieve objectives in other water bodies (Art. 4 para. 8 WFD). In the case of possible cross-border effects, the states - as in the past - will coordinate as early as possible on a bilateral level.

5.4.1 Extension of deadlines

Deadline extensions according to Article 4 para. 4 WFD are possible if

- the envisaged measures are technically feasible only gradually over a longer period of time, or
- compliance with the time limit would involve disproportionate effort, or
- the necessary improvements in water status cannot be achieved in time due to natural conditions.

Extension of deadline due to technical feasibility

It includes cases where a technical solution is not yet available, e.g. there is a need for research and development to derive suitable measures, or there is not enough information about the cause of the exposure.

Extension of time limit due to disproportionate effort

This extension of time is relevant if the realisation of the measures would cause a disproportionately high effort - in particular disproportionately high costs. The case that the financial burden of those who bear the costs ("cost bearers") is too high and a financial stretching has to be considered is also covered by this extension of the deadline.

Extension of deadline due to natural conditions

"Natural conditions" are all processes and conditions naturally occurring in a catchment that determine the rate of natural restoration of water bodies to good status or potential (e.g. hydrological, morphological, hydrogeological, chemical, biological, etc.). The achievement of the good status is therefore not considered impossible, but it is estimated that naturally given factors ensure that the water body will only develop towards good status at a later stage, despite taking all measures considered necessary. "Natural conditions" in this sense also include circumstances that, with their consequential effects, delay the recovery process of earlier human activities.

The deadline for achieving the target can be extended twice by six years each time, i.e. to a maximum of 2027. This does not apply to new priority substances, for which different regulations with deadlines until 2033 or 2039 apply. Otherwise, a deadline extension beyond 2027 is only permissible if the achievement of the target is missed due to natural circumstances. The same applies here as for the deadline extension to 2027.

The information on the reasons for the extension of the deadline and on the measures still required must be presented with reference to the water bodies concerned. The details can be found in the management plans (Parts B).

Examples of reasons for deadline extensions in the IRBD Rhine

Surface water bodies

For the extension of the deadline it is e.g. Possible to claim the lack of technical feasibility for water bodies for which further investigations are needed to find out the cause of the inadequate status and to develop cost-effective measures. The time required to carefully go through land acquisition procedures may also justify such a claim.

Due to the failure to achieve good chemical status because of the ubiquitous pollutants mercury and brominated diphenyl ethers (BDE), an extension of the deadline is claimed because of natural conditions.

Due to natural reproductive phases and/or immigration the fish biocoenoses required for the good status can only develop again with a delay in the required composition and abundance after river continuity has been re-established, the required habitats have been created and the limiting substance pollution has been eliminated.

<u>Groundwater</u>

For groundwater bodies, an extension of the deadline is claimed due to natural conditions because of nitrate or chloride pressures that still exceed the threshold values due to longer groundwater renewal periods and despite measures taken. Due to the composition of the soil, the geological conditions and the material conversion processes in the soil, pollutants only reach the groundwater with sometimes considerable delays and are also only transported away very slowly. Accordingly, the effect of measures only becomes apparent with a considerable time lag.

5.4.2 Setting less stringent objectives

For water bodies that are so impaired by human activity or whose natural conditions are such that, based on current knowledge, the achievement of good status is either

impossible or would involve disproportionate effort, less stringent objectives may be set under the conditions of Article 4 para. 5 WFD.

Human activities include all ongoing anthropogenic influences on the status of water bodies, such as water uses for transport, energy production, land reclamation and raw material extraction or lignite mining.

Achieving good status is (according to current knowledge) impossible for technical reasons, i.e. no suitable measures exist according to the current state of science and technology to achieve good status. Or, according to current knowledge, the achievement of the good status is associated with disproportionate effort.

Another prerequisite is that no better environmental option exists.

As a less stringent environmental objective, the best possible condition/potential must be achieved.

Examples

Lignite mining on the left bank of the Lower Rhine, which will continue for a longer period of time, will both lower the groundwater level and cause impacts on the water flow in a number of surface water bodies. The chemical groundwater status is also affected. The same applies to lime mining in the Mettmann/Wuppertal area.

Less stringent objectives are set for affected water bodies because of the long-term effects.

Article 4 para. 3 - 5 WFD have partly similar requirements and therefore the requirements and examples mentioned here are also used by states for the designation of heavily modified water bodies or when making use of Article 4 para. 4. With regard to the use of extensions and derogations, please refer to the national management plans for details.

5.4.3 Exception "temporary deterioration"

According to Article 4 para. 6 WFD, a temporary deterioration in status can be caused, for example, by circumstances arising from natural causes or force majeure that are exceptional or could not reasonably have been foreseen, in particular severe floods or prolonged droughts.

Examples

The Netherlands has made use of the "temporary deterioration" exemption for some surface water bodies to a greater extent than in the previous period of the Management Plan. This deterioration is particularly the result of the dry periods in 2018, 2019 and 2020.

5.4.4 Exceptions due to failure to achieve objectives or deterioration of status

According to Article 4 para. 7 WFD, failure to achieve the good groundwater status, good ecological status/potential or to prevent deterioration in the status of a water body is permissible if it is due to a new modification of the physical characteristics of the water body, if the reasons for the modification are of overriding public interest or if the benefits of the new modification for human health or safety or for sustainable development outweigh the benefits, the achievement of the management objectives for the environment and the general public, or if the objectives associated with the modification of the water body cannot be achieved by other appropriate measures which have significantly less adverse impact on the environment, are technically feasible and do not involve disproportionate effort.

An exception is also possible in the case of deterioration from high to good status of a surface water body if it is based on a new sustainable human development activity and the above conditions are met.

Examples

Both lignite mining on the left bank of the Lower Rhine and limestone extraction in the Wuppertal Massenkalk continue to progress and require further intervention in the water balance. For the water bodies concerned, appropriate exemptions are defined in accordance with Article 4 para. 7 WFD.

6. Economic analysis

The WFD integrates economic aspects into European water policy. Within the survey and for management plans it requires:

- An economic analysis of the water use presenting the economic background for present uses and contaminations of the water bodies (WFD Article 5, point 3 and Annex III of the WFD).
- A prognosis of the development of anthropogenic activities for the management period to come (until end 2027) within the so-called baseline scenario (WFD Article 5, para. 1, 3rd indent and Annex III of the WFD).
- To take into account the principle of covering the expenses for water services, including environmental and resource-related expenses (WFD Article 9 and Annex III).

On the one hand, the economic analysis contributes to pointing out the socio-economic importance of water use. On the other hand, the anthropogenic causes ("driving forces") behind the present pollution of waters are represented. Thus, the economic analysis of water use gives information required for planning measures.

The following presentation is a trans-national summary. Also, with respect to identifying the most cost-efficient combination of measures (WFD Annex III, b), reference is made to the detailed presentations in the management plans (B Parts). Chapter 7.2.2 gives information on the recovery of costs for water services.

6.1 Economic importance of water use

The economic description of water use underlines the economic importance (for value added, labour market and the supply of the population and of economy with required goods and resources) and the material extent of water use (abstraction or amount of discharge) for a catchment. This establishes a connection between economic activities and the environment.

Population

More than 60 million people live in the IRBD Rhine (basis: 2016), spread over 9 states. That amounts to about 2 million more than in 2000. The average population density represents about 321 inhabitants/km², however, the population is not evenly distributed over the different states. With about 56 inhabitants/km² the Walloon part of the IRBD Rhine has the least population density, while the Dutch part has the highest population density with 491 inhabitants/km² (see Table 2).

Almost the entire population (already about 99% in 2000) living in the IRBD Rhine is connected to public drinking water works.

The Rhine directly or indirectly supplies drinking water for approx. 30 million inhabitants. This corresponds to half of the population in the Rhine catchment. The drinking water consumption per capita was in overall decreasing, for a long time. In the Netherlands, however, it has increased again under the influence of warm summers.

The major part (about 96%) of the population in the IRBD Rhine is connected to a sewerage system.

On average, 2% of the population in the IRBD Rhine have septic tanks, which means that about one million inhabitants have their own treatment system.

Today, the treatment capacity of the sewerage treatment plants in the IRBD Rhine amounts to about 106 million population equivalents. At present, this treatment capacity which has hardly changed during the past years covers the requirements of the population and of those industrial plants connected to a public sewerage plant.

Agriculture

During the second half of the last century, agriculture in Europe, and therefore also in the IRBD Rhine, has been considerably intensified. Among others, due to the progressive extension of the exploitation only a few per cent of the working population are working in agriculture. About half of the surface of the international river basin district Rhine is being used for agricultural purposes.

The sector faces various challenges and uncertainties (including retail pressure on price margins, changing national and European regulations, climate change), which impact on costs and business continuity. As a result, diversification and expansion of activities are taking place.

The share of organic cropland in the total national agricultural area varied between about 3% and 39% in the countries of the IRBD Rhine in 2018 and is about 8.5% for the total national areas (cf. Figure 20). Liechtenstein has the highest share, followed by Austria and Switzerland. The lowest shares of organic farmland are found in Luxembourg and the Netherlands.

The increase in organic farming, which abstains from the use of synthetic plant protection products and synthetic mineral fertilisers (cf. ICPR Technical Reports No. 240 and 278) and produces less excreta through area-based animal husbandry, thus positively contributes to a reduction in water pollution with synthetic plant protection products and nutrient surpluses.



Figure 20: Share of organic cropland in total national agricultural land in % and ha in 2018 (*: Switzerland, Liechtenstein, Austria, Germany, France, Luxembourg, Belgium and the Netherlands)⁷²

⁷² https://statistics.fibl.org/europe/area.html
Industry

Over the last few centuries, industrial activities in the IRBD Rhine particularly concentrated on the metal processing and chemical industry. During the last century, coal and nuclear power plants producing energy and refineries settled in the area. In some regions (e.g. the Ruhr area) there was a decline in heavy industry and a shift to the service sector from the 1970s onwards. Since 2015, several nuclear power plants have been shut down (Mühleberg/CH 2019, Philippsburg/DE 2019, Fessenheim/FR 2020).

Due to the planned lignite phase-out by 2038, several lignite-fired power plants will be shut down on the left bank of the Lower Rhine from 2020 onwards. The first power plant unit with a capacity of 300 megawatts was shut down in 2020. Further power plant units with a total capacity of 2,500 MW will follow in the next two years. RWE will shut down two thirds of its lignite capacity by 2030.⁷³

To give an idea of the development in one of the most important industrial areas in the Rhine catchment during the past years, some facts and illustrations of the chemical industry in the European Union are given⁷⁴, however without wanting to give the impression that this applies "pars pro toto" to the entire industry.

In 2018, worldwide the turnover of the chemical production amounted to some 3,347 billion Euros. In 2013 it amounted to about 3,165 billion Euros. The EU share of global sales has fallen significantly from 2008 until approximately 2016. In 2019, the share was 17%, just ahead of the US and well behind China. In the last 5 years, the share has been constant (cf. Figure 21). In 2019, there were about 3.3 million direct employees in this sector in the EU.



World share (%)



⁷⁴ Cefic, The European chemical industry

⁷³ <u>https://www.group.rwe/presse/rwe-ag/2020-07-03-kohleausstieg-nach-zwei-jahren-gesetzlich-geregelt</u>

Hydropower plants for power generation

Today, the hydropower of the IRBD Rhine is intensively used for power generation. There are 24 hydropower plants along the Rhine between the confluence of the Anterior and Posterior Rhine to the estuary of the North Sea.

The installed power of the hydropower plants along the Rhine and its most important tributaries is more than 2,200 MW. The greatest concentration of power plant production is to be found on the High Rhine and the southern Upper Rhine. Before extending the Iffezheim power plant as of 2009, the maximal total production of all 10 hydro power plants on the Upper Rhine amounted to 1,400 MW, while the average production per year amounted to 8,7 billion kWh per year.⁷⁵ During 2009 to 2013, a fifth turbine was installed at the Iffezheim power plant. Small power plants (weir turbines) have been installed in the new fish passages at the impoundments in Strasbourg and Kembs/Märkt.

In the basic water network of the IRBD Rhine Part A (catchment > 2,500 km²), a total of 159 hydropower plants are installed (data refers only to transverse structures > 2 m head, processing status: 31 October 2019)

Hydropower also plays a role in the tributaries.

Navigation and transport

Navigation has long been an important use of the Rhine. As early as 1816, after the Congress of Vienna, a commission met (the later Central Commission for Navigation on the Rhine, CCNR) to work out a common agreement. The Mainz Act of 1831 and the Mannheim Act of 1868 established uniform regulations for shipping.

From its outlet into the North Sea until Rheinfelden near Basel some 800 km further upstream the Rhine resp. its estuary rivers Waal and Nederrijn/Lek are being used as shipping lane.

In order to keep up navigation, maintenance measures must be carried out on the banks, in the riverbed and regarding infrastructures. These works include, for example, the repair of the bank revetments, dredging to eliminate deficiencies in the navigation channel, the addition of bedload replacement material and the maintenance of groynes. Regularly, maintenance work is also required in installations such as sluices, berthing areas and ports.

The Rhine is the by far most important waterway in Europe: about two thirds of the entire transport of goods on European waterways is passing by the Rhine. The Rhine and the Moselle have a status as international navigation lane; their use is regulated by international treaties.

Apart from national transport, the goods handled in the ZARA-ports (Zeebrugge, Amsterdam, Rotterdam and Antwerp) are transported on the Rhine and its adjacent waterways to the Netherlands, to Germany, Luxembourg, Belgium, France, Switzerland and into the Danube area. On the other hand, the Rhine is also used for the transportation of export goods.

Annually, more than 300 million tons of goods are transported on the navigable Rhine. The transport of bulk goods over longer distances dominates. This is a decisive location factor for the industries concerned (steel industry, chemical industry, energy sector, etc.). The cargo types are distributed as follows: 56% dry bulk (coal, iron ore, sand/gravel), 23% liquid bulk, 7% general cargo and 2% other. The share of containerised goods is 12%, whereas the share of value added is significantly higher (cf. Figure 22). Container shipping represents an above average growing transportation market and has almost doubled between 2000 and 2017. According to their processing or production, upstream traffic dominates for ores and mineral oil and downstream traffic for sand/gravel.

⁷⁵ Information board at the Vogelgrun power plant, July 2015

The majority of the shipping companies is located in the Netherlands or Germany. The net turnover of German cargo shipping companies in 2016 was approximately \in 1.64 billion and in the Netherlands \in 2.36 billion.

Another important development is the increase in the average cargo capacity of ships, with a simultaneous decrease in the total number of ships.



Figure 22: Freight traffic on the Rhine by type of cargo and quarters in million t (Source: CCNR market monitoring)

For further information, please refer to the CCNR.

Passenger shipping also plays a role in Germany with over 700 passenger ships and \in 0.52 billion net turnover and in the Netherlands with over 600 passenger ships and \in 0.2 billion net turnover (data for entire states).

Lake Constance is important for leisure navigation and the tourism infrastructure. The International Commission for Navigation on Lake Constance (ISKB) deals with uniform regulations for shipping equally comprising exhaust emission standards. At present, some 58.000 boats/ships are registered on Lake Constance.

Fishery, tourism, sand and gravel pits

The net result of fishing in the Netherlands showed an upward trend from 2012 onwards and amounted to around \notin 90 million in 2016. In 2018, the net result was approximately \notin 50 million. For the Dutch fishery, the Rhine delta is the most important area. The most important segments of Dutch fishery are fishing from small vessels, deep sea fishing and mussel and oyster farming. Fishing in Lake IJssel and in other inland waters is of little importance.

Other uses, such as water tourism, for example on the Moselle and Lahn rivers, the operation of sand and gravel pits are only of regional importance.

6.2 Baseline Scenario

The "baseline scenario" with its 2027 deadline is to provide insights into the presumable development of water uses with decisive impact on the status of the water bodies. After a description of the actual situation of water uses (Chapter 6.1) the development of anthropogenic activities until 2027 is to be assessed within the framework of the risk analysis. It considers the development of the population, of economy and surface use as well as the water uses (water intake and wastewater discharge, agriculture, navigation, hydropower plants).

Apart from the development of relevant socio-economic parameters and the development of anthropogenic parameters liable to impact the pollution of water bodies, the risk analysis takes into account the effects of WFD measures implemented by 2021, as well as of climate development and its effects on water management.

Increasing demand for biomass products and exportation of foodstuff are e.g. expected to lead to increased production in agriculture. Against the background of the "European Green Deal" as well as increased efforts of all states in the Rhine catchment area to increase the share of agricultural land with ecological farming, a reduction of water pollution from agriculture seems possible in parallel to this growth trend.

Traffic volumes for shipping are currently stagnating and further development is difficult to forecast. So far, an annual increase of approx. 2-3% of the transport volume has been assumed.

In view of the low water years 2018 and 2019, there are discussions in the shipping sector about appropriate climate change adaptation measures⁷⁶. In addition to demands for the elimination of navigational channel narrows or more far-reaching measures, there are also voices calling for a turn away from the trend towards ever larger ships⁷⁷. But new ship types with less draught but the same unloading capacity are also under development

No data on the gross value added of business in all states of the international river basin district Rhine have been gathered. Since March 2020, the Rhine catchment area has also been affected by the COVID 19 pandemic. The pandemic with several "lock downs" has temporarily led to a sharp economic decline in economic activities in the Rhine catchment. In the meantime, the economy has recovered.

The gradual phasing out of fossil fuels and nuclear energy will lead to a trend towards a decrease in mining and the associated water pollution and a trend towards a decrease in heat discharges from power plants in the states in the Rhine catchment area.

Apart from recent developments in migration, demographic change is expected to lead to a decline in population numbers in the Rhine catchment area after a certain point in time, and the share of elderly citizens will increase (cf. Figure 23). However, regionally and locally, the population development will differ. Economically strong conurbations such as the Randstad in the Netherlands, the Cologne/Bonn area or Strasbourg and Basel are recording inward migration. For example, compared to 2019, the Netherlands expects a population growth of 4% in the Rhine catchment area by 2027 and the population would then amount to 12.8 million people. Compared to 2018 figures, Luxembourg is predicted to grow by a remarkable almost 56% by 2050, which would lead to a total population of 940,000. The population in Luxembourg is thus one of the fastest growing populations in the European Union.

Population growth can lead to greater pressure on the use of water bodies.

In rural areas or old industrial areas such as the Ruhr region, the population tends to decline. For spatial technical infrastructures such as water and wastewater this development requires an adaptation, since the efficiency of these infrastructures above

⁷⁶ cf. Action Plan "Low Water Rhine" ("8-point plan") signed on 4 July 2019 by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) and by representants of the chemical industry and inland navigation ⁷⁷ Reflection paper "Act now!" on the topic of low water and impacts on Rhine navigation, Edition 1.0 of 17 June 2020. https://www.ccr-zkr.org/files/documents/workshops/wrshp261119/ien20_06de.pdf

all depends on the population density. If the number of users decreases, operational issues could require additional technical changes.

For the water and wastewater infrastructure systems, high capital intensity and a long useful life, especially of the pipe networks, mean local flexibility is limited. This again requires foresighted planning and taking into account changing prerequisites on the long term.

Concerning the effects of the demographic change, a differentiation may be made between operational effects on water distribution, wastewater transportation systems and wastewater treatment plants and ecological, structural and economic effects. A declining number of inhabitants leads to less water consumption. Changes in the use of pharmaceuticals due to an ageing population may lead to higher concentrations of pharmaceutical residues in the wastewater. Less water consumption may lead to deposits, corrosion, odours development and to an unfavourable C/N relationship due to decomposition in the canal. Perhaps an adaptation of capacities of the sewer and the wastewater treatment plants may be required, eventually plants must even be shut down and dismantled.

For water supply and for sewage disposal, decreasing numbers of users mean less water and wastewater volumes which, considering today's rate structures mean less receipts.



Figure 23: Population development in the EU NUTS-II regions (2015- 2050). Data source: Eurostat

7. Summary of the programmes of measures

7.1 Summary of measures to solve the major management problems in the international Rhine river basin district

The measures of the EU states resp. federal states / regions aimed at solving the major management issues in the IRBD Rhine summarized in Chapter 7.1 on the one hand relate to **measures implemented during 2015 to 2021** and on the other hand, this chapter deals with the **measures within the River Basin Management Plan 2022-2027 IRBD Rhine still to be executed.**

7.1.1 Increase habitat diversity, restore ecological continuity

As a result of the successful restoration of Rhine water quality under the Rhine Action Programme (1987- 2000 2000) and due to the programme "Rhine 2020" (2001-2020), the biocoenosis of the Rhine has recovered. As the balance of the implementation of the programme "Rhine 2020"⁷⁸ shows, considerable progress has been made with respect to restoring river continuity and increasing habitat variety in the Rhine catchment. Further action is required to achieve the good ecological status or potential.

The effects of the programmes of measure on the biocoenosis cannot always be clearly distinguished from natural biological interactions. Much is being covered up by newly immigrating species (neozoa). Even though the present ecological classification of the Rhine ecosystem as presented in Chapter 4.1 only represents today's system status, distinct and sustainable ecological improvements can be seen in the long-term trends of the last 25 years. Table 10 shows how the future implementation of different ecological measures could contribute to continue this trend.

In future, the implementation of the different ecological measures and continued intensive, coordinated biological monitoring will make it possible to observe long-standing trends and developments on the basis of robust data. This is in particular valuable with respect to climate change.

In the following, general and specific measures are described which may further improve the conditions of life for flora and fauna in the Rhine and its tributaries, in other words, which may improve the ecological performance of the entire water system and which can contribute to the achievement of a good ecological status / potential. The necessary measures are included in the programmes of measures of the states in the Rhine catchment.

⁷⁸ Balance "Rhine 2020" (2020)

Table 10: Ecological measures in the main stream of the Rhine and their positive effect (+) on the biological quality components

	Effect on biological quality element						
Measure	Macrozoobenthos	Fish fauna	Phytoplankton	Phytobenthos	Macrophytes	Where observed	
Reduction of nutrient pollution (see Chapter 7.1.2)	(+) more natural community	(+) more natural community, less biomass	(+) more natural community, less biomass	(+) more natural community	(+) enhancement of stocks by less shading of the water bottom (less phytoplankton)	Entire main stream of the Rhine (see ICPR report no. 273, 275, 279 ⁷⁹)	
Removal of bank protections (especially bank reinforcement with armourstone) / Reduction of the degree of bank protection (see chapter 7.1.1.2)	(+) Increase species diversity; reduce alien (especially sessile) species	(+) reduction of invasive gobies			(+) Increase biodiversity	Entire main stream of the Rhine (see ICPR report no. 223)	
Parallel constructions or filled up groynes as shallow replacement habitats rich in structure, protected from the lapping of waves.(see Chapter 7.1.1.2)	(+)	(+) in particular enhancement of juvenile fish	(+)	(+)	(+) Increase biodiversity	Middle Rhine, Lower Rhine, Delta Rhine (see ICPR reports no. 274, 279)	
Improving the connection of tributaries, floodplain waters and oxbow lakes / lateral continuity, reconnection of floodplains (see chapter 7.1.1.2)	(+) Recolonisation by native species from refugia in tributaries	(+) enhancement of species spawning on plants and gravel; favouring the reproduction of rheophile species (rudd, pike, tench); juvenile fish habitats for other species			(+) Seed dispersal	Entire main stream the Rhine (see ICPR report no. 223, and Chapter 7 in the 2nd Management Plan for the Rhine 2022-2027)	
Construction or optimization of structures for up- and downstream fish migration(see Chapter 7.1.1.1)	(+) concerns only upstream migration facilities	(+) Long distance migratory fish reach spawning waters; middle-distance migratory fish may change habitat (according to their life- cycle); linking of local population shares => enhanced fitness			(+) spreading of seed with upstream migrating fish (zoochory)	Delta Rhine Upper Rhine High Rhine and Rhine tributaries (see Annex 7 in the Management Plan for the Rhine 2022-2027)	

⁷⁹ ICPR technical report no. 279 (2021)

7.1.1.1 Restoration of ecological continuity

The restoration of continuity in the Rhine river basin district in the basic network of water bodies of the IRBD Rhine (Level A, $> 2,500 \text{ km}^2$) plays the most important role for diadromous fish species. These are migratory fish migrating between fresh and salt water and which thus spend one phase of their life in the see and one in the Rhine or its tributaries.

Since the "Rhine Action Programme", the **salmon** (*Salmo salar*) is a symbol representing many other migratory fish species, such as sea trout, sea lamprey and eel. In the Alpine Rhine / Lake Constance sub-basin, the **Lake Constance lake trout** (*Salmo trutta-*) is the only long-distance migratory fish. Here, a successful programme has been going on since about two decades.

The "Master Plan Migratory Fish Rhine"⁸⁰, updated in 2018, shows how migratory fish species can be conserved and permanently reintroduced in the Rhine area. According to this study, in the so-called programme waters of the Rhine catchment, as many identified spawning and juvenile fish habitats as possible must again be made accessible and/or revitalised. Among others things, upstream migration must be improved. In particular the salmon characterized by a very strong homing depends on the accessibility of these waters from the sea. All of the measures indicated not only secure the positive development of fish stocks, but they equally contribute to an enhanced buffer capacity of the river system against an important increase in temperatures caused by climate change.

The progress made in restoring the ecological continuity of the Rhine and in its catchment area was documented in the balance "Rhine 2020"⁸¹ and presented on the occasion of the 16th Conference of Rhine Ministers 2020 and published subsequently.

The measures already implemented and aimed at improving river continuity for fish in the main stream of the Rhine and in the Dutch arms of the Rhine and the state of implementation of further measures relevant for the continuity of the Upper Rhine are detailed in the ICPR Technical report no. 262 (2019).

Map K 30 shows the progress achieved by the end of 2021 in restoring the accessibility of spawning and juvenile fish habitats in the programme waters for migratory fish as well as the need for further measures. Fish may freely migrate upstream the main stream of the Rhine as far as Iffezheim. Fish can reach as far as Rhinau (southern Upper Rhine) via the fish passes at the barrages Iffezheim, Gambsheim, Strasbourg and Gerstheim. In some tributaries such as Kinzig and Ahr, many of the ancestral spawning areas are connected to the Rhine, again and a natural reproduction is observed, regularly.

The overview in Annex 7 shows in which programme waters and where in the main stream of the Rhine transverse structures for migratory fish have been made passable by the end of 2021 or where such measures as well as further measures for migratory fish are planned until 2021. Altogether, more than 2000 measures at an estimated cost of nearly one billion euros will be implemented by 2027, since the beginning of the implementation of measures for migratory fish since the 1990s,.

The 16th Conference of Rhine Ministers has adopted the "Rhine 2040" Programme and considers it necessary to take measures in the following areas, among others:

• the ecological continuity of the Rhine for migratory fish from its mouth to the Rhine Falls (including thresholds in the Rhine loops), as well as in its major tributaries, in particular the Moselle (up to the mouth of the river Sauer) as an international tributary, including the programme waters of the Master Plan Migratory Fish, is to be restored;

⁸⁰ ICPR technical report no. 247 (2018)

⁸¹ Balance "Rhine 2020" (2020)

- the fish pass at Rhinau will be operational in 2024; the fish pass at Marckolsheim will be operational in 2026; the fish pass for the complex Vogelgrun area will be operational as soon as possible to ensure compliance with the relevant EU legislation in order to allow migratory fish to reach the Old (-Rest)-Rhine and Basel again. France will specify any necessary technical and financial measures beforehand;
- river continuity for fish in the High Rhine up to the Rhine Falls and in the Swiss programme waters (Aare, Reuss, Limmat) will be implemented by 2030;
- by 2030, another 300 fish migration obstacles in the catchment area are to be made passable again, thus reconnecting about 60% of the potential and valuable migratory fish habitats to the Rhine;

As a matter of principle, the restoration of river continuity concerns the **up- and downstream** migration of fish. However, few technical measures are known with respect to the question of how to **protect downstream migrating fish** at hydropower plants. Therefore, in a first approach, measures aimed at improving upstream migration were first considered for the main stream of the Rhine.

For smaller rivers, including some tributaries of the Rhine, functioning fish protection devices already exist, so that downstream migration through these waters will be included in the Master Plan.

Regular exchange of experience between experts has shown that the downstream fish migration (fish descent) at hydropower plants in the Rhine and its major tributaries including the programme waters of the Master Plan Migratory Fish has to be ensured in such a way that healthy fish populations are maintained in the long run. This was reaffirmed at the 16th Conference of Rhine Ministers in February 2020. States will assess available structural or operational measures to mitigate fish mortality during descent to identify the most appropriate measures for small, medium and large hydropower plants and implement them where feasible. The ICPR will develop recommendations for fish protection and fish migration by 2024. For the restoration of downstream fish migration for large hydropower plants, the research efforts from Switzerland (see below), among others, will be continued and the exchange on the state of research and knowledge in the ICPR will be continued.

On the whole, the following applies to the present state of knowledge and downstream fish migration in the Rhine catchment⁸²:

For existing small hydropower plants with a nominal discharge up to 50 m³/s we dispose of experience with well-functioning downstream fishways. Switzerland also disposes of experience with functioning devices for existing hydropower plants up to 100 m³/s.

At medium-sized power plants with a nominal discharge up to 150 m³/s several investigations were made in the past years, and these were retrofitted. For this order of magnitude several power plants have been equipped with functioning downstream fishways.

For big hydroelectric plants with a nominal discharge above 150 m³/s and in particular for the big hydropower plants along the Rhine there does not yet exist any satisfactory, implementable technique. There still is urgent need for research and development with respect to these issues. Also, the concepts must be investigated into under fishecological aspects, in order to determine their functionality.

However, during downstream migration, operational measures (for example turbine operation (full load instead of partial load) and periodical opening of weir fields) can already now potentially reduce losses. So far, there have been only a few accompanying ecological studies. Therefore, the different installations should also be examined with respect to their potential for optimization and effect.

⁸² ICPR technical report no. 247 (2018)

Measures for migratory fish in the main stream of the Rhine and in the programme waters

In the following, specific measures for migratory fish are described, which are implemented in the main stream of the Rhine and in the individual programme waters.

Delta Rhine

Due to the ramification of the Rhine just downstream of Lobith, at the German-Dutch border the total runoff of the Rhine spreads over all three arms (about 2/3 Waal, 2/9 Nederrijn-Lek und 1/9 IJssel).

Fish migrating upstream from the sea, such as Atlantic salmon, sea trout and allice shad may today freely migrate upstream from the North Sea via the Nieuwe Waterweg near Rotterdam and the (shipping lane) Waal.

With the implementation of the 'Kier' project (cost: 80 million \in) since 15 November 2018, the path for salmon migrating from the North Sea into the rivers Meuse and Rhine is also open again in the estuary area of the Haringvliet (south of Rotterdam), provided there is sufficient discharge.

Work is currently underway to further optimise the lock management at the Driel barrage in the Nederrijn-Lek so that the fishway also functions at low water levels.

At the Afsluitdijk, the continuity between Lake Ijssel and the North Sea will be further improved by the construction of a fish migration river at Kornwerderzand (lock complex on the eastern side of the Afsluitdijk; estimated costs € 55 million; construction start 2020, expected realisation 2024, cf. Figure 24).



Figure 24: Construction of the fish migration river, July 2020 © Rijkswaterstaat

Rhine from the German-Dutch border

From the German-Dutch border (Rhine km 700) onwards, fish may freely migrate upstream the main stream of the Rhine as far as Iffezheim (Rhine km 334) and can reach as far as Rhinau via the fish passes at the barrages Iffezheim, Gambsheim, Strasbourg and Gerstheim after the commissioning of the fish pass Gerstheim (Rhine km 272) in June 2019.

Many measures are implemented in the programme waters and in some large tributaries, especially those that serve as connecting waters between the Rhine and the programme waters.

Lower Rhine and tributaries

On the **Lower Rhine**, the tributaries **Wupper** and its tributary **Dhünn**, and the **Sieg** with its tributaries **Agger** and **Bröl** with more than 200 ha juvenile salmon habitats are of great importance for the reproduction of migratory fish and for establishing a stable salmon population. R. Lippe is no programme water; however, migratory fish (stray fish from salmon reintroduction, sea trout, lampreys) occur which means that measures aimed at restoring river continuity and at improving spawning habitats are important there too.

Middle Rhine and tributaries

Along the **Middle Rhine**, **Moselle** and **Lahn** are the biggest tributaries. They connect water bodies and their main function is to grant the greatest possible freedom of fish migration to the spawning grounds and juvenile habitats of migratory fish further upstream.

On the **Moselle**, passability (starting from the mouth) is being systematically improved at all 10 barrages from Koblenz to Trier on German territory as compensation for interventions in connection with the construction of second lock chambers. In Koblenz, the fish passage and its visitors' centre "Mosellum" were inaugurated in September 2011 (see Figure 25).



Figure 25: Fish passage and visitor's centre "Mosellum" at the lowermost barrage on the Moselle in Koblenz (photo: Bernd Mockenhaupt)

The modification of the further barrages at Lehmen, Müden, Fankel, St. Adelgund, Enkirch, Zeltingen, Wintrich, Detzem and Trier will, on the long term and in co-operation with Luxemburg, reopen the way towards the habitats in R. Sure (70 ha). For further details please refer to the management plan for the area of operation Moselle - Saar (part B).

Due to 11 barrages - of which only the Nassau barrage and the reactivated hydropower plant Bad Ems are passable so far, the lower and middle reaches of the Lahn in Rhineland-Palatinate are not passable. The technical solution for river continuity at the Lahnstein barrage is at present being analysed by the Bundesanstalt für Wasserbau with the help of a physical model. Upstream of this section, river continuity of the Hessian part of the Lahn was successively achieved at seven weirs or drop structures. 51 further transverse structures in the upper Lahn and 32 transverse structures in tributaries suitable for migratory fish will be modified by 2027 in order to restore river continuity. In the EU-funded integrated LIFE project "Living Lahn - one river, many interests" (LIFE 14-IPE/DE/000022), the Ministry of the Environment Hesse, together with its project partners (Federal Waterways and Shipping Administration, Federal Institute of Hydrology, Ministry of the Environment of Rhineland-Palatinate, Struktur- und Genehmigungsdirektion Nord, Regierungspräsidium Gießen) will set in motion different measures to establish ecological continuity in the Lahn and some of its tributaries. In addition, under the lead of the Waterways and Shipping Authority Mosel-Sahr-Lahn and in cooperation with the project partners, a future concept for the functions and the ecological upgrading of the federal waterway Lahn, will be launched and its implementation will be set in motion- in harmony with the different uses, including the restoration of river continuity (https://www.lila-livinglahn.de/). Different stakeholders, representants of the municipalities as well as citizens were and will be involved in the development. Based on the results of the interest survey and the legal framework, the ecological upgrading has a high priority in this context.

Further measures have been implemented or are planned for the Middle Rhine tributaries **Ahr, Nette, Saynbach, Wisper** and **Nahe**.

Upper Rhine and tributaries

Accessibility of spawning and juvenile habitats in the Hessian tributaries to the Main (Schwarzbach/Taunus, Nidda and Kinzig) and to the Bavarian Main and its tributaries, among other Sinn and the Fränkische Saale are interrupted by impoundments of the Main. In order to improve this situation, a comprehensive concept has been developed by operators of hydro power plants and the federal Wasser- und Schifffahrtsverwaltung (WSV) in Bavaria based on the "Study of river continuity of the navigable part of the Bavarian Main". In Hesse, the bypass at the lowermost barrage on the Main at Kostheim was achieved end 2009, function controls have however pointed out deficits of the upstream and downstream migration passages. Following a request from the regulatory authority, the construction of a second entrance was planned by the operator, approved in 2018 and implemented in 2019-2020. The Wasser- und Schifffahrtsverwaltung is investing a further € 2.3 million in the optimisation of the fish ladder at the Kostheim barrage. The planned modifications of the next barrage on the Main at Eddersheim is a pilot installation of the WSV; work is planned to begin in 2024. Once both these measures have been implemented, the rivers Schwarzbach and Nidda will again be accessible for spawning. Furthermore, the construction of fish passages at two more Hessian barrages on the Main in Offenbach and Mühlheim have been agreed (construction work will presumably not start before 2024). At the hydropower plants at the Offenbach and Mühlheim sites, each with an output of 180 m³/s, a screen field was fitted with a 15 mm screen as a temporary measure for the purpose of fish protection, the flow rates were reduced to maintain the inflow velocity at the screen and the discharge was regulated via the weir fields. The installation of the second screen field is currently being prepared. At the site of the Kostheim hydropower plant on the Main, the planning of a multi-field screen for fish protection is at an advanced stage.

The **Neckar** and its tributaries are neither important migration routes nor habitats for anadromous fish species. When planning and implementing measures, long distance

anadromous migratory fish species such as the eel as a catadromous migratory fish species will be taken in to account. Creating a network of spawning and juvenile habitats also for potamal species is of particular importance for the development of the fish fauna, above all in the 208 km long navigable section of the Neckar between Mannheim and Plochingen. The federal authorities have drafted a concept for action and priorities for restoring river continuity along federal waterways which equally includes the 27 barrages in the federal waterway Neckar.

Apart from restoring the ecological continuity of the entire navigable R. Neckar, measures aimed at creating habitats for species living in the river are to be carried out in the sections of the old Neckar. These sections present the best potential for the river fauna. Thus, sufficient water feeding is crucial. From here, the surrounding structurally impoverished sections of the Neckar and especially the tributaries, e.g. Jagst, Kocher, Enz can be recolonised. Furthermore, for species living in stagnant waters and species without high specific requirements concerning the current, measures must be taken to create habitats in side waters connected only at one end and thus without flow (replacement structures for floodplains) or in parallel channels resp. riverbank structures protected against the lapping of waves.

The lowermost transverse structure at Ladenburg has already been equipped with a fish passage. At the time being, the two upstream fishways at Kochendorf (construction presumably beginning in 2022) and Lauffen are being planned (construction presumably beginning by 2023). Furthermore, the upstream fish passages located at the weir/hydro power plant Wieblingen, the sluice/hydro power plant Horkheim and Gundelsheim are in their planning phases.

Other important tributaries of the Upper Rhine are the rivers **Wieslauter, Murg, Ill** with its tributary **Bruche**, **Alb**, **Rench**, **Kinzig** and **Elz** with its tributary Dreisam.

On the **southern Upper Rhine**, barrages interrupt the continuity of the Rhine. The Iffezheim (2000), Gambsheim (2006), Strasbourg (2016) and Gerstheim (2019) barrages are equipped with fish passes.

Within the migratory fish programme, securing upstream and downstream river continuity at **Rhinau, Marckolsheim and Vogelgrun** in the old bed of the Rhine is a prerequisite for the planned re-colonisation of the upstream waters along the High Rhine in the Basel area and the tributaries of Aare, where the salmon habitats have been mapped. Such measures will contribute to build migratory fish populations in the old bed of the Rhine. In Vogelgrun in particular, the situation is complex, among other things because the navigation canal and a Rhine island with a hill lie between the entrance of the upstream migrating fish at the barrage Vogelgrun and the Altrhein, which is the prioritary migration corridor.

The ICPR has developed two technically and fish-ecologically feasible solutions for a fish ladder in Vogelgrun.⁸³

In accordance with the resolutions of the 16th Conference of Rhine Ministers 2020, the fish pass near Rhinau will be operational in 2024; the fish pass near Marckolsheim will be operational in 2026; the fish pass for the complex Vogelgrun area will be operational as soon as possible.

Furthermore, several **fixed sills** in the **Gerstheim** and **Rhinau loops** are to be made fish-passable.

The 16th Conference of Rhine Ministers 2020 considers it necessary to realise ecological continuity in the Upper Rhine loops as follows:

- Gerstheim loop, the lower threshold (Rappenkopf) by 2023 at the latest,
- Rhinau loop, the two lower sills (Salmengrien and Hausgrund) by 2023 at the latest; if necessary, these two sills will be made passable as part of the planned larger Rhinau Taubergießen renaturation project, then by 2025 at the latest,

⁸³ ICPR technical report no. 262 (2019)

• with regard to further sills in the Gerstheim and Marckolsheim loops, the bilateral coordination in Committee A between Germany and France is continuing.

These measures will open a further section for river continuity into the tributaries and towards Basel. For this section, the total cost estimate is more than \in 80 million for the period of the 2022-2027 plan.

When the river continuity at the three fixed sills in the loops of the Rhine at Gerstheim and Rhein will have been achieved, upstream migration of migratory fish into the Elz-Dreisam catchment area presenting 59 ha spawning and juvenile habitat will be possible. In the Dreisam, the upper courses in the Black Forest are already accessible for migratory fish (see Map K30). In the Elz, migratory fish can already reach the Black Forest, the upper courses will be accessible in 2027 (total expenses: 25.8 million €).

At the **agricultural weirs Kehl and Breisach**, fish protection and downstream fish migration passages were built as part of the construction of small hydropower plants and the operability of the existing fish passages has been improved. The entrance of the fish passage at the agricultural weir Breisach is still to be optimized. A discussion of the process to improve its discoverableness is planned in the Franco-German Committee A. The ICPR will be informed of the results.

Since 2010, numerous measures have been implemented in connection with the concession renewal for the **Kembs** power plant. A new weir hydropower plant (with 2 horizontal-axis turbines with a capacity of 4.2 MW each) near the Kembs barrage (Märkt) was built. The minimum water quantity is 52 m³/s in winter (November – March), between 54 and 80 m³/s (depending on the influx) in April, May, September and October and up to 150 m³/s in summer (June – August). The concession includes a review clause with respect to a possible increase of the residual flow as of 2020.

At the new weir power plant situated on the island in the Rhine, 7 m³/s will be led into a side arm installed leading to the Old Rhine.

New fish passes, one for the ascent and one for the descent (with weir power plant) were installed in 2016 at the end of the power plant upstream the Old Rhine.

High Rhine and tributaries

In the German part of the High Rhine river system, the Wiese upstream its downstream section in Switzerland and some of its tributaries have been identified as areas for reintroducing salmon. In this section, the modification of more transverse structures in the river system and additional habitat measures are planned until 2027. All in all, 22 ha of spawning and juvenile habitats are planned to be made accessible.

Along the High Rhine, the continuity of the water systems of **Birs** and **Ergolz** as well as the **Aare** and its tributaries is being improved, so that more than 200 hectares of spawning habitats will be made accessible.

According to the Swiss law on water protection and fishery, the rehabilitation of all passages due for rehabilitation must be achieved by 2030 at latest, for hydro power plants on the borders the consent of the neighbouring country concerned is required. Also the 16th Conference of Rhine Ministers considers it necessary to restore the ecological continuity in the High Rhine up to the Rhine Falls of Schaffhausen and in the Swiss programme waters (Aare, Reuss, Limmat) by 2030, so that spawning habitats will be made accessible, again. The hydro power plants on the High Rhine are of utmost priority. As far as the Swiss share of the territory is concerned, rehabilitation with a view to restoring river continuity is entirely covered.

On the **High Rhine**, 10 of 11 power plants are equipped with fish passages (Birsfelden, Augst-Wyhlen, Rheinfelden, Ryburg-Schwörstadt, Säckingen, Laufenburg, Albruck-Dogern, Reckingen, Eglisau and Schaffhausen). As regards the fish ladders, there is a need for renewal, however, for some plants. River continuity for fish migration has

already been considerably improved at several hydroelectric plants on the Rhine between Basel and the mouth of the Aare (Augst-Wyhlen, Rheinfelden, Ryburg-Schwörstadt and Albbruck-Dogern) and everywhere at least two well-functioning possibilities for upstream migration have been created. For the power plants in Birsfelden, Säckingen and Laufenburg, the renewal orders have already been issued or planning in order to improve the situation has already begun. Upstream of the mouth of the river Aare, the fish ladder in the power plant Reckingen is currently being renewed – in the context of the ongoing reconcession. At the power plant Eglisau, the renewal has already been implemented. At the power plant Rheinau, the renewal of the residual waterway is long overdue and the renewal of the fish passage faces a rather complex environment. Altogether, it is indispensable that finally all power plant facilities dispose of at least two well-functioning fish ladders, in order to enable fish migration over several dams.

In Switzerland, the measures of the Master Plan Migratory Fish are being extended to the tributaries of the High Rhine and of River Aare so that, once they will have reached Basel, migratory fish may continue further upstream towards the spawning and juvenile habitats (according to new knowledge acquired in 2013 these are located in the **Aare** catchment, for example Aare until Bielersee, Limmat, Reuss, Sihl, Reppisch, Bünz, Suhre, Wigger and tributaries to the High Rhine such as Thur, Töss, Glatt, Mählinbach - about 200 ha for salmon).

The continuity of the Aare as far as the Bieler See (15 transverse structures) will be restored; in addition, there are 2 transverse structures in the Birs (7 have already been altered), one in the Ergolz, 6 in the Biber and one in the Swiss section of the Wiese.

Total costs are estimated to at least 200 to 300 million CHF.

In Switzerland, research continues with respect to restoring downstream fish migration at big hydropower plants. Also, two pilot projects have started on downstream migration in the Aare. Especially for the eel, threatened with extinction in Switzerland, a study for possible solutions for the downstream migration at the Rhine hydropower plants on the High Rhine is being prepared, in order to be able to reduce the high mortality rates. This indicates that great importance is also attached to downstream fish migration in the High Rhine and the other Swiss rivers. This also serves to support the implementation of the decisions of the Conference of Rhine Ministers on 13 February 2020 as regards downstream fish migration.

Alpine Rhine

Several measures aimed at improving river ecology are being implemented in the area of operation **Alpine Rhine / Lake Constance**. The focal points for improving the ecological status/potential of rivers include measures:

- to improve river continuity for fish; in this connection, the Lake Constance lake trout is publicly perceived as an important "symbol species" in the catchment of the Alpine Rhine/Lake Constance;
- to improve the water regime in river sections impacted by diversions (residual flow) or discharges (hydro-peaking);
- to improve river morphology and widening the watercourse corridor.

For the lake trout, the continuity of the **Alpine Rhine** is provided from the outlet into Lake Constance at Rhine-km 94 to the confluence of the Posterior Rhine and the Anterior Rhine at Rhine-km 0. The river bed sills at Buchs (Rhine-km 49.6) and Ellhorn (Rhine-km 33.9) are surmountable for the lake trout but constitute artificial limits of distribution for other fish species. In 2000, a technical fish passage was constructed at the Reichenau power plant (Rhine-km 7). Permanent monitoring proved that this plant does not obstruct upstream migration of the lake trout. Since 2010, both the catches of professional fishermen and the numbers of ascending Lake Constance lake trouts at the control stations on the Alpine Rhine in Reichenau are decreasing in spite of strict

protective regulations. In order to understand this decrease and to formulate countermeasures, an in-depth root cause analysis is being carried out. The focus is here on the runoff and the temperature in the tributaries.

The river section between the Austrian mouth of the III (Rhine-km 65.6) and Lake Constance is currently being planned⁸⁴, which will also involve improvements to the structure of the water body.

Other measures concerning migratory fish

But there is further need for action apart from the construction of new and the optimization of existing up- and downstream fish passages in the Rhine⁸⁵. In many places, further hydromorphological measures and habitat improvements for migratory fish stocks are being carried out (see also Annex 7). These measures will also have a positive effect on other fish species and the entire aquatic fauna and flora.

The **construction of bypasses** and the **nature-near connection of tributaries** are further important measures for migratory fish.

Migratory fish stocks in the Rhine catchment continue to depend on stocking with juvenile fish. Germany, France and Switzerland are trying to reintroduce Atlantic salmon into the Rhine system. Stocking programmes have been running for about 30 years. A small population has since become established, but the population size has not increased in recent years. As part of the search for the reasons, coordinated genetic monitoring was launched in 2018 to assess the success of natural reproduction and different stocking practices in order to develop the best possible stocking strategy.

Apart from these important measures the further reduction of the pollutant load, measures aimed at preserving temperatures near to the natural state and aimed at restoring bedload dynamics, and the restoration of a nature-near water balance are of importance. Measures taken in the marine environment may also greatly impact all longdistance migratory fish. So far, the impact of invasive species on fish communities in the Rhine is largely unknown.

In the entire Rhine catchment and in the Dutch coastal area, catching and possessing salmon and sea trout is forbidden by law. Nevertheless, fishing and also predation influence the population size. Predation is particularly about young salmon being eaten by other fish such as catfish and birds such as cormorants. Commercial and recreational fishers can influence the number of returning adult salmon.

The rate of returnees can only be increased, if by-catches and illegal catches of salmonids on the coast, in the Rhine delta and along the further course of the river will be reduced By creating areas with a ban on fishing (e.g. Along the Haringvliet), with information campaigns, intensified control measures and the consequent application of criminal law, attempts are being made to reduce the rate of salmonid mortality caused by fishery (see ICPR recommendations on the improvement of legal execution to reduce by-catches and forbidden salmon catches by professional and leisure anglers⁸⁶).

⁸⁴ https://rhesi.org

⁸⁵ ICPR technical report no. 247 (2018)

⁸⁶ ICPR technical report no. 167 (2009)

Projects and measures for individual migratory fish species

Allice shad

Since 2008, and within an EU-LIFE (2007-2010) and a LIFE+ project (2011-2015), comprehensive stocking exercises aimed at reintroducing the allice shad into the Rhine system have been implemented in the Upper Rhine downstream of Iffezheim and in the Lower Rhine as well as in the Sieg (NRW). Since 2017, the reintroduction programme has been coordinated and implemented within the framework of the transnational allis shad project. These measures ensure a continuation of the stocking strategy as well as the development and establishment of monitoring techniques for the documentation of stock development and the management of allis shad in the Rhine. The measures in the water bodies will benefit the allice shad just as much as the other migratory fish species so that, in the medium term, a sustainable re-introduction of this species in the Rhine system may be expected (see Chapter 4.1 Migratory Fish).

Lake Constance Lake Trout

In the sub-basin Alpine Rhine/Lake Constance the Lake Constance lake trout (*Salmo trutta* lake trout) is the fish species migrating over the longest distances. The successful programme aimed at saving the Lake Constance lake trout is being co-ordinated by the working group Migratory Fish of the Internationale Bevollmächtigtenkonferenz für die Bodenseefischerei (IBKF) (International Conference of Plenipotentiaries for Fishery in Lake Constance). In 2017 and based on findings of the studies carried out during the past years on spreading, development of stock and genetics of the Lake Constance lake trout the IBKF determined guidelines (see IBKF 2017) for the future fisheries management and supporting measures for this endangered fish species. Considerable deficits of habitats continue to exist in the tributaries to Lake Constance, in particular with respect to river continuity.

Eel

Contrary to other migratory fish, the eel does not reproduce in fresh water but in the sea (Caribbean Sea, presumably Sargasso Sea). Thus, for this fish species, unhindered downstream migration from the Rhine catchment into the North Sea is particularly important.

For protection purposes and future management of the endangered eel populations in Europe, the EU issued the regulation (EC No. 1100/2007) focussing on a reduction of eel mortality of anthropogenic origin. This regulation lists possible measures aimed at protecting the eel, such as restricting fishery and restoring or improving up- and downstream river continuity. According to this regulation, eel management plans were drafted and reported to the EU Commission by the end of 2008. The environmental objective set by the EC Eel Regulation is to secure a survival rate of 40% as compared to the natural stock. In June 2014, the OSPAR Commission issued a decision on the conservation of the European eel.

Detailed information on the present risks for the eel and on measures planned in the different states in the Rhine catchment are listed in the Master Plan Migratory Fish Rhine⁸⁷ and the report on the national measures in favour of the European eel in the Rhine catchment 2014-2016⁸⁸. An evaluation of the EU Eel Regulation by the EU Commission in 2020 showed that the European eel is still in a critical state.⁸⁹

In Switzerland, the eel is more strictly protected by the national Fisheries law since 1 January 2021. In Annex I of the Ordinance to the Federal Law on Fisheries, it is now

⁸⁷ ICPR technical report no. 247 (2018)

⁸⁸ICPR report no. 264 (2019)

⁸⁹ SWD(2020)35

defined as "threatened with extinction". Consequently, it may not longer be caught in Switzerland. Exceptions to these national regulations are possible under certain circumstances in international boundary waters. This is to be regulated within the framework of international cooperation in the relevant fisheries commissions.

7.1.1.2 Increasing habitat diversity

The species diversity of a river mainly depends on the diversity of its morphological structures. Therefore, above all, structural diversity in the river bed, along the banks and in floodplains must be increased and waterway maintenance must be environmentally compatible. When classifying the ecological status/potential according to WFD, hydro morphology is a supporting quality element.

These measures will contribute towards opening up further habitats for the flora and fauna living in the water, on its banks and in the floodplains.

Examples for measures aimed at increasing habitat diversity in the riverbank area and floodplains are:

- a) Improvement of the lateral cross-linking with the aquatic environment, where possible by creating and connecting secondary tributaries (with sufficient flow and varying flow velocity) in order to optimize the stepping stone function of the river bank and the aquatic surroundings in the network of biotopes and to open up side waters rich in aquatic plants, terraced scouring waters, impounded alluvial waters, alluvial zones with flow through and standing waters and bypasses as habitats for fish, invertebrates and aquatic plants;
- b) Enhancement of near-natural connections of tributaries in the Rhine estuary;
- c) Where possible, integration of dike relocations into the extension of alluvial areas when planning measures (also makes sense for reasons of flood protection);
- d) Enhancement of near-natural vegetation in the alluvial area, creation of timbered riparian zones granting nutrient retention, above all below sloping surfaces without vegetation (fields, etc.), dismantling drainages, enhancement of environmentally compatible agriculture and extensive agriculture to reduce inputs of fine sediments and diffuse discharges of nutrient and plant protection agents.

Measures aimed at increasing habitat diversity particularly in the riverbank area are:

- a) Dismantling of riverbank stabilizations in places, where these are not required for safety or maintenance reasons. Since the invasive gobies above all benefit from bank reinforcements with armourstones, the partial removal of riverbank stabilizations no longer strictly required (for example at sloping banks) is an effective measure to counterbalance the further spreading of these fish species. These measures can also improve access to water for the public, with simple projects such as creating foreshores where possible;
- b) Optimisation of river constructions, greater ecological design of the groynes, parallel diversion structures where this is spatially possible;
- c) Protection from the lapping of waves, e.g. due to parallel structures, bypasses or partially closed groynes gradually filling up. These areas may develop shallow replacement habitats and juvenile habitats protected against the lapping of waves in the river itself which, among others, benefit juvenile fish, water plants and invertebrates. From there, areas presenting deficits may again be colonized by many species; include problems posed by hydropeaking;
- d) Increasing runoff diversity;
- e) Revitalisation of spawning and juvenile habitats.
- f) Creation of new gravel islands, insertion of deadwood to create diverse habitats for juvenile fish, aquatic plants and micro-invertebrates such as crayfish and insect larvae

These Examples indicate general possibilities for the implementation of measures aimed at enhancing habitat diversity. Many of these measures (see figures 26 and 27) have been included in the national programmes of measures.



Figure 26: Ruhr near Wickede in 2014 after the renaturation measure. Photo: MKULNV NRW



Figure 27: R. Ruhr near Arnsberg; in the foreground a renatured section, in the background a not renatured section. Photo: G. Bockwinkel, MKULNV NRW

Biotope network

Possible measures for achieving a greater variety of habitats and species along the main river and its connected alluvial areas are included in the concept on achieving and preserving a vast, ecological and functioning network of biotopes according to the principle of steppingstones described in the report and the atlas of the ICPR "Habitat Patch Connectivity along the Rhine"⁹⁰:

- granting the required minimum flow;
- vitalising the water body (among others riverbed, variation, substrate) within the existing profile;

• habitat improvement in the water body by changing the river course, design of riverbanks or river bottom;

- improvement of habitats in the corridor of water body development including floodplain development;
- connecting side waters, oxbow lakes (establishing a transverse network);
- improving the bedload balance.

The concept gives evidence of the potential for preserving, improving and connecting valuable types of biotopes along the Rhine from Lake Constance to the estuary into the North Sea, it sets out precise development targets for sections of the Rhine and fixes

⁹⁰ ICPR technical report no. 154 (2006); Atlas Biotope Network along the Rhine (2006)

distinct spatial focal points. It simultaneously serves water protection, nature protection as well as flood protection and all related advantages.

In 2020, for the first time, the actual state of the biotope network along the Rhine was detected⁹¹ on an area-wide basis predominantly with the help of digital remote sensing. The different biotope type groups (BTG) (Table 11) could be classified for most of the Rhine floodplain based on satellite data from the European Copernicus programme (Sentinel-2). In future, the methodology will make it possible to carry out area-wide success monitoring of the biotope network for large-scale BTGs at more regular intervals in a partially automated and more cost-efficient manner.

Table 11: Biotope type groups on the main stream of the Rhine. (ICPR 2006, modified⁹²)

BTG	= biotope type group:
1	Aquatic and amphibious area of the watercourses
2	Natural floodplain waters and near-natural artificial stagnant waters
3	Swamps, reeds, tall herbaceous vegetation
4	Pasture land
5	Siccous biotopes
6	Alluvial forests in the present overbank area ⁹³
7	Native deciduous forests no longer subject to temporary or permanent flooding as a result of embankment (floodplain forest relicts) ⁹⁴
8	Other biotopes important for species protection / biotope network
	Remaining area that is currently not relevant for the biotope network ⁹⁵

In the period 2016-2020, a corresponding pilot project⁹⁶ of the North Rhine-Westphalia State Office for Nature, Environment and Consumer Protection (LANUV NRW) was technically accompanied by the ICPR. As part of the pilot project, LANUV NRW and EFTAS Fernerkundung Technologietransfer GmbH developed a methodology that enables the classification of biotope type groups in the Rhine floodplain based on Sentinel-2 data with a spatial resolution of 10 m * 10 m.

Based on the findings from the pilot project in NRW, EFTAS has mapped the biotope type groups in the affected Rhine floodplains using satellite data on behalf of the Rhine riparian states Switzerland, the Netherlands and France as well as the German Länder Hesse and Baden-Württemberg.

For various reasons, in Rhineland-Palatinate (DE), a satellite-based evaluation could not be carried out independently as originally planned. A current survey of the BTG in the Rhineland-Palatinate Rhine floodplain was carried out on the basis of the target maps of the "Planning of networked biotope systems Rhineland-Palatinate (VBS)" (status 2017-2020), which have been updated in the meantime.

⁹² ICPR technical report no. 155 (2006)

⁹¹ ICPR technical report no. 284, *in preparation*

⁹³Zukünftig könnte das Heranziehen von Überschwemmungsdaten (z. B. Höhe, Dauer, etc.) eine

Unterscheidung zwischen Weichholz- und Hartholzaue im aktuellen Überschwemmungsbereich ermöglichen. ⁹⁴ The 2006 definition of "other forests in the former floodplain" was clarified with regard to the remote sensingbased analysis (cf. ICPR technical report no. 154, p. 12).

⁹⁵ These include, for example, coniferous forests and non-indigenous deciduous forests.

⁹⁶ NUMO-NRW (Nature and Environment Monitoring NRW)

In North Rhine-Westphalia, a remote sensing-supported map of the ICPR biotope type groups was also produced for the Rhine floodplain area. This work was mainly carried out within the framework of the Copernicus project NUMO-NRW funded by the Federal Ministry of Transport and Digital Infrastructure (BMVI).

It can be stated that a systematic comparison of the results from 2006⁹⁷ and 2020 is only possible to a limited extent due to different methodologies and data resolution. For the moment, an approximate comparison of the relative BTG shares of the total area per Rhine section can be made between the state in 2020 and the actual state defined in 2006. The priority areas - with high as well as deficit importance - of 2006 can also be compared with the current situation. This work will make it possible, on the one hand, to produce an updated map of the biotope network and, on the other hand, to analyse its development quantitatively. These quantitative elements are complemented by a collection of exemplary measures and needs for action that are implemented in the Rhine floodplain.

In addition to the results of the biotope type group mapping of 2020, the digital Atlas⁹⁸ on the Biotope Network on the Rhine shows measures and their project description. In addition, priority and deficit areas with significance for or impact on the biotope network are presented, including recommendations for action per biotope type group.



Figure 28: Comparison of the distribution of the biotope type groups in relation to the total area (%) of the Rhine sections and for the entire Rhine main stream for 2006 and 2020

Figure 28 compares the information on the actual status 2020 of the biotope type groups with the actual status 2006, subdivided into the 5 main sections of the Rhine. It should be noted that methodological differences between the inventory 2006 and the area-wide survey 2020 must always be taken into account when comparing the distributions.

Looking at the "entire Rhine", the result is very similar to 2006. When considering the main sections of the Rhine individually, however, changes between 2006 and 2020 become evident: Especially on the High Rhine it becomes clear that new areas have been added. This can be explained for the most part by the choice of a different observation area.

The Upper Rhine also shows an increase in area, but to a lesser extent than the High Rhine, which can mainly be explained by the implemented measures. The different proportions for the forest [BTG 6 + 7] are due to the new data collection method by means of remote sensing.

The loss of area on the Middle Rhine is primarily related to the choice of method. However, even the area figures of 80 % for the biotope network 2006 seem to be very large, considering the naturally very narrow floodplain area on the Middle Rhine. On the Lower Rhine, a loss of area is also recorded, which is presumably method-related. Otherwise, the result seems plausible.

⁹⁷ <u>ICPR technical reports no. 154</u> and <u>no. 155 (2006)</u>

⁹⁸ https://geoportal.bafg.de/karten/iksr biotopatlas 2020/, in preparation

In this figure, the Delta Rhine was divided into "Delta Rhine rivers" and "Delta Rhine lakes", as was already done in 2006, so that the proportion of water courses and still waters [BTG 1 + 2] does not overlap the other BTGs, making them easier to recognise. "Delta Rhine rivers" include both an increase in the underlying area gained through dike relocations and a shift in BTG- shares.

For the further ecological improvement and restoration of a biotope network on the Rhine with its water-dependent habitats near the river the 16th Conference of Rhine Ministers in 2020 specifically agreed on the following goals to be achieved within the framework of the programme "Rhine 2040":

- Expansion of floodplains by 200 km²;
- Reconnection of 100 oxbow lakes;
- Increase structural diversity along 400 km of shoreline.

Examples of implemented renaturation measures

In recent decades, numerous renaturation measures have been carried out, especially within the framework of the "Rhine 2020" programme⁹⁹. Numerous measures are currently still being implemented or planned.

The renaturation of the Rohrschollen island near Strasbourg in the Upper Rhine is a good example¹⁰⁰.

Within Hesse's largest nature reserve "Kühkopf-Knoblochsaue", 2.5 kilometres of bank reinforcement were removed and made more natural. Thus, the Upper Rhine regains its natural dynamics at this point and new habitats for animals and plants can develop. This project was awarded the UN Decade of Biological Diversity because it promotes the conservation of biodiversity in a special way.

The target set for the reconnection of oxbow lakes in 2020 was clearly exceeded, but there is still a distinct need for action to increase structural diversity.

In many places, concreted banks or banks consisting of monotonous stone fills have been replaced by near-natural, shallow and gravel-rich banks (cf. Figure 29 and 30). The measure in figure 29 was taken by the German Wasserstraßen- und Schifffahrtsverwaltung and is one of the first projects of the federal programme "Blaues Band Deutschland", which promotes the biotope network between river, bank and floodplain on a national scale along federal waterways.

⁹⁹ Balance "Rhine 2020" (2020)

¹⁰⁰ https://www.rn-rohrschollen.strasbourg.eu/index.php?page=accueil



Figure 29: Bank of the Rhine at Mainz-Laubenheim (Rhineland-Palatinate) before (left) and after (right) structural improvements - from reinforced banks towards flat riverbanks (photos: Dorothea Gintz, BfG; Corinna Krempel, BfG).



Figure 30: Left bank of the Alt-/Restrhein between Basel and Breisach before (left) and after (right) implementing the measure (Photos: L. Schmitt, Laboratoire Image Ville Environnement, Université de Strasbourg, CNRS)

The federal programme "Blue Ribbon Germany" aims to set new accents for nature and water protection, flood prevention as well as water tourism, leisure sports and recreation for a total of 2,800 km of federal waterways, where there is no longer any significant freight navigation and also in the core network of federal waterways. More information on this can be found at www.blaues-band.bund.de.

The goal originally set in the "Rhine 2020" programme to improve the structural diversity on 800 km of the Rhine and its branches has not yet been achieved. The implementation of this goal is slow because it is both economically and socially challenging. For ambitious projects, large areas of land along the banks have to be acquired, and in some places users and residents are critical of measures. The transformation of the riparian areas towards a near-natural state is prevented or at least delayed because the responsibility for action and costs for large sections of the Rhine is not clear. In many places it also conflicts with the use of the Rhine as a navigation lane. If the use of the Rhine as a transport route is to remain possible, comprehensive renaturation is limited due to traffic safety. Due to climate change and more frequent low flow, adapted vessels (smaller or with shallower draft) could be useful in the medium to long term.

The importance of increasing riparian structural diversity has now been recognised and the framework conditions for implementing corresponding measures are increasingly improving. The European Commission and various national and local institutions are providing financial support for projects to create a "blue-green" infrastructure. In order to improve the bedload balance and to reduce streambed erosion, bedload is added in many places or sediment material is transferred into sections lacking bedload. In addition, experiments with more extensive hydromorphological processes (controlled erosion at two sites) have been carried out on the French bank of the Upper Rhine within the framework of an INTERREG project with the participation of experts from Alsace (F) and Baden-Württemberg (D).

Due to the intensive use of the main stream of the Rhine as navigation lane and to the density of settlements near most riverbank areas natural lateral erosion which would enable natural bedload transfer is only possible along certain sections. These river sections should be identified in the different states, and it should be examined, where lateral erosion might again be accepted or enhanced without impacting navigation.

Today, the 142 km of High Rhine are impounded by 11 barrages along a section of hardly 100 km between Lake Constance and Basel. This circumstance and lacking influx of bedload from the tributaries have considerably reduced the bedload discharge in the river and considerably limited the habitat of fish and small animals. In particular, the species of the original habitat are threatened. The Master Plan "Measures aimed at Reactivating Bedload in the High Rhine"¹⁰¹ commissioned by the Swiss Federal Agency for Energy and the Regierungspräsidium Freiburg indicates, how the bedload transport can be reactivated and how river sections can be ecologically improved. According to Swiss law the hydro power plants are obliged to remove major impairments of the bedload balance by 2030. With the measures described in the Master Plan, the requirements according to Swiss law will presumably be met.

With several m bedload influx annually amounting to several 10,000 m³ annually, the rivers Thur, Töss and Aare used to be the most important contributors of bedload for the Rhine. The construction of hydro power plants along the Rhine and the Aare beginning around 1900 and structures in the tributaries have increasingly limited the influx of bedload into the Rhine and the transport capacity. Natural or nature-near flow conditions are found in the four freely flowing sections after the outlet of Lake Constance before the Falls of the Rhine, before the mouth of the Thur and between the hydro power plant Reckingen and the mouth of the Aare, as well as in the head of reservoir areas of some power plants. Along these sections, there is little or no influence on the bedload transport capacity.

Due to the reservoir area of the hydro power plant Eglisau, the influx of bedload from R. Thur and R. Töss is cut off and, in the Klingnauer Stausee, the bedload from R. Aare is retained. That means that the originally dominant influx of bedload have been cut off from the High Rhine. Among the sections with natural or nature-near discharge conditions and bedload transport capacity, only a short section between Wutach and the hydro power plant Albbrug-Dogern is fed with bedload from R. Wutach.

The Master Plan Bedload shows, in which river sections the habitat for fish and small animals can be improved (see Figure 31). In particular the freely flowing river sections give evidence of a great bedload deficit and a great potential for ecological upgrading. The river sections concerned are those between the Reckingen hydro power plant and the Albbruck-Dogern hydro power plant) (Koblenzer Lauffen), the section of the residual flow at the Albbruck-Dogern hydro power plant and the sections downstream of the hydro power plants Säckingen and Rheinfelden. However, a reactivation of the bedload in the impoundment areas of hydro power plants does not lead to any considerable improvement for fish species spawning on gravel or for small animals living in the gravel.

The Master Plan Bedload makes precise proposals how to reactivate the bedload transport in sections with potential for ecological upgrading. These measures include artificial adding of gravel, permitting lateral erosion, filling up bedload traps and

¹⁰¹ Master Plan "Measures aimed at reactivating bedload in the High Rhine"

temporary lowering of the water table at hydro power plants in order to permit bedload transport in impoundments.

For at least 10 locations upstream the inflow of the Aare it has been recommended to add gravel. More than 25,000 m³ per year are planned as annual additions; currently just under half is already being brought in. The goal is to complete bedload remediation by 2030 at the latest.



Figure 31: Upgrading potential with respect to the bedload balance on the High Rhine, taking into account existing power plants. Scale 1 : 400,000; dam; Upgrading potential very large, large, medium, small / negligible

By the end of 2018, more than 130 km² of floodplain areas of the Rhine had been reactivated. The target of 160 km² set for 2020 has been steadily approached over the last few years.

The measures implemented until 2018 include dike relocations, the ecological flooding of flood retention areas behind dikes as well as the more natural design of estuaries at tributaries of the Rhine. More and more projects follow 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, as part of the Dutch programme "Room for the River", many areas in the Delta Rhine were reclaimed for flood retention and at the same time ecologically upgraded (cf. Figure 32).



Figure 32: Dike relocation and side channel Lent / Nijmegen (Waal-km 883) Situation before (left) and after (right) implementing the measure (Photos: Rijkswaterstaat)

The renaturation of the estuaries of the Lower Rhine tributaries Emscher and Lippe, the integrated EU-LIFE project on the Lahn, the development concept for the Alpine Rhine with the Rhesi project and the revitalisation of the Elz (cf. Figure 33) are further examples of holistic approaches in the international Rhine catchment.

The ecological renaturation of the river and the floodplain habitats must be continued and extended, e.g. within the framework of the Integrated Rhine Programme implemented by Germany or the new "Living Rhine" plan initiated by France.



Fotos: SV Geosolutions GmbH Freiburg

Figure 33: Revitalisation of the Elz near Köndringen (Baden-Württemberg). Top left before the implementation of the measures. Top right Overview of part of the revitalised area (Feb. 2020). Below: The same section of the revitalised area from three different years after several small and medium flood events, from left to right: November 2016, March 2017 and April 2018. Flow direction from right to left. The momentum with which the change is taking place is visible. (© RPF)

7.1.2 Reduction of diffuse inputs impacting surface water and groundwater (nutrients, pesticides, metals and arsenic, other noxious substances from historic pollution and others) and further reduction of pollution of industrial and municipal origin

Following the decreasing number of point inputs from sources among the total emissions into waters, the share of diffuse inputs increases so that these today represent the major part of water pollution. The further analyses of possible measures aimed at reducing emissions into water bodies must not only take into account input paths, but also their sources. As the relevance of substance inputs has changed, the improvement of water quality must not only imply the states, but often also other actors, such as EU or worldwide organisms.

7.1.2.1 Physical-chemical components

The EC Directives 91/676/EEC (nitrates directive), 91/271/EEC (urban wastewater directive) and, to a lesser degree, Directive 2010/75/EG (IPPC directive) are important instruments for the further reduction and avoidance of **nutrient emissions** into water bodies. Furthermore, during the past decades, the implementation of additional political programmes, such as the Rhine Action Programme and the Programme "Rhine 2020" - in connection with the considerable investments associated with its implementation as well as OSPAR recommendations were of great importance. These programmes contributed to a distinct reduction of phosphorous and nitrogen concentrations in the entire catchment area during the past decades.

The states, respectively federal states/regions, in the IRBD Rhine will continue to implement the measures already taken to reduce the nitrogen load, taking the polluterpays principle into account as well as applicable EU legislation, previous achievements and aspects of appropriateness. It is moreover assumed that the countries bordering the North Sea in charge of other catchments pouring into the North Sea will make equivalent reduction contributions.

Within implementation of the nitrates directive, the EU Member States of the IRBD Rhine have drafted action programmes. Apart from adapting fertilisation legislation, further measures are to be implemented or planned, such as:

- Establish rules of good agricultural practice to be applied by farmers on a voluntary basis;
- Prohibition of fertiliser distribution in autumn or winter or on water-saturated, frozen soil or soil covered with snow;
- Keeping bank and riparian strips areas free of fertiliser or cultivation;
- Prohibition of ploughing grassland;
- Cultivation of swamp areas and helophyte fields;
- Extensification of livestock breeding;
- Improvement of the rate of implementation and fertilisation;
- Advisory services aimed at further improving the efficiency of fertilization and land utilization, for example information on nutrient accounting procedures and planning of fertilisation,
- Enhance agri-environmental schemes, for example winter greening with intercropping and undersowing of arable areas aimed at reducing the nitrogen contents of the soil in autumn,
- Enhance investment in order to create additional storage capacity for farm manure.

In addition, there are special programmes, such as the Delta Plan Water Resource Management in Agriculture in the Netherlands, to further reduce nitrogen emissions. Furthermore, in the countries, different regulations apply to drinking water areas protecting drinking water supplies against inputs of nitrate and other substances such as pesticides. The intention is to tighten up these regulations in the most polluted drinking water abstraction areas in certain parts of the catchment.

The European Common Agricultural Policy (CAP) has an important impact on water management. It is designed for funding periods of seven years and should be reformed for the funding period 2021-2027. Since the EU member states were unable to agree on the details of the reform by the end of 2020, existing regulations will continue to apply until 2022. From 2023 onwards, innovations will take effect that are aimed at, among other things, taking greater account of ecological issues in the financial support for farmers (e.g. by linking support to environmental requirements, promoting organic farming and strengthening smaller farms). However, short-term positive effects on water quality are not to be expected, as the amendments are subject to transition periods.

At the European level, strategies were also developed, that may have a positive effect on water bodies (e.g. the Farm-to-Fork strategy in the framework of the European Green Deal¹⁰²). For example, the EU Biodiversity Strategy for 2030, adopted in 2020, aims to reduce nitrogen and phosphorus inputs by at least 50 %. Fertiliser use is to be reduced by at least 20 %. The Zero Pollution Action Plan published in 2021 also envisages a 50% reduction in the use of pesticides in air, water and soil by 2030.

As far as emissions from wastewater treatment plants are concerned, reduction measures taken since 2000 have continued to be successful. Often, improvements can already be achieved by optimising wastewater treatment plant operation within the existing concepts. Other measures are e.g. new sites for wastewater treatment plants or transfer/deviation of wastewater flow and/or merging wastewater treatment plants.

Considering the fact that only a small percentage of nutrient inputs is of industrial origin, no further significant improvement of the Rhine water quality with regard to nutrients is to be expected from measures aimed at a further reduction of direct inputs from industry.

Reduction measures taken during the past 30 years have reduced the total nitrogen load discharged from the river area into the coastal waters by about 40% (see Chapter 4.1.1.4). However, in particular in agriculture, reduction measures must be increased in order to achieve a stable good status of all water bodies.

Table 12 shows the nitrogen emissions as a sum according to national catchment areas, and differentiated according to input pathways (municipal, industrial, agriculture). Emissions in 2000, those included in the Management Plan 2010-2015, in 2010, of the Management Plan 2016-2021, 2019 and as indicative prognosis for 2027 are compared.

Calculated nitrogen emissions have decreased by about a quarter in 2019 compared to 2000. The real reduction will presumably be higher, as the calculations at hand of the diffuse nitrogen discharges include natural background contamination. This was not the case in the calculations for 2000. On the whole, a further 4% reduction is expected for 2027 (cf. Table 12).

¹⁰² <u>https://ec.europa.eu/food/farm2fork_en</u>

Table 12: Nitrogen	emissions (rounded)) from agriculture,	wastewater treatment p	ants and
industry in the river	basin district Rhine	and prognosis for	2027 (kilotons/year)	

Country	Emission 2000	Emission according to Management Plan 2010- 2015	Emission 2010	Emission Management Plan 2016- 2021	Emission today (2019) ¹⁰³	Prognosis 2027 ¹⁰³		
	(in kt)	(in kt)	(in kt)	(in kt)	(in kt)	(in kt)		
	Ag	Agriculture (as well as all diffuse inputs of anthropogenic origin) ¹⁰⁴						
AT	2	2	2.0	2.0	2.5 ¹⁰⁵	2.5		
LI	n. s.	n. s.	n. s.	n. s.	n. s.	n. s.		
CH ¹⁰⁶	12 (2001)	11 (2005)	13.0	16.5	17.2	17.2		
DE ¹⁰⁷	113	113	145	140 (2011)	107.5 (2016)	100		
FR	23	14 (2006)	3.7	3.7	3.6 (2016)	3.5		
LU	3.7	3.1	2.7	2.4 (2011)	3.1	3.1		
BE/Wallonia	n. s.	1.2	1.6	1.6	1.4	1.4		
NL ¹⁰⁸	42	34 (2006)	35.2	34.2 (2013)	31.7	29.3		
Rhine catchment area	> 196	> 178	203	200	167	157		
		Wastewater tre	atment pla	nts (including dif	fuse urban ¹⁰⁹	⁷)		
AT	0.8	0.6	0.5	0.5	0.5110	0.5		
LI	n. s.	0.1	n. s.	n. s.	0.1	0.1		
СН	13 (12+1)	12(11+1) (2005)	9.4	9.4	10.7	10.7		
DE	72 (63+9)	60	47.0	47.0 (2011)	47.6 (2016)	47		
FR	18 (15+3)	4 (2006)	7.2	7.2	7.2 (2016)	7.2		
LU	1.8	1.7	1.6	1.4 (2011)	0.9	0.9		
BE/Wallonia	n. s.	0.1	0.1	0.1	0.1	0.1		
NL	22 (20+2)	15 (2006)	12.5	11.0 (2013)	11.9	11.6		
Rhine catchment area	> 128	> 93	78.3	76.5	79.0	78.1		
	Industry							
AT	n. s.	0	0.2	n. s.	< 0.01110	< 0.01		
LI	n. s.	n. s.	0.0	n. s.	0	0		
СН	1	1 (2005)	1.3	1.3	0.1	0.1		
DE	15	15	9.1	9.1	4.4 (2016)	4.4		
FR	5	5 (2005)	2.8	2.8	2.8 (2016)	2.8		

¹⁰³ If no data were available, the data from previous years were used.

¹⁰⁴As of 2010 including natural background contamination

¹⁰⁵ Austria: Updated modelling data from STOBIMO, BMLRT, 2019; sum of atmospheric deposition, erosion incl. natural erosion, surface runoff, drainage and groundwater. Increase in emissions due to model adjustments and consideration of surface runoff and atmospheric deposition. ¹⁰⁶ Switzerland: Calculations with revised model (2014), increase of emissions of agricultural origin due to

¹⁰⁶ Switzerland: Calculations with revised model (2014), increase of emissions of agricultural origin due to model adaptations (including background contamination); all indications for Switzerland concern the Rhine catchment downstream of the lakes

¹⁰⁷ The calculation of German discharges of agricultural origin include erosion with 93%.

¹⁰⁸ Netherlands: Indications without atmospheric deposition (from 2010 on, about 9 kt)

¹⁰⁹ Municipal wastewater treatment systems including storm water overflow, combined mixed water inflows and sewer conducts not connected to the sewerage network etc.

¹¹⁰ Updated modelling data (STOBIMO, BMLRT, 2019)

Country	Emission 2000 (in kt)	Emission according to Management Plan 2010- 2015 (in kt)	Emission 2010 (in kt)	Emission Management Plan 2016- 2021 (in kt)	Emission today (2019) ¹⁰³	Prognosis 2027 ¹⁰³ (in kt)
LU	0.007	0.003	0.002	0.001	0.003	0.003
BE/Wallonia	n. s.	0.1	0.0	0.0	0.003	0.003
NL	3	2 (2006)	1.6	1.5 (2013)	1.3	1.3
Rhine catchment area	> 24	> 23	15.0	14.8	8.7	8.7
Total IRBD Rhine	> 348	> 294	296.4	291.6	254.7	243.8

n.s. Not specified

Today, values exceeding national assessment standards for phosphorous are stated at many monitoring stations (see Chapter 4.1.1.4 and Annex 2).

Table 13 shows the phosphorous emissions as a sum according to national catchment areas, and differentiated according to input pathways (municipal, industrial, agriculture). Emissions in 2000, 2010, Management plan 2015, 2021 and an indicative prognosis for 2027 are compared. Generally, a further reduction of phosphorous emissions is assumed.

Country	Emission 2000 (in t)	Emission 2010 (in t)	Emissions Management Plan 2016- 2021 ¹¹¹ (in t)	Emission today (2019) ¹¹¹ (in t)	Forecast 2027 ¹¹¹ (in t)		
	Agriculture (as well as all diffuse inputs of anthropogenic origin)						
AT	n. s.	17.5112	17.5	46.8 ¹¹³	46.8		
LI	n. s.	n. s.	n. s.	n. s.	n. s.		
CH ¹¹⁴	272 ¹¹⁵	368	368	540	n. s.		
DE	5,070 ¹¹⁵	4,810 ¹¹⁶	4,749 ¹¹⁶ (2011)	3,196 ¹¹⁶ (2016)	3,150		
FR	840 ¹¹⁵	780 (2012)	780 (2012)	730 (2016)	730		
LU	n. s.	n. s.	n. s.	n. s.	n. s.		
BE/Wallonia	n. s.	33.6	29.6 (2015)	30.1	30.1		
NL	3,930	2,946	2,900 (2013)	2,800	2,900		
Rhine catchment area	10,112	8,955	8,844	7,343	7,397		
	Wastewater treatment plants (including diffuse urban) ¹¹⁷						
AT	n. s.	75 ¹¹²	75	33 ¹¹⁸	33		
LI	n. s.	3	3	3	3		
CH ¹¹⁴	< 1,072 ¹¹⁹	< 1,062	519	420	420		
DE	5,585 ¹¹⁹	5,549	5,489 (2011)	4,470 (2016)	4,400		
FR	< 3,451 ¹¹⁹	2,565 (2012)	2,565 (2012)	2400 (2016)	2400		
LU	n. s.	n. s.	n. s.	121 (2016)	121		
BE/Wallonia	n. s.	11.6	11.7 (2015)	9.7	9.7		
NL	2,045 ¹¹⁹	1,629	1,514 (2013)	1,600	1,500		
Rhine catchment area	12,153	8,330	7,612	9,057	8,887		
			Industry				
AT	n. s.	9.5 ¹¹²	9.5	0.5 ¹¹⁸	0.5		
LI	n. s.	0	0	0	0		
CH ¹¹⁴	< 20	< 20	< 20	0	0		
DE	433	274	269 (2011)	200 (2016)	200		
FR	< 536	490 (2012)	490 (2012)	536 (2016)	500		
LU	n. s.	n. s.	n. s.	0.7 (2016)	0.7		
BE/Wallonia	n. s.	0.8	1.9 (2015)	0.2	0.2		
NL	1,434	158	154 (2013)	100	100		
Rhine catchment area	2,423	952	944	837.4	801.4		
Total IRBD Rhine	24,688	18,237	17,400	17,237	17,085		

Table 13: Phosphorous emissions (rounded) from agriculture, wastewater treatment plants and industry in the river basin district Rhine and forecast for 2027 (tons/year)

n.s. Not specified

With respect to the reduction of thermal pollution of the Rhine please refer to activities within climate protection (see Chapter 2.4) and to measures already taken within

¹¹¹ If no data were available, the data from previous years were used.

¹¹²Data from STOBIMO, UBA/TU-Vienna/BMLFUW, 2011; the total P-emissions into Austrian surface waters in the Rhine catchment including atmospheric deposition, erosion from natural surfaces and snow melt amounted to 122 tons per year.

¹¹³ Updated modelling data from STOBIMO, BMLRT, 2019); sum of atmospheric deposition, erosion from agricultural surfaces, surface runoff, drainage and groundwater. Increase in emissions from agriculture due to model adjustments and consideration of surface runoff as well as atmospheric deposition.

¹¹⁴ All data for Switzerland concern the Rhine catchment downstream the lakes

¹¹⁵ Data from report no. 134: Sum of farm effluents and drift, erosion, surface runoff, drainage and groundwater. ¹¹⁶The German discharges from agriculture and all anthropogenic diffuse discharges are determined without

¹¹⁶The German discharges from agriculture and all anthropogenic diffuse discharges are determined without taking into account atmospheric deposition.

¹¹⁷ Municipal wastewater treatment systems including storm water overflow, combined mixed water inflows and sewer conducts not connected to the sewerage network etc.

¹¹⁸ Updated modelling data (STOBIMO, BMLRT, 2019)

¹¹⁹ Data from report no. 134: Sum of point sources and diffuse sources of municipal origin

phasing out nuclear energy in Germany and the shutdown of further nuclear power plants and coal-fired power stations due to the fossil-fuel phase-out in Germany.

7.1.2.2 Substances relevant for the Rhine

Based on the measurement results (cf. Annex 2), the Rhine-relevant substances¹²⁰ **arsenic**, **zinc** and **copper**, and in some places also **PCBs** exceed the Rhine-EQS or orientation values. In addition, the national EQS for **dichlorvos** (Maassluis, Wadden Sea and Dutch coast), as well as **mecoprop** in the Erft were exceeded. Ammonium nitrogen also still causes problems in numerous tributaries, but not in the main stream of the Rhine (cf. also Report on the Assessment of Rhine Water Quality 2015-2016¹²¹).

With a view to fighting inputs of these substances, measures must be taken at the source for **zinc** and **copper**, in particular, since wastewater treatment plants were not designed to eliminate metals from wastewater. No obvious measures can be recommended for rehabilitation purposes. Alternatives for the use of copper and zinc are being looked into in different sectors.

In agriculture, copper is used as a disinfectant for the hoofs of dairy cattle. Often, residues of the so-called copper baths are mixed with manure. Different possibilities of reducing the copper emissions are being looked into.

As far as agriculture is concerned, harmonised EU standards apply to the maximum application of these metals in fodder (fertiliser and fodder containing copper). To a greater extent, the assessment of additives must take into account the impact of these substances on the soil and waters.

On the whole, the available operational measures for reducing the diffuse inputs of copper and zinc at the source have already been taken or started.

PCBs today worldwide spread in the environment mainly originate from earlier applications and are re-distributed between the individual environmental compartments due to remobilization processes. Transport is mainly by the atmosphere. The major share of PCB in the atmosphere is due to volatilization from the soils which, together with sediments in water bodies, are the main sink for PCBs. PCB, just as HCB, may have a negative impact on sediment quality. All measures to reduce emissions at the source have been taken, no direct PCB discharges are known. As far as possible, heavily polluted water sediments must be remediated. As releases from water body sediments continue, achievement of the objective in 2027 does not appear to be inherent.

Apart from the pollution of water bodies, the pollution of biota with PCBs is relevant for taking measures. Comprehensive data on the pollution of fish with PCB and other pollutants are available in the IRBD Rhine and have been compiled in reports.¹²² In 2014/2015 the ICPR conducted a pilot programme on the monitoring of the contamination of fish¹²³. For the first time, the pilot programme enabled comparable results for the entire Rhine catchment and gave a good overview of the pollution situation.¹²⁴ It was also the basis for a common approach to biota contamination measurements for the WFD¹²⁵.

The measures concerning the substances relevant for the Rhine arsenic, chromium and chlorotolurone will not be discussed in detail here. For further information, please refer to the Part B reports.

¹²⁰ ICPR technical report no. 215 (2014)

¹²¹ ICPR technical report no. 251 (2018)

¹²² ICPR technical report no. 195 (2011)

¹²³ ICPR technical report no. 216 (2014)

¹²⁴ ICPR report no. 252 (2018)

¹²⁵ ICPR technical report no. 259 (2019)

7.1.2.3 Priority (dangerous) substances and certain other substances

Of the 45 priority substances and certain other pollutants of Directive 2008/105/EC as amended by Directive 2013/39/EU, some substances in the IRBD Rhine are widely above the EQS:

- brominated diphenyl ethers (PBDE)
- hexachlorobenzene (HCB)
- heptachlorine and heptachlorine epoxide
- polycyclic aromatic hydrocarbons (PAH)
- mercury
- tributyl-tin compounds (TBT)
- PFOS

Except for the PAH substance fluoranthene and hexachlorobenzene, the other substances mentioned are classified as **ubiquitous** throughout the EU. Generally speaking, there are few measures apt for reducing the pollution with these substances on the short or medium term.

Since 2002, the use of PBDE has been restricted or largely forbidden in the EU.

PAH compounds: The sources of PAH are very varied. PAH concentrations today determined in water bodies are not directly bound to a local source of emission but are, above all, caused by diffuse emissions from combustion plants and motors, car tyres, navigation and the use of coal tar and creosote, primarily as wood protection agents in hydraulic engineering. Atmospheric deposition is the main pathway of emissions. This pathway of emission cab above all be impacted by means of an international approach towards reducing emissions into the air.

In most states belonging to the IRBD Rhine, it is prohibited to include PAH in coal tar coating used for ships in inland navigation. Discharges containing PAH that stem from wash or ballast water are regulated by the Convention on the Collection, Deposit and Reception of Waste generated during navigation on the Rhine and other inland waterways (CDNI), which entered into force on 1 November 2009. The enloading standards (which cover ballast water in particular) were revised in 2018, taking into account the environmental harmfulness of these substances.

The EQS for PAHs are not complied with, but a significant reduction can be achieved through measures.

According to the EU Ecodesign Directive, new stoves must comply with the so-called ecodesign requirements as of 1st January 2022 (in the Netherlands already as of 1st January 2020). In addition, communication with the public is used to try to reduce the use of open fireplaces, also in view of the fine dust that is released. The new requirements for stoves will help to reduce PAH emissions.

As far as **mercury** is concerned, atmospheric deposition is the most important emission pathway; coal-fired power plants are an important source. Activities towards reducing mercury emissions are going on at the national, European and worldwide level. Within the implementation of the worldwide Conventions on mercury (Minamata Convention of 2013) work is going on on describing the best available techniques and environmental practice. The target is to protect human health and the environment from mercury exposition by reducing the occurrence of mercury in the environment and, if possible, by gradually phasing out mercury. Both the European Union and the states in the Rhine catchment are Contracting Parties to this Convention. It entered into force on 16 August 2017.

For the substance group perfluorooctanesulfonic acid and its derivatives (**PFOS**), which as a new "ubiquitous substance" has to be taken into account in additional monitoring and action programmes since 22.12.2018 (Directive 2013/39/EU), the EQS was not met everywhere (Annex 5). PFOS is a known group of PFAS and may only be used as a

spray suppressant for non-decorative hard chrome plating (chromium VI) in closed loop systems by way of exception. The use of PFOS has already been largely restricted throughout the EU by Directive 2006/122/EC. PFOS is now restricted globally via the Stockholm Convention and the ban is regulated across Europe in the Persistent Organic Pollutants Regulation (EU) 2019/1021. Efforts to replace PFOS (and PFOA) in production are ongoing across the EU and at a wider international level. However, the use of other compounds from the group of fluorosurfactants and polyfluorinated alkyl substances (PFAS) is increasing.

Further measures

Pollutant releases from water sediments may be a long-term concern. Therefore, the objective of the good status may not be achieved.

HCB, like PCB, belongs to the category of pollutions with a negative impact on sediment quality. No direct HCB discharges are known, but indirect pollution is due to polluted water sediments. Heavily polluted sediments must be cleaned up to the greatest possible extent (see statements in the following paragraph). As releases from water body sediments continue, the achievement of the objective does not appear to be inherent.

Human interferences with the water system (construction of dikes and impoundments) have caused a thorough change of the sediment household of the Rhine. Apart from these hydromorphological changes, considerable discharges of substances over recent decades have generated great amounts of polluted sediments. This still continues to negatively impact sediment quality as old sediments in the Rhine and its tributaries may be whirled up during floods or dredging. When dealing with dredged material, ecological considerations are taken into account, in Germany e.g. based on the Guideline for Handling Dredged Material in the Inland.

The ICPR has drafted an overall Strategy for sediment management along the Rhine¹²⁶ aimed at the remediation of heavily polluting sediments: 22 of the 93 analysed sedimentation areas have been classified as areas at risk, 18 as "area of concern". For areas at risk remediation measures have been defined, for the "areas of concern" intensive surveillance was recommended. By the end of 2018^{127} , 10 of the 22 areas at risk identified in the Sediment Management Plan Rhine (2009) have been cleaned up. In the Netherlands, of the total of 22 identified sedimentation areas, remediation work has been completed at 16 sites. During this work, some 3.5 million m³ of polluted sediments have been deposited in different land fill deposits, the total costs entailed in the Netherlands amount to about 72 million \in . For five areas at risk, further investigations determined that remediation was not necessary. No remediation has yet been carried out for seven areas at risk (Marckolsheim, Rhinau, Eddersheim, Duisburg, Ehrenbreitstein, Brohl and Mondorf).

In the programme "Rhine 2040" it was agreed that the measures identified in the Sediment Management Plan should be implemented by 2025. In future, the aspects of quantity and hydro morphology of the sediments are to be considered beyond the current plan.

Within the Permanent Commission for the Upper Rhine, France and Germany are carrying out further investigations on the pollution of sediments of the Upper Rhine with hexachlorobenzene (HCB). As a result of these analysis, the impoundment Strasbourg can be excluded as area of risk type A. The results of investigations carried out at the weirs in Marckolsheim and Rhinau show that the HCB concentrations in sediments are distributed such that a selective removal of sediments for rehabilitation purposes does not seem to achieve the objectives. Apart from the sediments located immediately upstream of weirs (at a depth of 2 to 3 meters in Marckolsheim as well as in Rhinau) there are no areas in the centre of the weir fields to exclude from rehabilitation and securing measures due to economically viable reasons. During rehabilitation, heavily consolidated areas where no dredging is done due to navigation (upstream end of the

¹²⁶ ICPR technical report no. 175 (2009)

¹²⁷ ICPR technical report no. 269 (2020)
area of investigation at Marckolsheim) must not be taken into account. No risk of pollutant discharge is to be expected from these areas.

In addition to sediment loads, contaminated sites on the shore, e.g. in industrial areas, can also affect sediment and water quality. This is particularly problematic in the case of floods, run-off during heavy rainfall events or indirect inputs via groundwater.

7.1.2.4 Plant protection products (PPPs)

Plant protection products are used worldwide; in Europe, it is also widely applied. Agriculture is by far the most significant area of application of plant protection products. Plant protection products also have applications outside of the agricultural sector, e.g. on sealed surfaces, in private gardens, on public municipal grassy areas, sports grounds, along roads or as weed killers along railway lines. PPPs mainly enter water bodies via diffuse entry pathways.

The application of particular plant protection products is prohibited at European or national level. One example is the use of HCH, which has also been banned at European level since 2004.

The ICPR has collected information on the input pathways of various PPPs as well as information on measures in the states in the IFGE Rhine.¹²⁸ Inputs of PPPs from agriculture also belonged to the areas for which the ICPR made recommendations to reduce inputs to water bodies (see below).¹²⁹

7.1.2.5 Micro-pollutants

A new challenge for water protection is posed by micropollutants, which are only partially covered by the WFD or the EU Directive on Priority Substances. Since the ICPR has been dealing with this issue for years, it is addressed here.

Micro-pollutants are synthetic organic substances occurring in water bodies in concentrations between individual nanograms and few micrograms per litre. They can enter water bodies via various input pathways, but municipal wastewater collection and treatment systems represent a relevant input pathway for many substance groups. In today's normal mechanical-biological wastewater treatment plants many micro-pollutants are not or only partly treated and thus discharged into the water bodies. Micro-pollutants can have a negative impact on both the biocoenosis of waters as well as the production of drinking water.

Based on the decision of the Rhine Ministers in 2007, the ICPR has intensively worked on the assessment of the relevance of new micro-pollutants for the Rhine e.g. due to pharmaceutical residues. Evaluation reports are available for several substance groups, such as industrial chemicals¹³⁰, complexing agents¹³¹, odoriferous substances¹³², radio contrast agents¹³³, oestrogens¹³⁴, biocidal products and anti-corrosive agents¹³⁵ as well as medicinal products for human use¹³⁶. In addition, an evaluation report is available which deals with diffuse inputs using the example of pesticides (see above)¹³⁷ and an integral assessment of micropollutants and measures to reduce inputs from urban and industrial wastewater¹³⁸.

Different measures are applied which aim at reducing micro-pollutant inputs into water bodies. In 2017, the ICPR prepared a balance report that provides an overview of the

¹²⁸ ICPR technical report no. 240 (2016)

¹²⁹ ICPR technical report no. 253 (2019)

¹³⁰ ICPR technical report no. 202 (2013)

¹³¹ ICPR technical report no. 196 (2012)

¹³² ICPR technical report no. 194 (2011)

¹³³ ICPR technical report no. 187 (2011)

¹³⁴ <u>ICPR technical report no. 186 (2011)</u> 135 ICPR technical report no. 182 (2010)

¹³⁵ ICPR technical report no. 183 (2010)

¹³⁶ ICPR technical report no. 182 (2010)

¹³⁷ ICPR technical report no. 240 (2016)

¹³⁸ ICPR technical report no. 203 (2013)

development of micropollutant pollution and the measures taken and planned in the states.¹³⁹ Even though measures are already being taken in all countries to reduce the inputs and successes are already visible, micropollutants still represent a burden for the waters in the Rhine catchment.

The ICPR has therefore issued recommendations in 2019 to reduce inputs to water bodies. Three areas were covered:

- Municipal sewage collection and treatment systems (e.g. pharmaceutical residues and X-ray contrast media),
- agriculture (e.g. plant protection products) and
- industry and trade (e.g. industrial chemicals).

Where possible, measures at source are generally to be given preference. These measures help to prevent and/or reduce the amount of micropollutants entering the waters. These measures will only be able to partially solve the problem, in particular for wastewater from settlement areas, so that often a combination of measures from source to final (partial) purification is required.

For **municipal wastewater collection and treatment systems**, based on prioritisation criteria, accumulated experience and other aspects, the ICPR recommends the selection of eligible wastewater treatment plants to be equipped with an additional purification stage.

The prioritisation criteria for selection are:

- Discharge with a high proportion of pollution in the water to be discharged into;
- Discharge into ecologically sensitive waters;
- Discharge into waters used for the production of drinking water.

When developing the criteria, different approaches can be used.

In addition, regular communication in the Rhine catchment as well as mutual consultation and support are recommended.

In order to reduce pharmaceutical residues in water, the integral approach "pharmaceutical residues from water" is applied in the Netherlands, for example. This is an integrated approach with measures at the source, for example in the care sector, up to a hot-spot analysis to equip selected wastewater treatment plants with an additional treatment stage.

Already today (as of 2016), 26 wastewater treatment plants in the Rhine catchment are equipped with an additional treatment stage and the upgrading of further wastewater treatment plants is being planned or implemented.

For the **handling of X-ray contrast media**, the ICPR recommends that tests are carried out as to whether and how the separate collection of XCM in hospitals and x-ray practices can be applied or expanded, including accompanying awareness campaigns. In addition, further pilot projects for additional measures are to be tested.

For the **agriculture** sector, in addition to a regular international exchange of knowledge in the Rhine catchment area, the ICPR recommends that the focus is not only on individual active substances. Metabolites are also to be assessed. Furthermore, the measures set out in the action plans (chain of measures from source to disposal of products) must be consistently implemented in constructive cooperation with agriculture, retailers and consumer organisations. The promotion of environmentally and waterfriendly agriculture (especially organic farming) is also recommended.

The Farm to Fork Strategy within the scope of the European Green Deal envisages to reduce the use of plant protection products aimed at reducing the use of these agents by 50% by 2030.

¹³⁹ ICPR technical report no. 246 (2017)

In addition, there are campaigns for other areas that can emit pesticides, such as the "Pesticide-Free City" campaign in Germany, which aims to reduce the use of pesticides in cities and municipalities.¹⁴⁰

For the **industry and commerce** sector, the ICPR recommends that the pre-treatment of wastewater streams be discussed and regulated nationally. For persistent or persistent and mobile substances, it is recommended to consider a reduction requirement for precautionary reasons. Particular attention should be paid to substances¹⁴¹ of very high concern.

A stronger dialogue with industry and trade is recommended. In addition to the sum parameters CSB and/or TOC, specific requirements for individual substances and also impact-related requirements must be considered. The ICPR recommends an exchange of knowledge regarding the existing test systems.

In some states, a stronger dialogue with industry is already being sought. Switzerland, for example, has carried out an extra situation analysis of the pressures in order to identify the most relevant sectors for micropollutant inputs. The dialogue with these sectors on the topic of chemical discharges is now to be intensified.

The ICPR recommendations adopted in 2019 will now be implemented in the states, regularly reviewed and adapted.

In the "Rhine 2040" programme, it was determined that the inputs of micropollutants into water bodies from the sectors of municipal wastewater collection and treatment systems, agriculture, and industry and commerce should be reduced by at least 30% overall by 2040 compared to the period 2016-2018 - consistent with a longer-term ambition to further reduce pollution in the entire Rhine catchment. In order to be able to check the reduction of inputs at regular intervals and, if necessary, to increase the reduction target, the ICPR is currently developing a joint evaluation system for the reduction across the three areas.

¹⁴⁰ <u>https://www.bund.net/umweltgifte/pestizide/pestizidfreie-kommune</u>

¹⁴¹ REACH Regulation (EC) No. 1907/2006

7.1.2.6 Measures aimed at improving the quantitative groundwater status

In the lignite mining region along the German-Dutch border, percolation and compensatory measures ensure that ecosystems on both sides of the frontier depending on groundwater are not at risk.

7.1.3 Harmonisation of water uses (navigation, energy production, flood protection, space-relevant uses and others) with environmental objectives

This fourth important management issue in the IRBD Rhine is more of a cross-sector approach. The functions of drinking water, water for agriculture and factories, water and transportation, inland fishery, recreation and tourism must be harmonised with ecosystem protection. That also implies the necessity of continual exchange with water users.

The ICPR can look back upon a long tradition when cooperating with groups protecting and using the water environment. Already when implementing the Rhine Action Programme, the exchange of information with drinking water works, industry, navigation and ports was intensive. Since 1998, non-governmental organisations (NGO) and intergovernmental organisations (IGO) have had an observer status in almost all ICPR boards. Once these organisations are acknowledged as observers, they may not only participate in the plenary assemblies, but also in working and expert groups. Since 2016, two more NGOs have joined, so that now a total of 21 NGOs have observer status in the ICPR.

The present list of acknowledged NGO is attached as Annex 8. Therefore, by participating in the work of the ICPR, the representatives of environment organisations, industrial federations, drinking water works and scientific associations are aware of current issues and decisions and have taken part in discussions on the different levels of work.

During the last years, more and more congresses and workshops have been staged with participants from different user groups in order to sensitize them for the achievement of environmental objectives and to search for common solutions to the problems at stake.

The three "Rhine Commissions", the ICPR, the International Commission for the Hydrology of the Rhine Basin (CHR) and the Central Commission for the Navigation of the Rhine (CCNR), with the support of the Swiss Federal Office for the Environment (FOEN), have dealt in detail with the issue of low flows within the framework of the international symposium "Low flows in the Rhine catchment" on 20 - 21 September 2017.

In the coming years, cooperation with various user groups will be further intensified within the framework of the ICPR. A separate chapter is dedicated to this topic in the "Rhine 2040" programme. The ICPR will continue the exchange with other commissions and organisations and expand the cooperation with observers and stakeholders, also including agriculture. Specifically, the following workshops are planned until 2027:

Workshop for exchange on dealing with heavy rainfall events,

Workshop on the involvement of different stakeholder and user groups in the adaptation of the ICPR Climate Change Adaptation Strategy.

It is important that all users and stakeholders are involved in decision-making processes on measures to be taken in order to achieve sustainable development of the river system according to the requirements of the WFD. In all states, federal states or regions there are different bodies (for example representatives of local authorities, farmers, industry, consumers, NGO, power producers, chambers of commerce) which are informed at different levels and are thus involved in the planning of measures.

7.2 Summary of measures according to Annex VII A, No. 7 WFD

7.2.1 Implementation of EU regulations on water protection

Reference is made to the information on the implementation of the EU legal requirements for water protection in the programmes of measures of the EU states in the international river basin district Rhine.

7.2.2 Recovery of costs for water services

Article 9 (1) of the WFD regulates the principle of cost recovery in order to strengthen sustainable water use. Cost recovery is based on national regulations and is thus presented at the national level. Environmental and resource costs are currently only taken into account to the extent that they are internalised. The EU Member states located in the Rhine catchment area have analysed their cost recovery differently. Common to all analyses is that the costs of all steps of drinking water supply (drinking water production, treatment and distribution) and wastewater disposal (wastewater collection, discharge and treatment) have been examined. Another common feature - with the exception of the Netherlands and France - is that cost recovery is not examined separately for the household, industry and agriculture sectors because the necessary data are not available.

It should be emphasised that the cost recovery ratios found are not comparable in view of the different methods of analysis.

The analyses for the individual states shows the following.

Austria

For the National Water Management Plans 2009 and 2015, cost recovery for public water supply and sanitation had been calculated based on the total costs and total revenues of these water services, most of which are provided by municipalities.

According to expert estimates, the contributions of the industry sector to cover the costs of these water services were 20 to 25%, those of households 70 to 75% and those of agriculture 2 to 5%. The contribution shares also corresponded in magnitude to the respective sectoral cost share of the water services. Taking into account the current results of the economic analysis, these assumptions made in the National Water Management Plans (NGP) 2009 and 2015 still appear to be valid.

For the current analysis of water and wastewater prices and cost recovery (based on data from 2014 to 2018), all costs of ongoing operation as well as the investment costs of the facilities and the internalised environmental and resource costs were taken into account. The cost recovery ratio for water supply is 116%, and 114% for wastewater disposal.

Environmental and resource costs are internalised through the use of various financially relevant instruments (charges, environmental regulations, etc.) and are included in the detailed financial costs.

France

Calculation of the cost recovery ratio

In France, the analysis of cost recovery deals with water services related to the three sectors of industry, agriculture and households. In the household sector, production activities are considered separately and are treated as household activities. This analysis can be used to show the financial flows among the user categories, as well as the indirect environmental costs and benefits (e.g. self-purifying function of restored rivers). This analysis concerns the years 2013 until 2016.

Households and equivalent domestic activities

The objective of the calculation of cost recovery for households and production activities assimilated to household activities is to determine whether the revenues of the public drinking water supply and wastewater treatment simultaneously cover the running expenses and the costs for renewal of the infrastructure, i.e. the wastewater treatment plants, the drinking water treatment plants and the pipe networks.

Excluding environmental costs, cost recovery for domestic users in the river basin district is 100%. The payments made by the domestic users thus correspond to the benefits received.

If environmental costs are included, cost recovery drops by 16 points to 84%.

Excluding environmental costs, cost recovery for production activities equivalent to household activities is 96% in the river basin district. The payments made by these activities are thus lower than the benefits received.

If environmental costs are included, cost recovery drops by 17 points to 79%.

Industrial sector

The calculation of cost recovery for the industry is based on operating costs and investment costs. In this way, the industry's financial commitment to wastewater treatment and resource protection can be measured. This makes it possible to check whether the polluter pays principle applies.

Excluding environmental costs, cost recovery for industrial users in the river basin district is 101%. The payments made by industry are thus above the benefits received.

If environmental costs are included, cost recovery drops by 8 points to 93%.

Agricultural sector

In order to protect water resources, farmers, especially livestock farmers, have invested in equipment in recent years that helps to better control farm run-off. Irrigation also incurs operating and investment costs for farmers, which should be identified.

In order to show the polluter pays principle, these operating and investment costs must be compared to the costs for water supply and wastewater treatment.

Excluding environmental costs, cost recovery for agricultural users in the river basin district is 89%. The payments made by farmers are thus far lower than the benefits received.

If environmental costs are included, cost recovery drops by 23 points to 63%.

Germany

For the update of the economic analysis for the management period 2022-2027 to be carried out in 2019, the Federal Government/Länder Working Group on Water (LAWA) has updated its recommendation for action to ensure a uniform presentation of the analysis results (<u>https://www.lawa.de/documents/handlungsanleitung-wirtschaftliche-analyse 2 1595486010.pdf</u>). The data sources used to describe the economic importance of water uses were primarily the surveys of the Statistical Offices (2016) of the Länder with data as of 31 December 2016. Furthermore, the economic analysis deals with the topics of cost recovery of water services (according to Article 9 WFD) and the assessment of the cost-effectiveness of measures (according to Annex III WFD).

For the German Rhine catchment, the results of the economic analysis can be summarised as follows:

In Germany, water services are understood to mean drinking water supply and wastewater disposal. The principle of cost recovery of water services in accordance with the requirements of Art. 9 (1) WFD is already fulfilled by the requirements of the municipal levy laws. Accordingly, the fees must in principle be assessed in such a way that the fee revenue covers the costs, but does not exceed them. The costs are to be determined according to business principles. If the revenues of a costing period exceed or fall short of the actual costs for water supply or waste water disposal, this shall in principle be compensated for in the following costing period or periods. These principles apply irrespective of whether user charges or charges under private law are levied. The water service providers are subject to municipal supervision or abuse control under cartel law.

Cost recovery has been verified in various benchmarking projects of the Länder. Nationwide, the cost recovery ratios for drinking water supply are around 100%. The individual results of the projects of the Länder for drinking water supply ranged from 95% to 107%, and the cost recovery rates for wastewater disposal ranged from 93% to 105%.

In Germany, the consideration of environmental and resource costs in the cost recovery of water services of the supply and disposal companies, as WRRL required in Article 9, is implemented by two instruments in particular, in addition to the environmental law requirements for the water service providers: Water abstraction charges of the federal states and the federally applicable wastewater levy. In addition to internalising environmental and resource costs, these instruments contribute to achieving the management objectives of the WFD through their steering and financing function.

Article 9 para. 1 sentence 2 indent 2 WFD requires that the different water uses, which are to be divided at least into the sectors households, industry and agriculture, make an appropriate contribution to the recovery of the costs of water services. With regard to the cost recovery requirement and as a result of the decision of the European Court of Justice (ECJ) of 11 September 2014, it is sufficient to take a closer look at the water services of water supply and wastewater disposal.

Indirect dischargers (of households and industry) bear the costs of public wastewater disposal through connection fees and user fees, which can be divided into a basic fee (to cover fixed costs) and a volume fee. They therefore contribute appropriately to the costs. In the case of water withdrawals (by households, industry and agriculture) from the public network, the charge for the withdrawal of drinking water for the aforementioned uses, which covers the total costs, is regularly composed of a basic charge to cover fixed costs and a quantity-based charge. There is therefore also adequate participation here.

The high quality standards of water services, the high level of cost recovery and the existing considerable incentives of the pricing policy ensure efficient use of the resource water in the sense of the WFD in Germany, which is particularly evident in the low per capita water consumption, also in European comparison.

Although the procedure for identifying and selecting measures can vary by federal state, by type of water body, by type of measure, by natural region and many other parameters, it is generally true in Germany that a large number of similar mechanisms come into play at the various decision-making levels, thus ensuring the (cost) efficiency of measures within the decision-making processes. The main instruments and mechanisms that support the selection of cost-effective measures nationwide include procedural rules for the economic and parsimonious execution of public sector projects.

Further information can be found in the management plans of the federal states and in the joint overview report of the River Basin Community (FGG) Rhine (link).

Luxembourg

According to point 42 of Article 2 of the amended Luxembourg Water Act of 19 December 2008 (Loi modifiée du 19 décembre 2008 relative à l'eau), water services include all services that provide the following for households, public institutions or economic activities of any kind:

- Abstraction, impoundment, storage, treatment and distribution of surface water or groundwater;
- Installations for the collection and treatment of waste water or rainwater which subsequently discharge into surface waters.

The water price and the recovery of costs for services related to water use fall under Articles 12 to 17 of the Water Act of 19 December 2008. In order to achieve cost recovery, the water fees charged to the users of water services by the municipalities each consist of a partial fee for drinking water and for wastewater. In accordance with the requirements of Article 12 of the Water Act, the water pricing schemes distinguish four sectors. These are industry, households, agriculture and the hotel and catering industry (Horeca), each of which is expected to make an appropriate contribution to cost recovery.

As of 1st January 2010, the global costs for planning, constructing, operating, maintaining and servicing water supply and wastewater disposal infrastructures and their depreciation will be covered by the water fees for human consumption (*redevance eau destinée à la consommation humaine*) and wastewater (*redevance assainissement*). The water price results from these two fees among others collected by the municipalities and their agencies. This enables the municipalities to sustainably maintain the drinking water and wastewater infrastructures at a high qualitative level. Since the water price and the levy regulations are set by each individual municipality, the water price can vary from municipality to municipality.

In order to account for environmental and resource-related costs, two additional state taxes were introduced, the water abstraction tax *(taxe de prélèvement d'eau)* and the wastewater tax *(taxe de rejet des eaux usées)*. While the water abstraction tax was set by the Luxembourg Water Act, the wastewater tax is set annually by a Grand-Ducal regulation. This was 11 cents per m³ in 2021 compared to 15 cents per m³ in 2014. The revenue from these taxes flows integrally into the Water Management Fund *(fonds pour la gestion de l'eau)*, which provides state financial support for projects in the water management sector. For example, initial investment aid is granted from the Water Management, watercourse maintenance and renaturation. The terms of use and purposes of the Water Management Fund's subsidies for projects are regulated by the Water Act.

It should be noted that, taking into account the environmental and economic impacts, as well as certain geographical conditions in the different regions of the Grand Duchy of Luxembourg, the cost recovery at the end of 2012 for the three sectors of households, industry and agriculture was at a reasonable level of about 85% each.

Belgium (Wallonia)

In Wallonia, cost recovery for public drinking water supply and for wastewater disposal has been studied. The cost recovery ratio for drinking water production and supply in the IRBD Rhine in Wallonia was estimated for the reference year 2017. The results per economic sector are as follows:

- 115,6% for agriculture,
- 112.7% for industry,
- 95,0% for households.

The cost recovery ratio for public wastewater treatment (wastewater collection and treatment) in the IRBD Rhine was estimated for the reference year 2017. The results per economic sector are as follows:

- 9% for industry,
- 135,3% for households.

Netherlands

The total cost of protecting the Netherlands from flooding and providing sufficient and clean (drinking) water amount to 7.3 billion euros (2018). Of this, the water boards bear 42%, the municipalities 20%, the drinking water companies 21%, the Ministerie van Infrastructuur en Waterstaat [Ministry of Infrastructure and Water Management] 15% and the provinces 2%. In addition, a good 1 billion euros are spent on the management of the waterways. In total, this is a good 1% of the gross domestic product. Almost all costs for water quality management are financed by levies from water associations and municipalities and drinking water costs.

There are five different water services in the Netherlands:

- Production and supply of water: This involves the production and supply of drinking water, process water (including irrigation water for agriculture) and cooling water. The costs of drinking water production and supply in the Netherlands are borne by the water suppliers and passed on to consumers, partly through fixed costs (for the water supply network) and partly through a cost-covering tariff per m³ of water for the production and purification of tap water (Article 11 of the Drinking Water Act). The cost of treating surface and groundwater is increasing as new emerging substances become more common. The rising costs are compensated by savings elsewhere in the process. The average price of drinking water for a household in 2020 is €1.35 per cubic metre (before levies). In some cases, the water boards charge for the supply of fresh water to the agricultural sector, for example in areas with brackish water or for frost protection irrigation in fruit-growing;
- Collection and discharge of precipitation and wastewater: This concerns the sewerage system, including groundwater drainage in cities. It involves the collection and processing of wastewater and precipitation water and measures to avoid or limit adverse effects on groundwater levels. The costs for investments, for the administration and maintenance of the sewerage system are borne by the municipalities. Most of these costs are counter-financed by the sewerage levy (Article 228a of the municipal law).
- Wastewater treatment: The installation, acquisition, improvement, management, maintenance and operation of treatment infrastructures (transport pumps and pipelines, treatment and sludge processing plants) ensure that the wastewater produced is treated and discharged to surface waters within the applicable legal requirements. The costs are covered by the wastewater treatment levy (Article 122d of the Water Board Act), which is levied by the water boards (Waterschappen) on all discharges into the sewerage system and on purification-related infrastructure, and by the pollution levy (Article 7.2 Water Act) for discharges into surface waters. With these means, the domestic waste water is

treated at least in accordance with the requirements from the guideline for the treatment of municipal waste water. In many places, there is further treatment of nutrients in order to meet the environmental quality standards of the WFD. The levies are determined on the basis of the number of pollution units;

- Groundwater management: The water service groundwater management concerns the quantitative management of deep groundwater, consisting in particular of the regulation and control of abstractions. In this connection, the provinces are the authorised bodies and may levy a groundwater charge to finance the provincial costs of groundwater management (Article 7.7 of the Water Act). The levy is charged on large-scale abstractions, especially by drinking water companies and industry. For smaller withdrawals, for example for domestic or agricultural applications, the levy is not considered cost-effective, and it was decided not to measure the quantity used.
- Regional management of water systems: This includes the management of regional water systems, including the water system management of the water boards. Important tasks are flood protection, sufficient and clean water. Due to decisions on water levels the management of near-surface groundwater is also part of the regional water system management. Drainage by agriculture is also regulated by resolutions on water levels. The water boards cover the costs from the water system levy (Article 117 of the Water Associations Act).

For all water services (provided by public authorities and drinking water companies), the cost recovery mechanism is anchored (in the Drinking Water Act, Municipalities Act, Act on Water Boards, Water Act). By offsetting costs and revenues (from reserves) to largely avoid price fluctuations, the percentage may deviate from 100% in a particular year. Since all costs must be covered by the levies and no profit may be made, the percentage, viewed over a longer period of time, is by definition always 100%. The extent of cost recovery in 2020 is at comparable levels to those reported in the 2015 plans, as 96-104% of costs were recovered from users.

A large part of the costs for water services is due to environmental protection and can therefore be considered as environmental costs according to Article 9 (1) WFD. Thus, for 'wastewater treatment', the water service is fully in the service of environmental protection. The costs of the water service then correspond to the environmental and resource costs. These environmental and resource costs are also fully internalised in the price that users pay for this water service. For the other water services, the environmental and resource costs are also part of the total costs of the water service. However, the exact share can only be approximated, but again, the environmental costs were charged internally.

7.2.3 Water bodies for drinking water abstraction

In the states, resp. federal states/regions of the Rhine catchment area, a large share of the drinking water supplied comes from groundwater (via bank filtration, artificial groundwater recharge and direct abstraction). This also results in corresponding protection requirements for the management of these water bodies that are geared towards drinking water protection.

The definition of drinking water protection areas is one particular means of protecting drinking water supplies. See Map K 9.

7.2.4 Water abstraction or impoundment

n the basic water network of the IFGE Rhine, there are only withdrawals of surface water in Luxembourg and in Hesse (Germany) which are classified as significant pressures in the sense of the WFD. Furthermore, there are major water withdrawals for drinking water supply at Lake Constance and in the Rhine delta. Reference is made to the national legislation and the management plans (Parts B).

7.2.5 Point sources and other activities impacting on the state of waters

With respect to overall consideration of the international Rhine river basin district, attention is drawn to the four major management issues dealt with in Chapter 7.1.

7.2.6 Direct discharges into groundwater

Direct discharges are not relevant at river basin district level (Level A). A detailed description of the effects of cases in which authorisation was given for direct discharges into groundwater is provided in the Management Plans (Parts B).

Artificial filling or recharge of groundwater bodies is locally limited.

7.2.7 Priority substances

Please refer to details of Chapter 7.1.2 concerning the management issues concerned.

7.2.8 Accidental pollution

Prevention of accidents and security of industrial plants

In practice, accidents in industrial plants may result in far-reaching, transboundary effects on waters – in particular restrictions on their use as drinking water or industrial water, and may damage the aquatic ecosystem.

Therefore, "Recommendations of the International Commission for the Protection on the Rhine on the prevention of accidents and security of industrial plants" were drafted during recent years and can be downloaded from the ICPR homepage (www.iksr.org) In all Rhine-bordering countries, the national regulations correspond to these recommendations.

While the analyses of accident occurrences on the Rhine reveal a considerable reduction of accidents at such installations, they also show that discharges caused by shipping increased in the years 2004 to 2008 and then decreased again (cf. Figure 34).

Within the implementation and monitoring of the regulations of the CDNI Convention, the pollution of waters by ship-generated waste from inland navigation must be further reduced in the contracting states of the Netherlands, Germany, Belgium, France, Switzerland and Luxembourg.

International Warning and Alarm Plan

In the 1980s, the ICPR established an international warning and alarm plan (IWAP Rhine), which is both emission- and immission-oriented, in order to avert dangers from water pollution and to detect and pursue the causes of pollution (discharges, industrial accidents or shipwrecks, etc.).

An essential element of the IWAP are the water monitoring stations equipped with automatic early warning systems.

Seven international main warning centres collect and distribute the messages (see Figure 35). When assessing an alarm, the international main warning centres and the competent authorities have a flow time model, a set of guidance values for "alarm-relevant" concentrations and loads, lists of substance data banks and further means at their disposal.

Within the Rhine IWAP, the messages are passed on upstream (search messages) and downstream (information or warning) with standardised forms in three languages (German, French, Dutch). The exchange of these reports has been taking place via an

<u>internet platform</u> since 2020. The development of the reports submitted via the IWAP Rhine in the period from 1985 to 2019 can be seen in Figure 34 .



Figure 34: Development of the number of reports which most probably originate from shipping, industry or agriculture in the period 1985 to 2019

The number of reports that probably have an industrial origin varies between 2 and 32 reports per year in the period under consideration (1985-2019). The most reports (32 reports) were recorded in 1989, the fewest in 2002 and 2007.

Ship-related reports have increased significantly since 2001, with a maximum in 2006 and 2008 (31 reports each). Since 2011, the number of ship-related reports has been decreasing, but the share of shipping in the total number of reports has remained above 50% for almost the entire period under consideration.

The number of reports caused by agriculture fluctuates between 1 and 3, reaching a maximum of 7 in 2013. The share of the total number of reports has never exceeded 25% since 1985.

The International Main Alert Centres issue warnings beyond information reports in cases of water pollution incidents implying substances noxious to water, if the amounts or concentrations concerned may detrimentally impact the water quality of the Rhine or drinking water supply along the Rhine and/or are liable to raise great public interest.

Some the areas of operation in the Rhine river basin district (for example the International Commissions for the protection of Moselle and Saar) have their own warning and alarm plans in place which are detailed in the B reports.



Figure 35: Main international Warning Centres

7.2.9 Additional measures for water bodies which will presumably not achieve the objectives set out in WFD Article 4

At present, nothing can be said in respect to additional measures according to Articles 11, Par. 5 WFD, as these will only be determined should the objectives not have been achieved by implementing the measures planned in the programmes of measures.

7.2.10 Additional measures

As for additional measures concerning the main management issues, reference is made to Chapter 7.1. Further details can be obtained in Parts B of the Management Plans.

7.3 Pollution of the marine environment and connection between the WFD and the MSD

7.3.1 Pollution of the marine environment

The qualitative improvement of the marine environment, in particular of the coastal areas of the North Sea and Wadden Sea, is also achieved by inshore emission measures. Restoration and structural measures implemented in the delta and further upstream increase the self-purifying capacity of surface waters. This also applies to the restoration of natural transitions (freshwater – salt water, wet – dry) and increased water detention time due to longer water retention. In the long run, this will also be beneficial for the marine environment.

With respect to many priority substances and pollutants, the water quality of the marine environment corresponds to the environment objectives. Among the priority substances, the standards are exceeded for various PAH compounds and mercury. These substances are summarised by the term "ubiquitous substances". They are persistent (long-lived) substances that will be present in the aquatic environment for decades to come in concentrations that pose a significant risk, even if extensive measures have already been implemented to limit or stop emissions. Since the ban on the use of TBT as a marine coating came into force in 2003, trend measurements in suspended matter and sediment indicate a strong decrease. In contrast to the previous management plan, there are now almost no exceedances. In addition, exceedances of octylphenols, brominated diphenyl ethers, heptachlor/heptachlor epoxide and dichlorvos were measured on the Dutch coast. The standard for dichlorvos is also exceeded in the Wadden Sea. Of the other pollutants, the PMC limits were exceeded for arsenic and benzo(a)anthracene in the Wadden Sea and for arsenic and zinc on the Dutch coast.

Regarding the protection of the marine environment against nitrogen, reference is made to Chapter 5.1.1, for measures to Chapter 7.1.2.

7.3.2 Connection between the WFD and the MSFD

On 15 July 2008, the European Marine Strategy Framework Directive (Directive 2008/56/EC, MSFD) came into force. Member States are required to take the necessary measures to achieve or maintain good environmental status in the marine environment by 2020 at the latest, to ensure its protection and preservation on a permanent basis and to avoid future deterioration. States must regularly assess and monitor the state of the marine environment and develop programmes of measures. By the end of 2020, the good status has not yet been achieved.

The MSFD also includes dispositions aimed at granting coordination with other European regulations. For example, it provides for cooperation with the river basin commissions with regard to inland waters flowing into the seas. This has been started, but needs to be further intensified.

Essentially, there are three issues that make it necessary to dove tail the MSFD and the WFD:

- 1) Biodiversity / diadromous fish species (migratory fish and their migration between fresh and salt water),
- 2) Nutrients and pollutants, and
- 3) Waste.

The connections between the two directives are dealt with in various ICPR committees.

With regard to the first two topics, the measures already presented in the WFD and in this Management Plan are decisive; please refer to Chapters 7.1.1, 7.1.2 and 7.1.3.

For migratory fish species changing between fresh and salt water, free migration routes in the estuary are essential for their life cycle. Therefore, especially the measures to improve the upstream migration into the Rhine catchment as well as the downstream migration possibilities in the Netherlands are of great importance. The measures in the Rhine delta at the Haringvliet locks ("De Kier") listed in chapter 7.1.1 and the fish exchange facility under construction at the Afsluitdijk of the IJsselmeer, in the form of a fish migration river, should be highlighted.

According to the initial assessment under MSFD, the good environmental status for eutrophication in the Dutch part of the North Sea is achievable in the years after 2020.¹⁴² As rivers play a role as input pathways, the prerequisite for this is that the measures agreed in the (international) WFD framework to achieve the targets for nutrients are implemented. The environmental status will be carefully monitored.

For the third topic "waste", rivers also play a role as important input pathways. The input of microplastics must be distinguished from the transport of larger pieces of waste. Priority is given to product and waste policy in order to prevent waste, especially macroplastics, from entering the environment and thus also water bodies. To this end, there are numerous activities at national and EU level, such as the EU's Single-Use Plastic Directive.

Various studies on (macro-)waste from rivers in the Netherlands have provided initial insights into the composition of transported waste, the assessment of loads and the sources. Based on this information, the Netherlands will work, among other things, to effectively address the sources of litter in rivers through the MSFD programme of measures. Possible sources are the (plastics) industry, construction, the transport sector (especially inland navigation), sand extraction, the filling of sand extraction lakes and recreation. Similar studies exist in other countries.

With regard to waste, the Netherlands has set the following targets for the implementation of the MSFD for 2020: $^{\rm 142}$

- The amount of waste in the sea decreases over time;
- the amount of micro-litter in the sea decreases in the long term;
- the amount of waste and micro-waste ingested by marine animals is at a level that is not harmful to the health of the respective species.

Knowledge about the sources and occurrence of (primary) microplastics in the marine environment and in rivers is continuously improving. Possible sources here include fibres from textiles, tyre abrasion and plastic pellet loss in industry. However, there are still too few findings on microplastics in inland waters, and if there are, they are hardly comparable. There are no uniform assessment standards or methods. Therefore, further research is needed at national and EU level to deepen knowledge. At ICPR level, developments in the field of research, monitoring, pilot projects and possible approaches in the states are currently being collected and an exchange between the states is being promoted.

Within the framework of the OSPAR Commission, an OSPAR Action Plan on Marine Litter was adopted in June 2014. A corresponding exchange of information between OSPARCOM and the ICPR has begun and is to be continued, also in the spirit of the MSFD. OSPAR published a report in 2016 with an inventory of knowledge and measures on waste in rivers. Based on the knowledge gained from this report, OSPAR organised a workshop in 2017 for an exchange between experts from OSPAR and the river commissions. A review of the OSPAR Action Plan is currently underway at OSPAR level. It is expected that OPSAR will adopt an updated version of the Action Plan in 2022.

¹⁴²Mariene strategie voor het Nederlandse deel van de Noordzee 2012- 2020, deel 1, Ministerie van Infrastructuur en Milieu i.s.m. Ministerie van Economische Zaken, Den Haag, 2012; Mariene strategie (deel 1), Actualisatie van huidige milieutoestand, goede milieutoestand, milieudoelen en indicatorren, 2018-2024, Ministerie van Infrastructuur en Waterstaat i.s.m. Minister van LNV, Den Haag, 2018

7.4 Connection between the WFD, FRMD and other EU directives

The Flood Risk Management Directive (Directive 2007/60/ EC; FRMD) provides for an interlinking with the WFD on the measure level. The implementation of the FRMD significantly influences the work of current and future flood prevention in the IRBD Rhine. Therefore reference is made to the Flood Risk Management Plan for the IRBD Rhine¹⁴³ to be drafted in parallel by 22 December 2021.

With a view to creating synergies between measures of the FRMD and the WFD, the EU Resource Document "Links between the Floods Directive (FD 2007/60/EC) and Water Framework Directive (WFD 2000/60/EC)" is being taken into account.¹⁴⁴ The same applies to the final report from the 2019 workshop on hydromorphological measures of the FRMD and WFD "Finding Synergies and Addressing Challenges"¹⁴⁵ as well as to the results of ECOSTAT/ATG hydromorphological activities on ecological potential and possible impairments from water uses¹⁴⁶.

In the Rhine catchment, there are already many examples, including transboundary ones, that demonstrate synergies between flood protection, water protection and nature protection. Example projects for synergies were presented, among others, in the international FRM plan of the IRBD Rhine, in the framework of the success control 2005-2013 for the biotope network on the Rhine¹⁴⁷ as well as in the final report of the ICPR workshop of the working groups Flood and Low Water and Ecology on "Flood prevention and watercourse enhancement in the Rhine catchment - challenges and success factors¹⁴⁸", which took place in2018. Such an integrated approach will be taken forward in the future.

The ICPR workshop 2018 also identified key factors for a successful implementation of integrated measures such as the development of common visions, goals and projects by different actors. Compromises have to be found. Important elements are awareness raising as well as appropriate use of the land still available.

With respect to including further EU directives the Rhine Ministers confirmed in Basel in 2013 and in Amsterdam in 2020 that, in future, the interlinking of activities within water protection and nature protection will have to be improved in order to profit from mutual synergy effects. Among others, the targets for NATURA 2000 sites depending on water will have to be integrated into the WFD implementation. The creation of floodplains serves ecological improvement and natural water retention at the same time. In terms of an ecologically holistic approach, the cross-sectoral approach (ecology - flood protection and further utilisation/protection functions) is anchored in the programme "Rhine 2040¹⁴⁹" (Rhine Ministerial Conference 2020).

7.5 Adaptation to the impacts of climate change

Concerning this issue, the ICPR has drafted a **Strategy for Adapting to Climate Change for the IRBD Rhine** for which regular updates are planned.¹⁵⁰ The strategy also includes in short form the current state of knowledge about possible impacts of changes in runoff

Part 3: Affected by drainage systems: <u>http://publications.jrc.ec.europa.eu/repository/handle/JRC110959</u> ¹⁴⁷ <u>ICPR technical report no. 223 (2015)</u>

¹⁴³ <u>https://www.iksr.org/de/eu-richtlinien/hochwasserrichtlinie/hochwasserrisikomanagementplan</u>

¹⁴⁴ Technical Report - 2014 - 078

¹⁴⁵ See <u>https://circabc.europa.eu/ui/group/9ab5926d-bed4-4322-9aa7-9964bbe8312d/library/4fd3feb2-388a-</u> 49d2-a688-88064ae0dfd7

¹⁴⁶ Part 1: Influenced by water storage: <u>http://publications.jrc.ec.europa.eu/repository/handle/JRC103830</u> Part 2: Impacts of flood protection structures:

http://publications.jrc.ec.europa.eu/repository/handle/JRC110957

¹⁴⁸ <u>ICPR technical report no. 260 (2019)</u>

¹⁴⁹ ICPR "Rhine 2040" Programme (2020)

¹⁵⁰ ICPR technical report no. 219 (2015)

patterns and water temperature on the ecosystem, water quality and uses of the Rhine¹⁵¹ as well as possible perspectives for action.

Pronounced low water phases, as in 2018 and 2019, lead to impairments of the ecology, the water quality and the uses of the Rhine, e.g. for navigation and drinking water use.¹⁵² Effects of low water events on the ecosystem were dealt with in the inventory of low water conditions on the Rhine. In 2019, uniform low water monitoring was introduced across the Rhine.¹⁵³ Possible effects of water temperature changes on ecology and water quality have already been mentioned in chapter 2.4.

Based on the studies mentioned in chapter 2.4, increased water temperatures and reduced discharges due to low flow periods have impacts on oxygen levels and water ecology that should be taken into account when implementing measures. In lakes and dammed river sections, the change in the stratification of the water will alter the natural processes. If migration in the water bodies is impaired, animals living in the water have no alternative to migrate to colder water bodies (sections) and to settle again later in sections that have temporarily dried up. Based on the calculations of low flow values in conjunction with water temperature, it is possible to assess the stress on water ecology and consider measures in situations of low flow. Due to increasing heavy rainfall events, which are also a consequence of climate change, more sediments are also being introduced into water bodies, which can also impair their quality.

Hydromorphological measures to shade the water bodies and promote water dynamics will become more important with increasing low water events. The pressures brought about by low water and higher water temperatures are reflected in the species community of fish, macroinvertebrates and also phytoplankton (e.g. increased occurrence of algal blooms) and should be included in the inventories as well as in the implementation of measures to protect the water bodies.

An assessment of the influence of low water on water bodies is of utmost importance in the future in order to be able to implement practical measures to counteract low water periods or reduce their negative effects.

The ICPR's climate change adaptation strategy is to be continued until 2025 in accordance with the programme "Rhine 2040" adopted at the Conference of Rhine Ministers 2020¹⁵⁴ in Amsterdam. For this purpose, the discharge projections are to be updated by 2023 and the projections for water temperatures in the Rhine are to be updated by 2024.

¹⁵¹ ICPR technical report no. 204 (2013)

¹⁵² ICPR technical report no. 263 (2019)

¹⁵³ ICPR technical report no. 261 (2019)

¹⁵⁴ ICPR Communique, Conference of Ministers 2020

8. List of detailed programmes and management plans

8.1 Detailed management plans according to Article 13 (5) WFD

The ICPMS are developing their own international management plan for the Moselle and Saar river basins (www.iksms-cipms.org). Likewise, the IGKB takes care of the implementation of the WFD for Lake Constance(www.igkb.org).

Furthermore, reference is made to the Management Plans Parts B of the states and regions/federal states:

Wallonia (Belgium): <u>http://environnement.wallonie.be</u>

Germany:

River Basin Community Rhine <u>www.fgg-rhein.de</u>

Baden-Wuerttemberg: <u>www.wrrl.baden-wuerttemberg.de</u>

Bavaria: <u>www.wrrl.bayern.de</u>

Hesse: www.flussgebiete.hessen.de

Lower Saxony: <u>www.nlwkn.niedersachsen.de</u>

North Rhine-Westphalia: www.flussgebiete.nrw.de

Rhineland-Palatinate: <u>www.wrrl.rlp.de</u>

Saarland: <u>www.saarland.de/wrrl.htm</u>

Thuringia: https://aktion-fluss.de/

France: <u>http://www.eau-rhin-meuse.fr/</u>

Liechtenstein: <u>http://www.au.llv.li/</u>

Luxemburg: www.waasser.lu

Netherlands: <u>http://www.iplo.nl/water-sgbp3</u>

Austria: https://www.bmlrt.gv.at/wasser/wisa/ www.vorarlberg.at

Switzerland: www.bafu.admin.ch/wasser

8.2 Programmes going beyond Article 13 (5) WFD

Beyond Article 13. (5) WFD, the following programmes have been elaborated within the framework of the ICPR and other international cooperation in the Rhine catchment, which deal with special aspects of water management: The Master Plan Migratory Fish¹⁵⁵ and the Lake Constance Lake Trout Programme¹⁵⁶ as well as the Biotope Network¹⁵⁷.

The ICPR has adopted the new programme "Rhine 2040¹⁵⁸" as successor to the programme "Rhine 2020¹⁵⁹" that has expired in 2020. Both programmes contain objectives that have also contributed or will contribute to the implementation of the WFD.

¹⁵⁵ ICPR technical report no. 247 (2018)

¹⁵⁶ http://www.ibkf.org/publikationen/

¹⁵⁷ ICPR technical report no. 154 (2006); Atlas Biotope Network along the Rhine (2006)

¹⁵⁸ ICPR "Rhine 2040" Programme (2020)

¹⁵⁹ Rhine Ministerial Conference 2001: Rhine 2020

9. Information of the public and public hearings as well as their results

Article 14 of the WFD requires Member States to inform and consult the public - i.e. all citizens in the Rhine catchment - and to actively involve all interested bodies. The Directive provides for the following three stages of consultation on the main steps of implementation:

- concerning schedule and work programme;
- concerning the most important water management issues;
- Concerning the management plan.

These consultations have been or are being organised by the member states resp. federal states/regions. For details, please refer to the Management Plans (Parts B).

In the IRBD Rhine, the public is also informed at international level. Comprehensive information on the Rhine river basin district and the WFD is available to the public on the ICPR website <u>www.iksr.org</u>. Moreover, all reports, in particular those issued at international level, and publications (brochure "Rhine unlimited") are available as downloads. In the ICPR, the acknowledged observers are represented in the working groups and the Plenary Assembly/Coordination Committee and can, therefore, participate in the discussions and present their issues. The ICPR has actively involved its recognised observers in the work on the preparation of this third Management Plan. Annex 8 contains the list of NGOs acknowledged by the ICPR (as of 2020).

The draft River Basin Management Plan 2022-2027 IRBD Rhine was published on <u>www.iksr.org on 15 April 2021</u> and was available for public consultation until 15 October 2021. During this period, a total of two comments were received by the secretariat. Numerous suggestions were taken into account during the revision of the plan. A coordinated overview of the aspects addressed in the comments and answer has been provided . It will be sent to the stakeholders and published on the ICPR website (https://www.iksr.org/en/eu-directives/european-water-framework-directive/public-participation).

In order to promote the active involvement, especially of the organised public (agricultural associations, environmental protection, hydropower producers, etc.) in the WFD implementation process at national level, the states or countries/regions have chosen different approaches - depending on the specific circumstances. In several cases, temporary or permanent discussion groups to assist the implementation process were established at national or regional level at an early stage. For details, please refer to the Management Plans (Parts B) and the information on national consultations linked at <u>www.iksr.org</u>.

10. List of competent authorities according to Annex I WFD

The list of competent authorities can be found in Appendix 9.

11. Contact addresses and procedures for obtaining background documents

We refer to the list of competent authorities in Annex 9. Furthermore, reference is made to the ICPR website (<u>www.iksr.org</u>) and to the detailed information – including the procedure of how to procure background documents – in the Management Plans (Parts B), and also to relevant national websites.

12. Summary and outlook

The European Water Framework Directive (Directive 2000/60/EC, WFD) has set new standards in water policy for EU Member States. The target of the WFD is to achieve the good status of all surface waters and of the groundwater by 2015, as a matter of principle. The international river basin commissions, such as the International Commission for the Protection of the Rhine (ICPR), serve as transboundary coordination platforms to jointly achieve this goal. For the benefit of the Rhine and all waters flowing into it, the states in the Rhine catchment have been cooperating in the ICPR since 1950 and have together already made significant progress in water protection before implementing the WFD.

The internationally coordinated River Basin Management Plan 2022- 2027 for the international river basin district (IRBD) Rhine(part A basins > 2,500 km²) – in this document consistently referred to as "River Basin Management Plan 2022-2027 IRBD Rhine" – describes monitoring results of the Measurement programmes Chemistry and Biology for the Rhine, the targets to achieve and the programmes of measure. It serves as an information tool for the public and the European Commission and documents the international coordination and cooperation of the states in the river basin district.

Some developments since the publication of the management plan for the IRBD Rhine 2016-2021 in 2015 can be found in separate text boxes in the chapters.

Based on the data of the biological monitoring programmes 2018 / 2019, the surface water bodies in the basic water body network of the IRBD Rhine (catchment > 2500 km²) were assessed as follows: 10% achieved good ecological status / potential, which is an improvement of 7%; 48% was rated moderate and the rest worse. In the main stream of the Rhine, 79 % of the water bodies were classified as moderate, 21 % as poor. This represents an improvement of 16% compared to 2015. In 2027, the ecological status / potential objectives are expected to be met in a further 22% of surface water bodies. For 65%, target achievement is expected after 2027. For 3% of the surface water bodies there is no information on the achievement of targets with respect to the year 2027 available. In the main stream of the Rhine, 21% are expected to achieve their objectives by 2027 and 72% of the water bodies are expected to achieve their objectives after 2027.

For the chemical status of the surface water bodies in the basic water body network of the IRBD Rhine, 100%, are classified as not good for the main stream of the Rhine due to pollution by priority pollutants with ubiquitous distribution. Without taking the ubiquitous substances into account, the situation looks much better. Then, more than half of the surface water bodies can be classified as good (59% overall and 53% in the main stream of the Rhine).

In 2027, the chemical status objectives are expected to be achieved in 10% of the surface water bodies. For 88%, target achievement is expected after 2027. For 2% of the surface water bodies there is no information on the achievement of targets with respect to the year 2027 available. In the main stream of the Rhine, 36% are expected to achieve the objectives by 2027 and 64% of the surface water bodies are expected to achieve the objectives after 2027.

The quantitative and chemical groundwater status has improved slightly compared to the 2016 - 2021 management plan. In the meantime, 97% of groundwater bodies are in good quantitative status and 75% in good chemical status. In 2027, the quantitative status objectives will probably be achieved in 97.2% of the groundwater bodies. For 3% of the groundwater bodies there is no information on the target achievement with respect to the year 2027 available. For the chemical status, in addition to the 74% of groundwater bodies that have already achieved the objective of the good chemical status, a further 3% are expected to achieve the objective in the period 2022-2027 and a

further 22% only after 2027. For 1% of the groundwater bodies there is no information on the target achievement with regard to the year 2027 available.

Even though good status or good potential has still not been achieved everywhere, important progress has been made in the IRBD Rhine by 2021 since the WFD came into force with regard to the **four essential management issues**. However, further measures are needed:

1. Restoration¹⁶⁰ of ecological river continuity, increased habitat diversity:

Progress

Since 2000, almost 600 obstacles to migration in the Rhine and in the tributaries important for the resettlement of migratory fish have been removed or equipped with fish ways. More than 28 % of the valuable habitat areas for salmon are thus accessible again and further dispersal possibilities for other fish and animal species are given. The goal of restoring the **ecological continuity** of the Rhine from the North Sea to Switzerland has gradually come closer, but has not yet been achieved. Many valuable spawning and juvenile fish habitats are still inaccessible due to existing migration obstacles.

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 theOld Rhine/ Rest Rhine , in the Basel tributaries Birs, Ergolz and Wiese as well as in other tributaries of the High Rhine once the three remaining barrages Rhinau, Marckolsheim and Vogelgrun in the Upper Rhine have been made passable. When fish passage is also restored at three agricultural weirs in the Rhine loops Gerstheim and Rhinau, these will allow migratory fish to continue their ascent into the Elz-Dreisam catchment with 59 ha of spawning and juvenile fish habitats.

In order to **increase habitat diversity**, bank protections were removed on more than 160 km of Rhine banks in the period 2000-2018, and parallel structures or silted-up groyne fields were created on the Middle, Lower and Delta Rhine as flow-calmed, wave-protected and structurally rich replacement biotopes in the river. 124 oxbow lakes and tributaries have been reconnected to the stream dynamics. More than 130 km² of Rhine floodplains have been reactivated. These measures improve lateral continuity, enable the recolonisation of habitats, promote the distribution and exchange of aquatic animals and plants and increase biodiversity.

State of affairs

The current assessment of the Rhine ecosystem only reflects the current state of the system. Due to the one-out-all-out principle the improvements that can be observed in individual biological quality elements do not manifest themselves in the overall assessment if one of the other elements is assessed as worse. However, the long-term trends of the last 25 years also indicate distinct, sustainable ecological improvements. The future implementation of the ecological measures described will help to continue this trend.

¹⁶⁰ As far as possible, river continuity is to be restored.

<u>Measures</u>

The fish pass at Rhinau shall be operational in 2024, the fish pass at Marckolsheim in 2026 and the fish pass for the complex Vogelgrun area as soon as possible in order to ensure compliance with the relevant EU legislation so that migratory fish can again reach the Old (Rest) Rhine and the spawning grounds in the Basel tributaries Birs, Ergolz and Wiese as well as in other tributaries of the High Rhine.

Numerous further measures are planned to advance the restoration of river continuity in the Rhine catchment and to increase habitat diversity, e.g. with the further implementation of the "Biotope Network on the Rhine". Within the framework of the programme "Rhine 2040", it was agreed that 200 km² of floodplain areas (= inundation areas) should be restored and 100 oxbow lakes and tributaries should be reconnected to the Rhine. The structural diversity of 400 km of banks is to be increased, e.g. by removing bank obstructions.

2. Reduction of diffuse inputs interfering with surface waters and groundwater (nutrients, pesticides, metals, dangerous substances from historical contamination and others)

Progress

The 17% reduction of load convened for nitrogen will be achieved when the annual average value for total N in the Rhine at Bimmen/Lobith and in the North Sea estuary is not greater than 2.8 mg/l (target value). The annual mean values of total N at Lobith were in the range of the target value of 2.8 mg/l from 2009 to 2015. Since 2015, the average annual concentrations at Bimmen/Lobith have been inconclusive. But also, for this period the values were in the range of the target of the target value of 2.8 mg/l.

By the end of 2018, 10 of the 22 areas at risk identified in the Sediment Management Plan Rhine (2009) have been cleaned up. In the Netherlands, of the total of 22 identified sedimentation areas, remediation work has been completed at 16 sites. For five areas at risk, further investigations determined that remediation was not necessary.

Compared to the Management Plan 2016-2021, the quantitative as well as the chemical state of groundwater bodies has slightly improved in the Rhine catchment.

State of affairs

Due to the significant reduction in point industrial and municipal discharges, the percentage of pollution caused by diffuse substance inputs is increasing.

Almost all water bodies in the basic waterbody network in the Rhine catchment show exceedances of the EQS for the ubiquitous substances mercury, PBDE, heptachlor/heptachlor epoxide, PAH compounds and PFOS. The PAH compound fluoranthene, which is not classified as ubiquitous, also exceeds the EQS at many monitoring sites, so that this substance is also responsible for the classification "not good".

In addition, there are PCB and HCB contaminations in sediments for which the Sediment Management Plan was adopted in 2009 and continues to be implemented.

The pollution of the upper main aquifer by excessive nitrogen inputs (nitrate and ammonium) continues to be the main problem for the chemical groundwater status. The vast majority of polluted groundwater bodies are in poor chemical status due to nitrate pollution. Furthermore, inputs of pesticides (and their degradation products / metabolic products) lead to a bad chemical status of certain groundwater bodies.

The groundwater can still be said to be good.

<u>Measures</u>

Measures to further reduce the nutrients nitrogen and phosphorus, which are largely based on changes in agricultural land use and soil cultivation, can only be realised together with agriculture. The ongoing implementation of the Nitrates Directive (Directive 91/676/EEC), the Directive on the Sustainable Use of Pesticides (Directive 2009/128/EC) and national regulations as well as recommendations on the appropriate use of plant protection products must be continued unabated.

Due to their persistence and widespread occurrence, there are few measures apt for reducing the pollution with ubiquitous substances on the short or medium term.

Other possible measures are the remediation of the remaining risk areas of the Sediment Management Plan which have to be implemented according to the Programme "Rhine 2040" until 2025.

The quantitatively poor condition of a few groundwater bodies will continue to exist for the most part, as they are affected by opencast lignite mining.

In particular, the action programmes for the implementation of the Nitrates Directive should contribute to reducing the pollution of groundwater bodies with nitrogen.

3. Further reduction of classical pollution of industrial and municipal point sources

Progress

Pollution from industrial and municipal point sources was further **reduced**. The discharges of priority substances and substances relevant to the Rhine from wastewater treatment plants and industry have been significantly reduced since 1985, and the point source discharges of nitrogen and phosphorus from industry have been reduced by more than half, those from municipal wastewater treatment plants by about one third. Since the early 1970s, intensive prevention and reduction measures of substance discharges have been implemented in industry. Emissions have also been further reduced in the past years, but to a much lesser extent.

State of affairs

Between 2010 and 2016, the treatment capacity of the municipal wastewater treatment plants in the IRBD Rhine was expanded from a total of just over 100 million population equivalents (p.e.) to about 106 million p.e..

In addition to almost 100% mechanical and biological treatment, targeted nitrogen and phosphorus reduction is also present in about 50% of municipal wastewater treatment plants. More advanced treatment to eliminate micropollutants, which is not required by the Urban Wastewater Directive, is currently installed at a total of 26 municipal wastewater treatment plants, mainly in Switzerland and the German states of Baden-Württemberg and North Rhine-Westphalia.

Industrial and municipal wastewater treatment plants can be of particular local significance for exceedances of the EQS or orientation values.

The majority of the surface water bodies exceeds the EQS of some priority substances, the orientation values of some physico-chemical parameters and some substances relevant to the Rhine.

<u>Measures</u>

Inits recommendations for the reduction of micropollutants published in 2019, the ICPR recommended, among other things, equipping suitable wastewater treatment plants with

an additional treatment stage on the basis of prioritisation criteria, accumulated experience and other aspects.

Optimisations of wastewater treatment plant operation within the existing concepts will also further contribute to the reduction of emissions. This also applies in particular to measures to reduce phosphorus inputs that go beyond the requirements of the Urban Wastewater Directive.

4. Harmonisation of water uses with environmental objectives.

The fourth important management issue is cross-sectoral, meaning that different **use functions** such as drinking water, water for agriculture and business, water and navigation, inland fisheries, recreation and tourism have to be **reconciled with the protection of the ecosystem.** That also implies the necessity of continual exchange with water users. This is done within the framework of NGO participation in the ICPR as well as through the involvement of all users in various workshops.

The share of organically farmed agricultural land has increased continuously over the last six years and shows a further upward trend. This considerably contributes to reducing water pollution. The shutdown of further coal-fired and nuclear power plants in the coming years will also have a positive impact. The shutdown of some power plants between Karlsruhe and Mainz has already led to a demonstrable relief of Rhine water temperatures in the northern Upper Rhine in winter. The volume of shipping traffic is stagnating.

In the coming years, cooperation with various user groups will be intensified within the framework of the ICPR. The ICPR will continue the exchange with other commissions and organisations and expand the cooperation with observers and stakeholders, including agriculture in particular.

Micro-pollutants

The ICPR strategy for dealing with micropollutants and the recommendations it formulated are the basis for further work.

In the programme "Rhine 2040", the Rhine Ministerial Conference 2020 in Amsterdam agreed on the goal of reducing the inputs of micropollutants into water bodies by at least 30% by 2040 compared to the period 2016-2018.

Climate change

The **effects of climate change**, and the changes of the discharge regime in the Rhine with, among others, **more frequent flood events and longer lasting low water phases** as well as the rise in water temperature have to be increasingly taken into account in the future when dealing with the four main management issues. The foundations for this have been laid with various scenario studies on the **water balance and water temperature** within the framework of the ICPR. The ICPR's climate change adaptation strategy addresses this in detail and will be updated until 2025. Different groups of water users are also to be included.

ANNEXES

Annex 1: Ecological assessment of the monitoring stations incorporated in the surveillance monitoring programme according to WFD

							Ecol. state	Ecol. potential	Conoral ph	rcico-chomi	al parametr	and river	hacin-
State: 13 January 2022						very good	1	-	specific pol	lutants			
*Category: For High Rhine 2, the category "	heavily modifie	ed" still applied in 2009				good	2	2	All environmer respected	ntal quality sta	ndards		
** Phytoplankton, macrophytes / phytobent modified water bodies. In DE-BW, the result macrophytes were assessed and the potentia	hos: In DE, the for macrophyt al was determir	e ecological status and not the po es / phytobenthos refers to the c ned for phytobenthos.	tential is also d omplete biocom	letermined in nponent. In Fr	heavily ance, no	moderate	3	3	one or more e standards not	nvironmental c respected	quality		
*** Makrozoobenthos and fish: No assessm determined for the tributaries of the Lower bodies Upper Rhine 7 and Middle Rhine is co representative). In AT, the macrozoobentho fish fauna.	ent procedure i Rhine. The dev oordinated betw s method only	s available in FR. In DE-NW no e iation from the one-out-all-out p reen DE-RP and DE-HE (the resul reflects the material load. The hy	cological potent rinciple for the ts for fish in DE dromorphologic	tial has yet be fish fauna in t E-RP are more cal load is reco	een the water orded by the	poor	4	4	Assessment of required	quality compo	nent not	./.	
****Overall assessment: If the 4 biological good", the overall ecological rating is downg used for the physico-chemical parameters.	components ha raded to "mode	ave all been rated as "good" and a erate" (= 3 = yellow). In the Netl	one of the supp nerlands, the 5	orting parame -scale assessn	eters as "not nent is also	bad	5	5	No inventory c component / ir	or assessment o nsufficient data	of the		
											[
Water body	River-km	ICPR overview monitoring point in the water body	State / federal state	Category*	Phytoplanki on **	Makrophytes/ Phytobenthos **	Makrozoo- benthos ***	Fish fauna***	Specific pollutants * (see annex 2)	chemical parameter (see Annex 2)	Overall assessment 2009 ****	Overall assessment 2015 ****	Overall assessment 2021 ****
ALPINE RHINE - Reichenau - Bodensee			AT/	1									
Alpine Rhine		Fussach	AT/ Vorarlberg/ CH (SG)	heavily modified		2	2	3			3	3	3
LAKE CONSTANCE				,									
BOD-OS Lake Constance-Obersee	No kilometer	Fischbach-Uttwil	DE-BW	Natural	2	2		2			2	2	2
BOD-USZ Lake Constance-Untersee	milage	Zellersee	CH / St. Gallen	Natural	2	2		2			2	2	2
HIGH RHINE Lake Constance - Basel	24-170		1										
High Rhine 1 Eschenzer Horn until upstream River Aare High Rhine 2	24-45	Öhningen	CH/ DE-BW	Natural	1	2	3	3			2	3	3
downstream river Aare until R. Wiese	45-170		CH/ DE-BW	Natural	1	3	3	3				3	3
UPPER RHINE Basel - Bingen	170-529		DE 014	heavily			_				_	_	
Upper Rhine 1 - OR 1 - Rhine 1 - Old Rhine, Basel to Breisach	170-225	Weil am Rhein Result	FR of coordination	modified heavily modified heavily	./.	3	3	3			3 3 3	3	
Upper Rhine 2 - OR 2 - Rhine 2 - loop of the Rhine, Breisach to Strasbourg	225-292	Upstream Rhinau	DE-BW FR	heavily modified heavily modified	1	3 2	3	4			3	4	4
		Result	of coordination	heavily modified		-						4	4
Upper Rhine 3 - OR 3 - Rhine 3 - regulated			DE-BW	heavily modified	1	3	3	3				3	3
section of the Rhine, Strasbourg to Iffezheim	292-352	upstream of Gambsheim	FR	heavily modified	./.	3					4	3	3
		Result	of coordination	heavily modified								3	3
Upper Rhine 4 - OR 4 - Rhine 4 -		Karlsruhe	DE-BW	heavily modified	1	3	3	3			4	3	3
loop of the Rhine Iffezheim barrage to upstream mouth of River Lauter	352-428	upstream Lauterbourg/Karlsruhe	FR	heavily modified	./.	3					4	3	3
		Result	of coordination	heavily modified			4					3	3
Upper Rhine 5 - OR 5 -	252-428		DE-BW	heavily modified	1	3	3	3				4	3
mouth R. Lauter to mouth R. Neckar	352-428		DE-RP	heavily modified	1	2	3	3			3	4	3
			DE-BW	heavily modified	2	3	3	3				_	
Upper Rhine 6 - OR 6 - mouth R. Neckar to mouth R. Main	428-497		DE-HE	modified	2	3	3	3				3	3
		Worms	DE-RP	modified	2	3	3	3			4		
Upper Rhine 7 - OR 7 - mouth R. Main to mouth R. Nahe	497-529	Mainz/Wiesbaden	DE-HE	modified	3	3	3	2			Δ	- 3	3
MIDDLE RHINE Bingen - Bonn	529-639			modified			,	-			-		
Middle Rhine (MR)	529-639	Koblenz	DE-HE DE-RP	heavily modified heavily modified	3 3	3 3	2 2	2			4	3	3
LOWER RHINE Bonn - Kleve-Bimmen/ Lobith	639-865.5		1			1							
Lower Rhine 1 - NR 1 - Bad Honnef to Leverkusen	639-701	Cologne-Godorf	DE-NW	modified	3	3	2	3			4	3	3
Lower Rhine 2 - NR 2 - Leverkusen to Duisburg	701-764	Düsseldorf harbour	DE-NW	modified	3	3	2	3			4	4	3
Lower Rhine 3 - NR 3 - Duisburg to Wesel	764-811	Duisburg-Walsum/Orsoy	DE-NW	modified	3	3	3	4			5	4	4
Lower Knine 4 - NK 4 - Wesel to Kleve	811-865	Niedermoermter/Rees	DE-NW	neavily modified	3	3	3	4			5	4	4
Holland	865.5 -1032			heavily									
Boven-Rijn, Waal	880-930	Lobith	NL	modified		2	3	4			4	4	4
Beerkanaal	998-1013	Maassluis	NL	artificial heavily	2	2	2	3			3	3	3
Lake IJssel	n.a.	Vrouwezand	NL	modified	3	2	2	3			3	3	
Wadden Sea	n.a.	Dantziggat, Doove Balg west	NL	Natural	3	4	2				4	4	
Dutch coast (coastal waters)	n.a.	Noordwijk 2	NL	Natural	2		2				3	3	3
Coast Wadden Sea (coastal waters)	n.a.	Boomkensdiep	NL	Natural	2		2				3	3	3

Water body	River-km	ICPR overview monitoring point in the water body	State / federal state	Category*	Phytoplankt on **	Makrophytes/ Phytobenthos **	Makrozoo- benthos ***	Fish fauna***	Specific pollutants * (see annex 2)	General physico- chemical parameter (see Annex 2)	Overall assessment 2009 ****	Overall assessment 2015 ****	Overall assessment 2021 ****
TRIBUTARIES - UPPER RHINE													•
Neckar 4-03 (downstream Fils to upstream Enz)	140-208	Neckar near Deizisau	DE-BW	heavily modified	3	3	4	3			3	4	4
Neckar 4-04 (downstream Enz to upstream Kocher)	105-140	Neckar near Kochendorf	DE-BW	heavily modified	3	3	5	3			5	4	5
Neckar 4-05 (downstream Kocher to mouth)	0-105	Neckar near Mannheim	DE-BW	heavily modified	3	4	5	3			4	4	5
Weschnitz		Weschnitz near Biblis-Wattenheim	DE-HE	Natural	./.	4	4	4			4	4	4
Schwarzbach/Astheim		Schwarzbach near Trebur-Astheim	DE-HE	Natural	./.	4	5	3			4	5	5
Main river basin district													
Regnitz from confluence of Rednitz and Pegnitz to confluence with Main-Danube-		Regnitz near Hausen	DE-BAV	heavily modified	./.	3	3	3			4	4	3
Main from confluence Main Canal to	211-299.7	Main near Erlabrunn	DE-BAV	heavily	3	3	3	3			3	3	3
Main from Kloster Banz to confluence of	384.5-422.4	Main near Hallstadt	DE-BAV	Natural	2	3	2	4			3	4	4
Main from barrage Wallstadt to federal state	101.4-66.6	Main near Kahl	DE-BAV	heavily	3	3	4	3			3	4	4
boundary HE/BY near Kahl (2_F146) Main		Main near Bischofsheim	DE-HE	heavily	1	4	3	3			4	4	4
Nidda		Nidda near Frankfurt-Nied	DE-HE	modified heavily	-	4	3	-				4	
Kinzio		Kinzia near Hanau	DE-HE	modified Natural	.,.	3	4	4			5	4	4
Nabe													
Lower Nabe		Nahe near Dietersheim		Natural	2	3	2	3			3	3	3
			DE-RF	Naturai	2	5	2	5			5	5	5
Lahn		l abo pear Limburg-Staffel	DE-HE	heavily	/	5	5	4			5	5	5
Lahn		Lahn near Solms-Oberbiel	DE-HE	modified heavily	.,.	4	4	4			5	4	4
Lower Lahn		Lahn near Lahnstein	DE-RP	modified heavily	.,.	3	4	3			5	4	4
Moselle-Saar area				modified									
Blies		Blies near Reinheim	DE-SL	Natural	./.	3	2	2		./.	4	3	3
Nied		Nied near Niedaltdorf	DE-SL	Natural	2	3	2	2		./.	2	3	3
Saar Saarland - State boundary ED to		Saar near Güdingen	DE-SL	heavily	2	3	2	2		./.	4	4	3
federal state boundary DE-RP	25.9-102.8	Sarre near Fremersdorf	DE-SL	heavily	3	4	3	4		./.	4	4	4
Saar (DE-RP)	0-25.9	Saar near Serrig (no surveillance monitoring	DE-RP	heavily	3	4	4	3			5	4	4
Saar - Wiltinger Bogen (DE-RP)	4.75-7.81	Sarre near Kanzem	DE-RP	Natural	2	3	5	3			5	4	5
Alzette		Alzette near Ettelbruck	LU	Natural	./.	3	4	3			4	4	4
Syr		Syr near Merter	LU	Natural	./.	3	4	3			4	3	4
Sauer		Sauer near Erpeldingen	LU	Natural	./.	3	2	3			4	3	3
Sauer		Sauer, mouth near Wasserbillig	LU and DE- RF	Natural	3	3	2	3			3	3	3
Upper Moselle	206-242	Moselle near Palzem	LU and DE- RF	heavily modified	3	4	4	3			5	4	4
		Moselle near Fankel	DE-RP	heavily modified	3	4	5	з			5	4	5
Lower Moselle	0-206	Moselle near Koblenz	DE-RP	heavily modified	3	4	5	3			5	4	5
TRIBUTARIES - LOWER RHINE													
Sieg		Sieg near Menden (St. Augustin)	DE-NW	Natural	./.	3	2	4			4	3	4
Ruhr		Ruhr near Fröndenberg	DE-NW	heavily modified	./.	3	3	2			5	4	3
Ruhr		Mouth R. Ruhr (Duisburg Ruhrort)	DE-NW	heavily modified	./.	3	4	4			5	5	4
Lippe		Lippe near Lippborg	DE-NW	Natural	./.	2	2	3			4	3	3
Lippe		Lippe near Wesel	DE-NW	Natural	./.	3	5	5			5	4	5
TRIBUTARIES - DELTA RHINE													
Vechte, upper section		Vechte near Laar	DE-NI	heavily	./.	3	3	3			4	3	3
Vechtdelta Groot Salland	n.a.	Vechterweerd	NL	heavily		2	3	3			3	4	3

Annex 2: Results of the evaluation at monitoring stations of the programme for surveillance monitoring of physical-chemical parameters and substances relevant for the Rhine according to WFD

Physico-chemical pa relevant for the Rhi	arameters an ine according	nd substances g to the WFD	In excess of EQS/guidance value Lower than EQS/guidance value x no decision possible because of too high limit of deter on on measurements available Coastal waters outside the 1-mile zone: No classification required Numb No EQS determined as yet (measurement value)						Measuring points at inland surface waters it of determination Measuring points at "other surface waters" Nue)													
		River	Bregenzerach		Rhine			Neckar	Weschnitz	Schwarzbach	Main	Regnitz	Kinzig Nidda	Nahe	Lahn	Moselle	Sa	ar	Blies	Nied Alzette	Syr	Sauer
State: 15.01.2021 Data basis 2017		Monitoring station no Monitoriug station to the Same Same Same Same Same Same Same Sam	e61 6	ssach/Alpine Rhine 00 uingen *** Kingen*** Bil am Rhein 2 risruhe/Lauterbourg 2	1 12 13 32 blenz d Honnef	34 32 41 43 nmen hid bith	3 42 sinise	chendorf 6 8 nnheim 01	olis-Wattenheim	abur-Astheim	abrunn da constant	55 uesn	26 27	etersheim mientsheim	Ims-Oberbiel 66 65 hburg 06 65 hostein 06 66	15 17 18 umage line line line line line line line lin	arbrücken	2 14 uopsuality	mieim 25	edaltdorf 29 29 29 20 20 20 20 20 20 20 20 20 20 20 20 20	etert 62	oeldingen
Substance	CAS No. Value (WFD- Codelist)	Unit Status WFD or list of Rhine substances (rhr)	<u>[</u> <u>क</u>][<u>i</u>	포 호 호 호	Ba Ko Xa	<u> 9 </u>	W	<u>2 2 2 1</u>	ā	<u>F</u>	E E E	<u> </u>	ž	<u>ă</u>	La Li S	Fa Ko	Sa 1	E X	Re	žË	Ψ	<u> </u>
Physical-chemical parameters (supporting the assessment of	the ecological st	ate/potential)																				
according to WFD, Annex V Dissolved oxygen Water temperature	n.a. 321 n.a. 226	Annex V Annex V																				
pn Conductivity Cl ⁻	n.a. 330 n.a. 97	μS/cm Annex V Annex V	-	- 310 335 364 3	96 415 555 507	564 694		820 868 837	69	1110	619 694 644 663	595	477 861	485**	427 45 481**	1160 968 1200	596 77	70 643	465	1170 708	1090	266 63
Total hitrogen Nitrate nitrogen Orthophosphate phosphorous Total phosphorous	n.a. 228 n.a. 228 n.a. 227	mg/I Annex V mg/I Annex V Annex V Annex V		- 0,83 1,40 1,60 1,	90 2,30 2,30 2,18	-		,/2 4,82 4,3/	4,80	4,21	4,67	-	- 3,9	3,7	3,53 3,42 3,2	2,60 3,40 3,50	3,13 3,4	45 3,40	2,39	4,13 4,90	4,70	5,10 5,
In excess of one or more natio Lower than all national referen	onal reference val ice values	ue(s)																				
Substances relevant for the Rhine																						
Inorganic substances NH₄-N	14798-03-9 4	2011																				
Heavy metals and metalloids (solute) As sol.	7440-38-2 5	2011 2014 2017	2016 20	016										2018	- 2018	2018 2018		2018				20
Cr sol. Cu sol. Za sol	7440-47-3 6 7440-50-8 7	2011 2014 2017 2011 2014 2017 2011 2014 2017	2016 20 2016 20 2016 20	016										2018	- 2018 - 2018	2018 2018 2018 2018 2018 2018		2018 2018 2018				20
Non-volatile hydrocarbons	7440-00-0 0	2011 2014 2017	2016 20	010										2010	2010	2016 2018		2018				
4-chloroaniline Pesticides	106-47-8 4	2011		- -		-		- -	-		- - -				- - -	<u> - - -</u>		- -	-			-
bentazone chlorotolurone dichloronen (2.4.DB)	25057-89-0 9 15545-48-9 10 120-36-5 11	2011 2011 2014 2017 2011		-																		
dichlorvos	62-73-7 12	2011 2011 - priority substance since 2013		- x x x	X	x x		x x x	х	х	x - x x	x	x x	-	х х -				-		×	-
dimethoate MCPA	60-51-5 13 94-74-6 15	2011 2011		-	-						-								-	-		
PCB	93-65-2 14	2011		-																		
PCB 28 PCB 52 PCB 101	7012-37-5 17 35693-99-3 18 37680-73-2 19	2011 2014 2017 2011 2014 2017 2011 2014 2017))					-	-	X - X - X - X - X - X -	X		X	X X	X X X X X X X X X		- X - X	-	- X - X	X X X	X
PCB 118 PCB 138	31508-00-6 20 35065-28-2 21	2011 2014 2017 2011 2014 2017			<pre>X X X</pre>				-	-	 X - X -	- X		X	X X	X X X X X X		- X - X	-	- X - X	X	X
PCB 153 PCB 180 PCB 28 in suspended matter	35065-27-1 22 28655-71-2 23 7012-37-5	2011 2014 2017 2011 2014 2017 2011 2014 2017 2011 2014 2017))	X X				-	-	X - X - X - X -	X		X	X	X X X X X X		- X - X	-	- X - X	X	X .
PCB 52 in suspended matter PCB 101 in suspended matter	35693-99-3	2011 2014 2017 2011 2014 2017	ĒĒ	-												-				-		-
PCB 118 in suspended matter	31508-00-6	2011 2014 2017														-				-		-
PCB 150 in suspended matter PCB 153 in suspended matter	35065-28-2 35065-27-1	2011 2014 2017 2011 2014 2017		-			-									-				-		-
PCB 180 in suspended matter Organo-tin compounds	28655-71-2	2011 2014 2017					-				- -					-				-		-
dibutyltin-cation	14488-53-0	2011						[- [- [-	-			-
Calculation based on suspended material PCB	tter:																					
PCB 28 PCB 52 PCB 101	7012-37-5 35693-99-3 37680-73-7	2011 2014 2017 2011 2014 2017 2011 2014 2017							Ē	Ē			<u></u>	-								Ē
PCB 118 PCB 138	31508-00-6 35065-28-2	2011 2014 2017 2011 2014 2017 2011 2014 2017	ĒĒ						-	-		Ê	-						Ē			
PCB 153 PCB 180	35065-27-1 28655-71-2	2011 2014 2017 2011 2014 2017			·		-		-	-		-		-					-			-
Heasured in suspended matter: Heavy metals and metalloids												_							_		,, ·	
AS Cr III+VI Cu Zn	/440-38-2 n.a. 7440-50-8 7440-66-6	2011 2014 2017 2011 2014 2017 2011 2014 2017 2011 2014 2017														-				-		-+
Organo-tin compounds dibutyltin-cation	14488-53-0	2011 2014 2017			- X				- 1				- [-		- -	x -		-			, [-]	
In excess of one or more EQS	for substances re	levant for the Rhine																				
Below all EQS for substances re ** Data basis 2018 *** Even though Bekingen figures among the interr	elevant for the Rh	nine	ting as it is	cituated in Switzerland																		



Annex 3: Environmental Quality Standards for the Rhine (EQS Rhine)* for substances relevant for the Rhine according to the technical ICPR reports no. 164 and no. 234**

Substance	MAV-EQS Rhine Inland surface waters according to WFD (in µg/l)	PMC-EQS Rhine Inland surface waters according to WFD (in µg/l)	EQS Rhine inland surface waters "Water for human consumption" (98/83/EC) ⁶⁾ (in µg/l)	MAV-EQS Rhine Coastal and transitional waters according to WFD (in µg/l)	PMC-EQS Rhine Coastal and transitional waters according to WFD (in µg/l)
arsenic ¹⁾	$BC^{2)} + 0.5$	$BC^{2)} + 8.0$	10	$BC^{2)} + 0.6$	$BC^{2)} + 1.1$
chromium ¹⁾	$BC^{2)} + 3.4$	_7)	50	$BC^{2)} + 0.6$	_7)
zinc ¹⁾	$BC^{2)} + 7.8$	$BC^{2)} + 15.6$	-	BC^{2} + 3	-
copper ^{1) 3)}	2.8	3.6	2,000	3.5	4.5
bentazone	73	450	0.1	7.3	45
4-chloroaniline	0.22	1.2	0.1 ⁵⁾	0.057	0.12
chlorotolurone	0.4	2.3	0.1	0.04	0.23
dichlorvos	0.0006	0.0007	0.1	0.00006	0.00007
dichloroprop	1.0	7.6	0.1	0.13	0.76
dimethoate	0.07	0.7	0.1	0.07	0.7
mecoprop	18	160	0.1	1.8	16
МСРА	1.4	15	0.1	0.14	1.5
dibutyl-tin compounds (related to cation)	0.09	-	-	0.09	-
ammonium-N ⁴⁾	Depending on temperature and pH; see Table a	Depending on temperature and pH; see Table b	390	-	-
PCB 28, 52, 101, 118, 138, 153	Wait for termination of work on EU level.	Wait for termination of work on EU level.	-	Wait for termination of work on EU level.	Wait for termination of work on EU level.

EQS Rhine = Environmental quality standard Rhine; PMC = permitted maximum concentration; MAV = mean annual value

* In the Netherlands set by law as concentration values

** The ICPR target values for the main stream (cf. www.iksr.org: ICPR - Document No. 159) continue to apply. On the long term, concentrations may not significantly rise (interdiction of deterioration). More exacting national standards are not concerned.

¹⁾ The EQS concern the dissolved share (filtered sample); for chromium they concern the sum of chromium (III and VI)

²⁾ BC = background concentration

arsenic: BC = $1 \mu g/I$ (Rhine and tributaries)

chromium (sum Cr III and VI): BC = 0.38 µg/l (Rhine and tributaries), ca. 0.02 – 0.5 µg/l (other waters)

zinc: BC = $3 \mu g/l$ (Rhine and tributaries), $1 \mu g/l$ other water bodies

³⁾ If an exceedance of the standard is detected, a correction for the availability of the metal can be made when checking monitoring data, taking into account the influence of pH, DOC, hardness and other relevant parameters.

⁴⁾ See substance data sheet with corrected values for pH and temperature

⁵⁾ 4-chloroaniline is not only a chemical substance applied in industry but also a pesticide degradation product. ⁶⁾ For surface water bodies used for drinking water abstraction the maximum value of the directive "Water for human consumption" (98/83/EC) must be strived for, if this value is below the EQS-Rhine value according to WFD derived for inland surface water bodies.

⁷⁾ The derived value cannot be applied. The mean annual value of EQS Rhine confers sufficient protection.

Addition to footnote 4: Substance data sheet with corrected values for pH and temperature Table a

MAV EQS Rhine Inland waters according to WFD NH_3-N transposed into total ammonium nitrogen ($NH_4-N + NH_3-N$) in mg/l

		Tempera	ature					
		0	5	10	15	20	25	30
рΗ	5.5	157.467	104.122	69.862	47.529	32.763	22.869	16.153
	6	49.798	32.929	22.095	15.033	10.363	7.237	5.111
	6.5	15.750	10.416	6.990	4.757	3.280	2.291	1.619
	7	4.984	3.297	2.213	1.507	1.040	0.727	0.515
	7.5	1.579	1.045	0.703	0.479	0.332	0.233	0.166
	7.6	1.255	0.831	0.559	0.382	0.264	0.186	0.132
	7.7	0.998	0.661	0.445	0.304	0.211	0.148	0.106
	7.8	0.793	0.526	0.354	0.242	0.168	0.119	0.085
	7.9	0.631	0.419	0.282	0.193	0.135	0.095	0.068
	8	0.502	0.333	0.225	0.154	0.108	0.076	0.055
	8.1	0.400	0.266	0.180	0.123	0.086	0.062	0.045
	8.2	0.318	0.212	0.143	0.099	0.069	0.050	0.036
	8.3	0.254	0.169	0.115	0.079	0.056	0.040	0.030
	8.4	0.202	0.135	0.092	0.064	0.045	0.033	0.024
	8.5	0.162	0.108	0.074	0.052	0.037	0.027	0.020
	9	0.054	0.037	0.026	0.019	0.014	0.011	0.009

Grey background: exceeds of the imperative value of the former Directive for Fish Waters: 0.778 mg/l NH_4 -N + NH_3 -N resp. 1 mg/l ammonium

Table b

MAV EQS Rhine inland surface waters according to WFD NH_3-N transposed into total ammonium nitrogen ($NH_4-N + NH_3-N$) in mg/l

		Tempera	ature					
		0	5	10	15	20	25	30
рΗ	5.5	314.950	208.243	139.724	95.057	65.526	45.737	32.306
	6	99.597	65.858	44.190	30.065	20.727	14.469	10.222
	6.5	31.501	20.838	13.980	9.513	6.560	4.581	3.238
	7	9.967	6.593	4.426	3.014	2.080	1.454	1.030
	7.5	3.157	2.091	1.405	0.959	0.663	0.465	0.331
	7.6	2.510	1.662	1.118	0.763	0.529	0.371	0.265
	7.7	1.995	1.322	0.890	0.608	0.422	0.297	0.212
	7.8	1.587	0.780	0.708	0.485	0.337	0.237	0.170
	7.9	1.262	0.979	0.564	0.387	0.269	0.190	0.137
	8	1.004	0.667	0.450	0.309	0.215	0.153	0.110
	8.1	0.799	0.535	0.359	0.247	0.173	0.123	0.089
	8.2	0.637	0.424	0.287	0.198	0.139	0.099	0.073
	8.3	0.507	0.338	0.230	0.159	0.112	0.081	0.059
	8.4	0.405	0.270	0.184	0.128	0.091	0.066	0.049
	8.5	0.323	0.216	0.148	0.103	0.074	0.054	0.040
	9	0.108	0.074	0.052	0.038	0.029	0.023	0.018

Grey background: exceeds of the imperative value of the former Directive for Fish Waters: 0.778 mg/l NH_4 -N + NH_3 -N resp. 1 mg/l ammonium.

Annex 4: Environmental quality standards for priority substances and certain other pollutants

MAV: Mean Annual Value; PMC: maximum permissible concentration; unit: [µg/I]

Number	Name of substance	CAS Number ⁱ	MAV-EQS ⁱⁱ Inland surface waters ⁱⁱⁱ	MAV-EQS ⁱⁱ Other surface waters	PMC-EQS ^{iv} Inland surface waters ⁱⁱⁱ	PMC-EQS ^{iv} Other surface waters	EQS Biota ^v [µg/kg wet]	EQS valid from	Achievement of good chemical status to
1	alachlor	15972-60-8	0.3	0.3	0.7	0.7		13 January	22 December
2	anthracene	120-12-7	0.1	0.1	0.1	0.1		2009 22 December 2015	2015 22 December 2021
3	atrazine	1912-24-9	0.6	0.6	2.0	2.0		13 January 2009	22 December 2015
4	benzene	71-43-2	10	8	50	50		13 January 2009	22 December 2015
5	brominated diphenylether	32534-81-9	-	-	0.14	0.014	0.0085	22 December 2015	22 December 2021
6	cadmium and compounds (according to water hardness class) ^{vii}	7440-43-9	≤ 0.08 (cl. 1) 0.08 (cl. 2) 0.09 (cl. 3) 0.15 (cl. 4) 0.25 (cl. 5)	0.2	≤ 0.45 (cl. 1) 0.45 (cl. 2) 0.6 (cl. 3) 0.9 (cl. 4) 1.5 (cl. 5)	≤ 0.45 (cl. 1) 0.45 (cl. 2) 0.6 (cl. 3) 0.9 (cl. 4) 1.5 (cl. 5)		13 January 2009	22 December 2015
6bis	carbon tetrachloride ^{viii}	56-23-5	12	12	not applicable	not applicable		13 January 2009	22 December 2015
7	C ₁₀₋₁₃ -chloroalkanes (SCCP)	85535-84-8	0.4	0.4	1.4	1.4		13 January 2009	22 December 2015
8	chlorofenvinphos	470-90-6	0.1	0.1	0.3	0.3		13 January 2009	22 December 2015
9	chloropyriphos	2921-88-2	0.03	0.03	0.1	0.1		13 January 2009	22 December 2015
9bis	cycloidian pesticides: aldrin ^{viii} dieldrin ^{viii} endrin ^{viii} isodrin ^{viii}	309-00-2 60-57-1 72-20-8 465-73-6	Σ=0,01	Σ=0,005	not applicable	not applicable		13 January 2009	22 December 2015
9ter	DDT-sum ^{viii, ix} p.p.'-DDT ^{vii}	not applicable 50-29-3	0.025 0.01	0.025 0.01	not applicable not applicable	not applicable not applicable		13 January 2009 13 January	22 December 2015 22 December
10	1,2-dichlorethane	107-06-2	10	10	not applicable	not applicable		2009 13 January	2015 22 December
11	dichloromethane (methylene chloride)	75-09-2	20	20	not applicable	not applicable		2009 13 January 2009	2015 22 December 2015
12	bis(2-ethylhexyl)phthalate (DEHP)	117-81-7	1.3	1.3	not applicable	not applicable		13 January 2009	22 December 2015
13	diuron	330-54-1	0.2	0.2	1.8	1.8		13 January 2009	22 December 2015
14	endosulfan	115-29-7	0.005	0.0005	0.01	0.004		13 January 2009	22 December 2015
15	fluoranthene	206-44-0	0.0063	0.0063	0.12	0.12	30	22 December 2015	22 December 2021
16	hexachlorobenzene	118-74-1	-	-	0.05	0.05	10	13 January 2009	22 December 2015
17	hexachlorbutadiene	87-68-3	-	-	0.6	0.6	55	13 January 2009	22 December 2015
18	hexachlorocyclohexane	608-73-1	0.02	0.002	0.04	0.02		13 January 2009	22 December 2015
19	isoproturon	34123-59-6	0.3	0.3	1.0	1.0		13 January 2009	22 December 2015
20	lead and lead compounds	7439-92-1	1.2 ^{xi}	1.3	14	14		22 December 2015	22 December 2021

				Ann	ex II Directive 2013/3	9/EU			
Number	Name of substance	CAS Number ⁱ	MAV-EQS ⁱⁱ Inland surface waters ⁱⁱⁱ	MAV-EQS ⁱⁱ Other surface waters	PMC-EQS ^{iv} Inland surface waters ⁱⁱⁱ	PMC-EQS ^{iv} Other surface waters	EQS Biota ^v [µg/kg wet]	EQS valid from	Achievement of good chemical status to
21	mercury and mercury compounds	7439-97-6	-	-	0.07	0.07	20	13 January 2009	22 December 2015
22	naphthalene	91-20-3	2	2	130	130		22 December 2015	22 December 2021
23	nickel and nickel compounds	7440-02-0	4 ^{xi}	8.6	34	34		22 December	22 December
24	nonylphenol (4-nonylphenol)	104-40-5	0.3	0.3	2.0	2.0		13 January 2009	2021 22 December 2015
25	octyl phenol (4-(1,1',3,3'-	140-66-9	0.1	0.01	not applicable	not applicable		13 January	22 December
26	pentachloro benzene	608-93-5	0.007	0.0007	not applicable	not applicable		13 January	22 December 2015
27	pentachlorophenol	87-86-5	0.4	0.4	1	1		13 January	22 December
28	polycyclic aromatic hydrocarbons (PAH) ^{xii}	not applicable	not applicable	not applicable	not applicable	not applicable		22 December 2015	22 December 2021
	benzo(a)pyrene	50-32-8	0.00017	0.00017	0.27	0.027	5	13 January 2009	22 December 2015
	benzo(b)fluoranthene	205-99-2	xiii	xiii	0.017	0.017	xiii	13 January 2009	22 December 2015
	benzo(k)fluoranthene	207-08-9	xiii	xiii	0.017	0.017	xiii	13 January 2009	22 December 2015
	benzo(g,h,i)perylene	191-24-2	xiii	xiii	0.0082	0.00082	xiii	13 January 2009	22 December 2015
	indeno(1,2,3-cd)pyrene	193-39-5	xiii	xiii	not applicable	not applicable	xiii	13 January 2009	22 December 2015
29	simazine	122-34-9	1	1	4	4		13 January 2009	22 December 2015
29bis	tetrachloroethylene ^{viii}	127-18-4	10	10	not applicable	not applicable		13 January 2009	22 December 2015
29ter	trichloroethylene ^{viii}	79-01-6	10	10	not applicable	not applicable		13 January 2009	22 December 2015
30	tributyltin compounds (tributyltin cation)	36643-28-4	0.0002	0.0002	0.0015	0.0015		13 January 2009	22 December 2015
31	trichlorobenzenes	12002-48-1	0.4	0.4	not applicable	not applicable		13 January 2009	22 December 2015
32	trichloromethane	67-66-3	2.5	2.5	not applicable	not applicable		13 January 2009	22 December 2015
33	trifluralin	08 September 1582	0.03	0.03	not applicable	not applicable		13 January 2009	22 December 2015
34	dicofol	115-32-2	0.0013	0.000032	not applicable	not applicable	33	22 December 2018	22 December 2027
35	perfluoro octane sulfonic acid and its derivatives (PFOS)	1763-23-1	0.00065	0.00013	36	7.2	9.1	22 December 2018	22 December 2027
36	quinoxyfen	124495-18-7	0.15	0.015	2.7	0.54		22 December 2018	22 December 2027
37	dioxines and dioxin-like compounds				not applicable	not applicable	Sum PCDD + PCDF + PCB-DL 0.0065 ug.kg-1 TEO ×iv	22 December 2018	22 December 2027
38	acolnifen	74070-46-5	0.12	0.012	0.12	0.012		22 December 2018	22 December 2027
39	bifenox	42576-02-3	0.012	0.0012	0.04	0.004		22 December	22 December
40	cybutryne	28159-98-0	0.0025	0.0025	0.016	0.016		22 December	22 December
41	cypermethrin	52315-07-8	0.00008	0.00008	0.0006	0.00006		2018 22 December 2018	2027 22 December 2027

Number	Name of substance	CAS Number ⁱ	MAV-EQS ⁱⁱ Inland surface waters ⁱⁱⁱ	MAV-EQS ⁱⁱ Other surface waters	PMC-EQS ^{iv} Inland surface waters ⁱⁱⁱ	PMC-EQS ^{iv} Other surface waters	EQS Biota ^v [µg/kg wet]	EQS valid from	Achievement of good chemical status to
42	dichlorvos	62-73-7	0.0006	0.00006	0.0007	0.00007		22 December 2018	r 22 December 2027
43	hexabromcyclododecan (HBCDD)		0.0016	0.0008	0.5	0.05	167	22 Decembe 2018	r 22 December 2027
44	heptachlorine and heptachlorine epoxide	76-44-8/ 1024-57-3	0.000002	0.0000001	0.0003	0.00003	6.7×10^{-3}	22 Decembe 2018	r 22 December 2027
45	terbutryne	886-50-0	0.065	0.0065	0.34	0.34		22 December 2018	r 22 December 2027

CAS: Chemical Abstracts Service.

ⁱⁱ This parameter corresponds to the environmental quality standard (EQS) expressed as mean average value (MAV-EQS), If nothing else is indicated it applies to the total concentration of all isomers.

ⁱⁱⁱ Surface water bodies comprise rivers and lakes as well as connected artificial or heavily modified water bodies.

- ^{iv} This parameter corresponds to the environmental guality standard expressed as permitted maximum concentration (PMC-EQS). If the PMC-EQS is indicated as "not applicable", the MAV-EQS values also apply as sufficient level of protection during short pollution peaks due to continuous discharges, as they are considerably lower than values determined on the basis of acute toxicity.
- Unless otherwise stated, the biota EQS refers to fish. An alternative biota taxon or alternative matrix may be monitored instead, provided that the EQS applied offers an equivalent level of protection. For substances numbered 15 (fluoranthene) and 28 (PAHs), the biota EQS refers to crustaceans and molluscs. For the purposes of chemical status assessment, monitoring of fluoranthene and PAHs in fish is not appropriate. For substance number 37 (dioxins and dioxin-like compounds), the biota EQS refers to fish, crustaceans and molluscs; in accordance with Section 5.3 of the Annex to Commission Regulation (EU) no. 1259/2011 of 2 December 2011 amending Regulation (EC) no 1881/2006 as regards maximum levels for dioxins, dioxinlike PCBs and non-dioxin-like PCBs in foodstuffs (OJ L 320, 3.12.2011, p. 18).

vi For the group of priority substances belonging to the brominated diphenyl ethers (no. 5) listed in Decision no. 2455/2001/EC an environmental quality standard is only determined for the congeners of the numbers 28, 7, 99, 100, 153 and 154. vii For cadmium and cadmium compounds (no. 6) the EQS depends on water hardness presented in five categories (class 1: <40 mg CaCO₃/I, class 2: 40 to <50 mg CaCO₃/I, class 3: 50 to <100 mg CaCO₃/I, class 4: 100 to <200 mg CaCO₃/I and: class 5: ≥200 mg CaCO3/I).

viii This is not a priority substance but a substance belonging to the other pollutants for which environmental quality standards are identical to those determined in legal provisions applicable before 13 January 2009. ^{ix} Total DDT comprises the sum of the isomers 1,1,1-trichloro-2,2-bis-(p-chlor-ophe-nyl)ethane (CAS no. 50- 29- 3; EU no. 200- 024- 3), 1,1,1-trichloro-2(o-chlorophenyl)-2-(p-chlorophenyl)ethane (CAS no. 789- 02- 6; EU no. 212- 332- 5), 1,1-Dichloro-2,2bis-(p-chlorophenyl)ethylene (CAS no. 72- 55- 9; EU-no. 200- 784- 6) and 1,1-dichloro-2,2-bis-(p-chloro-phenyl)ethane (CAS no. 72- 54- 8; EU no. 200- 783-0).

* If a Member State does not apply the environmental quality standard for biota it introduces more stringent environmental quality standards for water, so that the same level of protection is achieved as would have been the case when applying the environmental quality standards for biota determined in Article 3, Paragraph 2 of this Directive. The Member State informs the Commission and the other Member States through the Committee addressed in Article 21 of the Directive 200/60/EC about the reasons for why this approach is chosen and the alternative environmental quality standards determined for water as well as the data and methods for deriving the alternative environmental quality standards and the category of surface water bodies for which they are applicable.

These EOS refer to bioavailable concentrations of the substances

xⁱⁱ As far as the group of polycyclic aromatic hydrocarbons (PAH) (no. 28) is concerned, each individual environmental quality standard applies. This means that the environmental quality standard for benzo(a)pyrene and the environmental quality standard for the sum of benzo(b)fluoranthene and benzo(k)fluoranthene and the environmental quality standard for the sum of benzo(q,h,i)perylene and indeno(1,2,3-cd)pyrene must be respected.

xiii For the group of polycyclic aromatic hydrocarbons (PAHs) (no. 28), the biota EQS and the corresponding MAV EQS in water refer to the concentration of benzo(a)pyrene, on whose toxicity they are based. Benzo(a)pyrene can be considered as a marker for the other PAHs; therefore, only benzo(a)pyrene shall be monitored for comparison with the biota EQS and the corresponding MAV EQS in water

xiv PCDD: polychlorinated dibenzoparadioxins; PCDF: polychlorinated dibenzofurans; PCB-DL: dioxin-like polychlorinated biphenyls; TEQ: Toxicity equivalents according to the World Health Organization's 2005 Toxicity Equivalence Factors.

Annex 5: Assessment results for the monitoring stations incorporated in the "Chemistry" surveillance monitoring programme according to WFD

Priority substances						I	Legend fo	or the assessme	nt			7				Legend	for the meas	uring point		[
									Below EQS							. ·	Measuring	points a	t inland surfa	ce waters													
								X no	o decision possible beca o measurements availab	use of too high le	limit of determinati	on					Measuring	points a	t "other surfa	ace waters"													
Directive 2008/105/EC, as amende European Parliament in relation to priority substanc	ed by Directive 2 t and of the Cou ses in the field o	2013/39/El Incil f water pol	U of the licy				River	Bregenzerach		Rhine		Necka	۲ Weschnitz	Schwarzbach	Main	Regnitz	Kinzig Nidda	Nahe	Lahn	Moselle	Saar	Blies	Alzette	Syr	Sauer	Sieg Wupper	Erft	Ruhr Emscher	Lippe	vecnt Lake IJssel	Wadden Sea	Dutch coast	Wadden Sea
State: 11.10.2021						Monito Name of mo	ring station no nitoring statior	n 61 1	4 pire Rhine 4	1 12 13 32	<u>9</u> <u>9</u> <u>1</u> <u>1</u> <u>1</u> <u>1</u> <u>1</u> <u>1</u> <u>1</u> <u>1</u> <u>1</u> <u>1</u>	42 8 9	10 31	28 Elefter	54 24 23 25	5 55	26 27	<u>19</u> 2	9 30 20 .	15 17 18	21 22 14	52 5	3 56	<u>62</u> 63 දි	<u>16</u>	36 37	40 5	Emscher	39 5	vechterweerd v	10 west at	47 48	49 50 daips
Data basis 2017								Bregenz	Fussach/, Öhningen Rekingen Weil am F Karlsruhe	worms Mainz Koblenz Bad Honn	Düsseldo Bimmen Lobith Kampen	Maasstuis Deizisau Kochendo	Mannhein Biblis-Wa	Trebur-A	Hallstadt Erlabrunn Kahl a. M Bischofsh	Hausen	Hanau Nied	Dietershe	Limburg Lahnstein	Palzem Fankel Koblenz	Saarbrúcl Fremersd Kanzem	Reinheim	Ettelbrud	Mertert Erpelding	Was serbil	Menden Opladen	Epinghow	Mülheim Mouth R.	Wesel	Vecht stu Vrouweza	Doove Ba Dantziggi	Noordwijk Noordwijk	Boomken Terschelli
Substance	Value (WFD- CAS Codelist)	Unit	No. WFD	MAV- EQS WFD	MAV- EQS WFD	PMC-EQS WFD	PMC-EQS WFD																										
Chemical parameter (chemical state)				Inland surface water	Other surface waters	Inland surface water	Other surface waters																										
Heavy metals and metalloids (solute)	1	- 1		water	waters	water	waters	İ				_																					
Cd sol. Ha	56 7439-97-	9 μg/l 6 μg/l	6 < 21	<= 0.08-0.25 0 µg/kg wet weight	0,2 20 µg/kg wet weight	<= 0.45-1.5	<= 0.45-1.5	2013 2	2013	2016	2016 2016													×	- 2	016 2016	2016	2016	2015 20	015 2015			
Ni sol.	58 7440-02-	0 μg/l	23	(biota) 4	(biota) 8,6	34	34																x	x x	x		2018						
Pb sol.	55 7439-92-	1 µg/l	20	1,2	1,3	14	14																										
dichloromethane	44 75-09-2	µg/l	11	20	20	-	-																-		- 2	014-							
trichloromethane 1,2-dichlorethane	76 67-66-3 43 107-06-2	μg/l μg/l	32	2,5	2,5	-	-																		- 2	017 014- 017 014-							
carbon tetrachloride	26 56-23-5	µg/1 µg/1	6 a	10	12	-	-															-	· ·		- 2	017 014- 017 014-							
tetrachloroethylene	33 127-18-4	μg/l	290 29 a	10	10		-																		- 2	017 214- 017			2017- 2018				
non-volatile hydrocarbons		- T	5	5 µg/kg wet	55 ug/kg	1 1	[
hexachlorbutadiene	51 87-68-3	µg/I	17	weight (biota)	wet weight (biota)	0,6	0,6			2016	2016 2016										-		-		- 21	016 2016	2016	2016 -	2015				
sum trichlorobenzenes 1.2.3-trichlorobenzene	74 12002-48- 224 87-61-6	-1	21																														
1.2.4-trichlorobenzene 1.3.5-trichlorobenzene	75 120-82-1 248 108-70-3	μg/1	31	Σ=0,4	Σ=0,4	-	-																-										
hexachlorobenzene	50 118-74-1		16	0 µg/kg wet weight	10 µg/kg wet weight	0,05	0,05	2013 2	2013	2016	2016 2016												-		- 2	2016/	2016	2016/	2016 -	-			
pentachlorobenzene	63 608-93-5	j µg/l	26	(biota) 0,007	(biota) 0,0007	-	-								X								-		-		-		-				
4-nonylphenol octylphenol ((4-(1,1',3,3'-tetramethylbutyl)-phen	59 84852-15- ol) 62 140-66-9	-3 µg/l 9 µg/l	24 25	0,3 0,1	0,3 0,01	2	2																-		-								
bis(2-ethylhexyl)phthalate (DEHP) brominated diphenyl ethers	45 117-81-7 38 32534-81-	μ g/l 9	12	1,3	1,3					-													-		-		-		-				
BDE 28 BDE 47	299 41318-75- 300 5436-43-	- <u>6</u> 1	0).0085 µg∕kg	0.0085																					2016/		2016/					
BDE 99 BDE 100	301 60348-60- 302 189084-64	- <u>9</u> μg/l -8	5	wet weight (biota)	weight (biota)	0,14	0,014	2013 2	2013	2016	2016 2016										2014 2016		-		- 21	2010/ 2019	2016	2019	2016	-			
BDE 153 BDE 154	303 68631-49- 304 207122-15	- <u>2</u> -4			(,																												
C10-13-chloroalkanes chloropesticides	40 85535-84-	8 µg/i	7	0,4	0,4	1,4	1,4	2014 2	2014				-										- <u> </u>										
endosulfan	47 115-29-7	/ un/l	14	5-0.00F	5-0.000F	5-0.01	5-0.004																										
β-endosulfan	90 33213-65-	9 49/1	27	0.4	2=0,0003	2=0,01	2=0,004	┥━┥┝		2018	- 2018					┥┝━╸┝											H	_					
Sum hexachlorocyclohexane (α- bis δ-HCH) γ-HCH (lindane)	52 608-73-1 53 58-89-9						-																										
α-HCH β-HCH	305 319-84-6 306 33213-65-	μg/l 9	18	Σ=0,02	Σ=0,002	Σ=0.04	Σ=0.02			-													-		-	- -	-		-				
8-HCH Total DDT	307 319-86-8 310 n.a.	3						┤┣═┥┝						┥┝╼┥┝		┥┝━╾┤┝											$\left - \right \right $						
p,p'-DDD p,p'-DDE	311 72-54-8 312 72-55-9	μg/l	9Ь	Σ=0,025	Σ=0,025	.	-			-	- -										- -	-	-		-	- -	-	- -	-				
o,p'-DDT p,p'-DDT	313 789-02-6 27 50-29-3	<u>i</u>																									Ш						
p,p'-DDT dichlorvos	27 50-29-3 62-73-7	µд/I µд/I	9b 42	0,01 0,0006	0,01 0,00006	0,0007	0,00007		x x x	- X X	 X X	хх	x x	x	x x x x	x	x x)	хх	X			- - X	х х		<u>-</u> - X	x	x x	x				
dicofol	115-22.2		24 3	0,0013 and	0.000032 and 33.uc/kg		_	2012	2013	v	2016 2016		•				↓ ↓		, , 							016 2016	2016	2016 -	2016		v v		
	115-52-2	P3/1	^ [^]	weight (biota)	wet weight (biota)								1	_[[^	*		<u>^ ^ </u>	– (<u> </u>												^ ^		
guinoxyfen acolnifen	124495-18 74070-46-	-7 μg/l -5 μg/l	36 38	0,15 0,12	0,015 0,012	2,7 0,12	0,54 0,012				- X X X X	X			-							EF	-		-			-		x x x x	X X X X	X X X X	X X X X
bifenox cypermethrin	42576-02- 52315-07-	-3 μg/l -8 μg/l	39 41	0,012 0,00008	0,0012 0,000008	0,04 0,0006	0,004 0,00006	x	x x x x x	X X X X	- X X X X X X X	X X X	x x	x	x x x	x	x x	x)	x x x	X X -	X	-	- - X	x	-	 X X	X	- X X X	- <u>)</u>	X X X X	X X X X	X X X X	X X X X
				0.0000002 and	0.00000001 and																												
heptachlorine and heptachlorine epoxide	/6-44-8/ 1024-57-	3 µg/l	44	6.7× 10-3 µg/kg wet weight (biota)	6./× 10-3 µg/kg wet weight (biota)	0,0003	0,00003	×	×	2016	2016 2016		x	x	×		xx	-)	x x -		- 2016	-	- X	xx	- 2	016 2016	2016 :	2016 -	2015	x	x x		x x
phenylurea derivatives diurone	46 330-54-1	µg/l	13	0,2	0,2	1,8	1,8																		-								
isoproturon phosphorous acid esters	54 34123-59-	6 µg/l	19	0,3	0,3	1	1	┤╺═╸╸																	-								
chlorofenvinphos	41 470-90-6	μg/l	8	0,1	0,1	0,3	0,3								-										-								
triazines	42 2921-88-3	≤ i µg/i	9	0,03	0,03	0,1	0,1	╡┻┻╹																									
atrazine simazine	36 1912-24- 71 122-34-9	9 µg/l	3 29	0,6	0,6	2 4	2																		-								
cybutryne terbutryne	28159-98- 886-50-0	0 μg/l	40 45	0,0025 0,065	0,0025 0,0065	0,016 0,34	0,016 0,034			x x x	xx		X	X	- X		xx		x x x	x x x	X				X	xx	×	xx	X				
Other plant protection agents	24 1 100 5 1																																
alacnior trifluralin	34 122-34-9 77 1582-09-0	μg/l 8 μg/l	1 33	0,3	0,3	0,7	0,7	╡══┫														_	-										
drins cyclodien pesticides	314 n.a	1				,																											
aldrin dieldrin	28 309-00-2 29 60-57-1	ua/I	9 a	Σ=0.01	Σ=0,005	.	- I			- I													-							
endrin	30 72-20-8				.,																												



144
Priority substances				Legend for the assessment In excess of EQS Below EQS							Legend for the measuring point Measuring points at inland surface waters																								
							X no d	ecision pose	sible becaus Its available	se of too hi	igh limit of	f determina	ition					Me	asuring po	oints at "o	other surfa	ace waters"													
Directive 2008/105/EC, as amended l European Parliament ar in relation to priority substances	by Directive 20 nd of the Coun in the field of	013/39/EU ncil water poli	of the cy			Rive	Bregenzerach			Rhine				Neckar	Weschnitz Schwarzbach		Main	Regnitz Kinziq	Nidda	Zahe	.ahn	Moselle	Saa	ar	Blies	Alzette Svr	Sauer	Sieg	Wupper Erft	Ruhr Emscher	Lippe	Vecht Lake IJssel	Wadden Sea	Dutch coast	Wadden Sea
State: 11.10.2021 Data basis 2017	Value				Moni	toring station no	Bregen z Fussach/Alpine Rhine	Öhningen Rekingen*)	Weil am Rhein Karlsnuhe/Lauterbourg Worms	Koblen z Koblen z Koblen z	32 34 3 Düssektorf-Fiehe	41 43	sinisseew	Deizisau Kochendorf 6 8 Mannheim 01 6	31 58 Biblis-Wattenheim Trebur-Astheim	tpetsiler	Erlabrunn Kahl a. Main Bischofsheim	U SS 26		Dietersheim Solms-Oberbiel	100 20 Limpurg	LIS 17 18	Fremersdorf 6	2 14	Reinheim Niedaltdorf	Ettelbruck Mertert Mertert	63 1	Menden Menden	37 40 upjaden Epinghoven	Mulheim Mouth R. Emscher	39	Vecht stuw Vechterweerd 15	Doove Balg west Dan triggat	47 48 c the state of the state	49 20 Boomkensdiep Terschelling 10
Substance Chemical parameter (chemical state) PAH	(WFD- CAS Codelist)	Unit	No. MAV- EC WFD WFD Inland surface water	2S MAV- EQS WFD Other surface waters	PMC-EQS WFD Inland surface water	PMC-EQS WFD Other surface waters																													
anthracene fluoranthene naphthalene benzo(a)pyrene (1) benzo(b)fluoranthene (2) benzo(k)fluoranthene (3) benzo(k)fluoranthene (4) indeno(1:.23-cd)pyrene Organo-tin compounds	35 120-12-7 49 206-44-0 57 91-20-3 66 50-32-8 67 205-99-2 69 207-08-9 68 191-24-2 70 193-39-5	μg/l μg/l μg/l μg/l μg/l μg/l μg/l μg/l	2 0,1 0.0063 2 15 0.007 kg 0.00017 28 59/kg weigh (biota 28 59/kg weigh (biota 28 5ee ** 28 5ee **	0,1 nd 0.0063 and wet 30 µg/kg wet weight (biota) 2 and 0.00017 an. weight (biota) See **)) See **)) See **)	0,1 i t 0,12 130 d tt 0,27 0,017 0,017 0,0082 -	0,1 0,12 130 0,027 0,017 0,017 0,0082	2013 2013 2013 2013 2013 2013 2013 2013 2013 2013 2013 2013 2013 2013 2013 2013																					- - - - - - - - - - - - - - - - - - -		 X -	- - -				
tributyltin-cation Per- and polyfluorinated alkyl compounds perfluorooctane sulfonic acid and its derivatives (PFOS) Dioxines	73 36643-28-4	μg/l	30 0,000 0.000 35 0.000 35 9.1 µg/ wet weig (biota	2 0,0002 5 0.00013 and 9.1 µg/kg wet weight (biota)	0,0015 t 36	7,2	2013 2013															- - -	2015 201	16 16				- 2016	 2016 2016	2016	2015	-			
dioxines and dioxin-like compounds		μg/I	Sum PCDD + P 37 + PCB-I 0.006! μg.kg ⁻¹ TI	CDF DL 0.0065 ; g.w µg.kg ⁻¹ TEC	- 2	-	2013 2013				2016 2016 20	016								-	-		2014					2016	2016 2016	2016 -	2015	-			
hexabromcyclododecan (HBCDD)	3194-55-6	µg/I	43 167 µg/ wet weig (biota	i 0.0008 and kg 167 μg/kg ht wet weight (biota)	0,5	0,05	2013 2013		-		2016 2016 20	016			-						x		-					2016	2016 2016	2016 -	2015				
Excess of one or more EQS Below all EQS Without ubiquitous substances: Excess of one or more EQS Below all EQS																																			
Calculation based on suspended n total DDT p.p.º-DOD p.p.º-DOE o.p.º-DOT p.p.º-DOT p.p.º-DOT cyclodian pesticides adrin dieldrin endrin isodrin isodrin	natter: n.a. 72-54-8 72-55-9 789-02-6 50-29-3 n.a. 309-00-2 60-57-1 72-20-8 465-73-6	µg/I µg/I µg/I	9b 9b 9 a		-	-		-	 -	2	2016/2 2016/2 201 017 017 0 2016/2 2016/2 201 017 017 0	16/2 117 116/2 116/2			-			-		•	-					 		-		2018 201	6 2018 6 2018				
PAH anthracene fluoranthene naphthalene benzo(a)pyrene (2) benzo(k)fluoranthene (3) benzo(k)fluoranthene (4) indeno(1.2.3-cd)pyrene (4) indeno(1.2.3-cd)pyrene organo-tin compounds	120-12-7 206-44-0 91-20-3 50-32-8 205-99-2 207-08-09 191-24-2 193-39-5	рд/I рд/I рд/I рд/I рд/I рд/I рд/I рд/I	2 15 22 28 28 28 28 28 28 28 28 28		0,1 0,12 130 0,27 0,017 0,017 -	0,1 0,12 130 0,027 0,017 0,017 0,00082			- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -																										
Utbuckytlin-cation hexachlorobenzene pentachlorobenzene bist2-etthyfhexyl)phthalate (DEHP) endossuffan e-endossuffan y-HCH (indane) w-HCH p-HCH p-HCH p-HCH p-HCH p-HCH	36643-28-4	_µg/I	30		0,0015	0,0015																								201 201 201 201	6				
Excess of one or more EQS Below all EQS																						-													
Without ubiquitous substances: Excess of one or more EQS Below all EQS		1		1	1	í			++-		•		+-1									-					┨══┼╴				┩┍═┩╒				

Wbiquitous substances
 New compulsory substances according to the WFD in red letters
 **) Fore though Rekingen figures among the international main monitoring stations, it is not part of the WFD reporting, as it is situated in Switzerland.
 ***) For the group of polycyclic aromatic hydrocarbons (PAHs) (No. 28), the biota EQS and the corresponding MAV EQS in water refer to the concentration of
 benzo(a)pyrene, on whose toxicity they are based. Benzo(a)pyrene can be considered as a marker for the other PAHs; therefore, only benzo(a)pyrene shall be
 monitored for comparison with the biota EQS and the corresponding MAV EQS in water.
 At the Wadden Sea, Duch Coast and Wadden Sea Coast monitoring sites, the MPC value for benzo(a)pyrene is exceeded. This obscures the marker function of
 benzo(a)pyrene based on the MAV EQS, which means that the overall assessment for these water bodies is ultimately not good.

Annex 6: Groundwater quality standards and threshold values

State: 11 December 2020

Parameter			Quality standards /2006/118/EC)											
nitrate	NO ₃ -	mg/l	50 (C	H: 25)										
sum pesticides		µg/l	0.5											
individual pesticide		µg/l	0.1											
			Three	shold va	alues									
			AT	CH*	DE	FR	LU	BE /WAL	NL					
Conductivity		µS/cm	2250			1000 (20°C) 1100 (25°C)	2,500 (at 20 °C)							
arsenic	As	µg/l	9		10	10	10	10	13.2**					
tetrachloroethylene	C_2Cl_4	µg/l		1		10		4						
trichloroethylene	C ₂ HCl ₃	µg/l		1		10		7						
Sum trichloroethylene and tetrachloroethylene		µg/l	9		10	10	10							
cadmium	Cd	µg/l	4.5		0.5	5	1	3	0.35					
chloride	Cl ⁻	mg/l	180	40	250	250	250	150	160**					
cyanure (sum)	CN	µg/l				50		50						
chromium	Cr	µg/l	45			50		9 (Cr VI)						
copper	Cu	µg/l	1800			2000		100						
mercury	Hg	µg/l	0.9		0.2	1	1	1						
sodium	Na	mg/l				200	-							
ammonium	NH_4^+	mg/l	0.45		0.5	0.5	0.5	0.5						
nickel	Ni	µg/l	18			20		20	20					
nitrite	NO ₂ ⁻	mg/l			0.5	0.3	0.5	0.1						
oxidability (KMnO4)	organic substance	mg/l O₂				5								
total phosphorous	Р	mg/l P₂O₅			161	0.5 (orthophosphates)	0.3 (phosphate)	1.15	2,0 mg P/l**					
lead	Pb	µg/l	9		10	10	10	10	7.4					
antimon	Sb	µg/l				5								
sulphate	SO42-	mg/l	225	40	250	250	250***	250						
total organic carbon	тос	mg/l C		2 (DOC)										
zinc	Zn	µg/l				5,000		200						

Geogenic pollution does not result in a bad groundwater status.

* Requirements to groundwater used as drinking water or intended for use as such.

** In two groundwater bodies the threshold value for chloride is not relevant, for total phosphorus 6.9 mg P/l and for arsenic 18.7 ug/l.

*** Depending on the geology, this threshold value may be locally exceeded.

 $^{^{161}}$ The Groundwater Regulation sets a threshold value for ortho-phosphate of 0.5 mg/l (corresponding to 0.163 mg/l as ortho-phosphate-P).

Annex 7: Master Plan Migratory Fish Rhine: hydro-morphological measures implemented and planned

State: November 2021							
		Implementation by 2021			Implementation 2022-2027		
		Number of measures			Number of measures		
		Construction of fish pass /	Habitat		Construction of fish pass /	Habitat	
	Removal transverse	fish-friendly management of tidal	measures and	Removal transverse	fish-friendly management of	measures and	
Section of the Rhine / tributary system	structures	gates and locks	other	structures	tidal gates and locks	other	Country
Delta Rhine & branches of the Rhine		1					
Main stream (including Haringvliet)	6	24	44		16	14	NL
Vecht*	2	3	8				DENI
Lower Rhine & tributaries							
Wupper	2	2	14	1		7	DENW
Sieg			42				DENW
Sieg	19		1	2		1	DERP
Middle Rhine & tributaries							
Main stream			2			16	DEHE
Main stream			1				DERP
Ahr	12		4				DERP
Nette	19	1	5			3	DERP
Saynbach	16		2	2			DERP
Moselle including tributaries	11	2	3	1	1	4	DERP
Moselle including tributaries				2	11	47	LU
Lahn	1	73	80		38	93	DEHE
Lahn	23	1	4	1			DERP
Wisper		4			1	2	DEHE
Nahe	25		7	6		13	DERP
Nahe	1		4				DESL
Remodelling river bank in Bacharach							
(Restoration mouth of Münzbach)			1				DERP
Upper Rhine & tributaries		·					
Main stream			2				DEBW
Main stream			11			86	DEHE
Main stream			3			1	DERP
Main including tributaries*			1				DE-BW
Main including tributaries*		1			2**		DEBY
Main including tributaries*	3	57	96		15	386	DEHE
Kinzig (tributary of the Main)	5	27	28		7	55	DEHE
Weschnitz		1		2**			DEBW
Weschnitz		5	21			20	DEHE
Neckar*	3	19	42	2**	6**	3	DEBW
Neckar*			3		4	4	DEHE
(Wies)Lauter	6		4			2	DERP
(Wies)Lauter	4**			1**			FR
Alb/Moosalb	3	3	6				DEBW
Murg / Oos system	1	14	8	2**		2	DEBW
Main stream (Iffezheim)		1					FRXX. DE
Main stream (Gambsheim)		1					FRXX. DE
Main stream (Straßburg)		1					FRXX
Main stream (loop Straßburg							
Rohrschollen island)			4				FRXX
Main stream (Gerstheim)		1					FRXX
					*		

		Implementation by 2021		Implementation 2022-2027						
		Number of measures			Number of measures					
		Construction of fish pass /	Habitat		Construction of fish pass /	Habitat				
	Removal transverse	fish-friendly management of tidal	measures and	Removal transverse	fish-friendly management of	measures and				
Section of the Rhine / tributary system	structures	gates and locks	other	structures	tidal gates and locks	other	Country			
Main stream (loop Gerstheim,										
low weir Rappenkopf)					1		FRXX			
Rheinhauptstrom (Rhinau)					1		FRXX			
Main stream (loop Rhinau, Rhinau island)			2				FRXX			
Main stream (loop Rhinau,										
2 low weirs Salmengrien und Hausgrund)					2		FRXX			
Rheinhauptstrom (Marckolsheim)					1		FRXX			
Main stream (Vogelgrün)***							FRXX			
Kembs (Märkt)		1					FRXX			
III (France)	152**		4				FRXX			
Rench		12	3	5**		1	DEBW			
Kinzig		33	9	2**		2	DEBW			
Elz-Dreisam system		35	5	5**		2	DEBW			
Sandbach		1					DEBW			
other direct tributaries to the main stream			9			1	DERP			
igh Rhine & tributaries					·	,				
Main stream			1		12		CH/DEB			
Main stream		1	16	1**		3	DEBW			
Wiese		7	2	5**		1	DEBW			
other direct tributaries to the main stream		5					DEBW			
ake Constance / Alpine Rhine & tributaries					·	,				
ake Constance sea trout)										
Tributaries to Lake Constance		3	3		17	6	AT			
Tributaries to Lake Constance		43	11	4**			DEBW			
Tributaries to Lake Constance	4		3				DEBY			
III (Austria)	3	16	6		3	5	AT			
Ehbach					1	1	AT			
Nonnenbach		1	1				DEBW			
um	165	399	526	15	131	781				
um overall measures (by 2027)	2017									
verall sum cost estimation in euro (bv 2027)	979.833.111									
River(section) is not the focus in terms of miaration corrid	lor or habitat for miaratory fish. W	hen planning and implementing mea	sures, reauiremen	ts for diadromous fish	are also taken into account.					
* Removal transverse structure or construction fish pass or	r fish-friendly manaaement of tidal	aates and locks	.,							

Annex 8: Non-governmental organisations with observer status in the ICPR

AK Wasser im BBU Alfred-Döblin-Platz 1 D - 79100 Freiburg www.akwasser.de

Alsace Nature 8, rue Adèle Riton F - 67000 Strasbourg www.alsacenature.org

Arbeitsgemeinschaft Revitalisierung Alpenrhein/Bodensee c/o WWF Regiobüro St. Gallen Merkurstr. 2 CH - 9001 St. Gallen www.lebendigerrhein.org

Arbeitsgemeinschaft Renaturierung des Hochrheins Weinsteig 192, Postfach 1157 CH - 8201 Schaffhausen www.arge-hochrhein.ch

Bund für Umwelt und Naturschutz Deutschland Landesgeschäftsstelle Rheinland-Pfalz Hindenburgplatz 3 D - 55118 Mainz www.bund-rlp.de

Conseil Européen de l'Industrie Chimique (CEFIC) Avenue E. Van Nieuwenhuyse 4 box 1 B - 1160 Bruxelles <u>www.cefic.be</u>

Deutscher Angelfischerverband e.V. Reinhardtstr. 14 D - 10117 Berlin www.dafv.de

DWA Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. Theodor-Heuss-Allee 17 D - 53773 Hennef www.dwa.de

EBU - UENF Postbus 23210 NL - 3001 KE Rotterdam www.ebu-uenf.org EurAqua Network Deltares Princetonlaan P.O.Box 85467 NL - 3508 AL Utrecht www.euraqua.org

European Union of National Associations of Water Suppliers and Waste Water Services EurEau Rue du Luxembourg 47-51 B - 1050 Bruxelles www.eureau.org

Fédération Nationale de la Pêche en France et de la protection du milieu aquatique 108/110 rue Saint-Maur F - 75011 Paris www.federationpeche.fr

Greenpeace International Ottho Heldringstraat 5 NL - 1016 AZ Amsterdam www.greenpeace.org/international

Hochwassernotgemeinschaft Rhein Gemeinde- und Städtebund Deutschhausplatz 1 D - 55116 Mainz www.hochwassernotgemeinschaft-rhein.de

IAWR - Internationale Arbeitsgemeinschaft der Wasserwerke im Rheineinzugsgebiet c/o Stadtwerke Karlsruhe Deggendorfer Straße 72 D - 76185 Karlsruhe www.iawr.org

NABU-Naturschutzstation Niederrhein Im Hammereisen 27E D - 47559 Kranenburg www.nabu.de and www.nabu-naturschutzstation.de

Rheinkolleg e.V. Stadthaus Maximilianstr. 100 D - 67346 Speyer www.rheinkolleg.de

Sportvisserij Nederland Postbus 162 NL - 3720 AD Bilthoven www.sportvisserijnederland.nl

VGB PowerTech Service GmbH Deilbachtal 173 D - 45257 Essen www.vgb.org Wereld Natuur Fonds Driebergseweg 10 Postbus 7 NL - 3700 AA Zeist www.wnf.nl

WWF Schweiz Hohlstraße 110 Postfach CH - 8010 Zürich www.wwf.ch

Annex 9: List of competent authorities for river management in the IRBD Rhine according to WFD, Article 3, (8) and Annex I

Country	Switzerland	Italy	Liechtenstein	Austria	Germany	Germany	Germany	Germany	Germany	Germany	Germany	Germany	France	Luxembourg	Belgium	Netherlands
Country		Lombardy region		Vorarlberg	Baden- Württemberg	Bavaria	Hesse	Rhineland- Palatinate	Saarland	North Rhine- Westphalia	Lower Saxony	Thuringia		Luxembourg	Wallonia	
Name of the authority in charge	Switzerland is not obliged to implement the EU WFD (CH) Authority in charge of information / coordination: Bundesamt für Umwelt BAFU	Lombardy region, for great constructions such as dams the state Ministry for Environment (IT)	Government of the principality of Liechtenstein	Federal Ministry for Agriculture, Regions and Tourism (AT)	Ministry for Environment, Climate and Energy, Baden- Württemberg (UM)	Bavarian Ministry for Environment and Consumer Protection (StMUV)	Hessian Ministry for Environment, Climate Protection, Agriculture and Consumer Protection (HMUKLV)	Ministry for Environment, Energy, Nutrition and Forestry of the Land Rhineland- Palatinate (MUEEF)	Ministry for Environment and Consumer Protection of the Saarland (MUV)	Ministry for Environment, Agriculture, Nature Protection and Consumer Protection of the Land North Rhine- Westphalia (MULNV)	Ministry of Environment , Energy, Construction and Climate Protection of Lower Saxony (MU)	Ministry of Environment, Energy and Nature Protection of Thuringia (TMUEN)	The co- ordinating Prefect for the Rhine-Meuse catchment, Prefect of the Department Bas-Rhin, Prefect of the Region Grand- Est	Ministry of Environment, Climate and Sustainable Development Authority in charge of information / coordination: Administration de la Gestion de l' Eau (Water Board for Luxemburg)	Walloon Government	Ministry for Infrastructure and Water management, if necessary together with the Ministry of Interior / Royal Affairs and the Ministry of Economy and Climate
Address of the authority in charge	BAFU CH-3003 Bern	Regione Lombardia Via Pola, 14 I - 20125 Milano	Regierungsgebä ude Peter-Kaiser- Platz 1 9490 Vaduz	Stubenring 1 A - 1010 Wien	Kernerplatz 9 D- 70182 Stuttgart	Rosenkavalierpl atz 2 D-81925 München	Mainzer Str. 80 D-65189 Wiesbaden	Kaiser-Friedrich- Str. 1 D-55116 Mainz	Keplerstr. 18 D- 66117 Saarbrücken	Schwannstr. 3 D-40476 Düsseldorf	Archivstr. 2 D-30169 Hannover	Beethovenstraß e 3, D-99096 Erfurt	5 place de la République F – 67000 Strasbourg	4, Place de l' Europe L-1499 Luxemburg	Rue Mazy, 25* 27 B -5100 Namur (Jambes)	Postbus 20901 2500 EX Den Haag The Netherlands
Legal status of the authority in charge	National regulatory body	Supreme water authority of the region		Supreme water authority of the Republic of Austria	Supreme water authority of the federal state	Supreme water authority of the federal state	Supreme water authority of the federal state	Supreme water authority of the federal state	Supreme water authority of the federal state	Supreme water authority of the federal state	Supreme water authority of the federal state	Supreme water authority of the federal state	The co- ordinating Prefect for the catchment area co-ordinates and implements the state policy concerning water management and legal compliance (Article L 213- 3 of among others the Environmental Code)	Ministry	Regional government	Supreme state authority for water management
Competencies	Legal and technical control, co- ordination	Legal and technical control, co- ordination	Legal and technical control, co- ordination	Legal and technical control, co- ordination	Legal and technical control, co- ordination	Legal and technical control, co- ordination	Legal and technical control, co- ordination	Legal and technical control, co- ordination	Legal and technical control, co- ordination	Legal and technical control, co- ordination	Legal and technical control, co- ordination	Legal and technical control, co- ordination	Implementation and co- ordination of state policy concerning water management and legal compliance	Legal and technical control	Political planning, execution, control and coordination	Political planning, execution, control and coordination

In all states, regions and countries, numerous authorities are actively involved in the implementation of the WFD at various levels.

Annex 10: Derivation of the good ecological status / potential

The interstate comparability of the ecological status / potential of water bodies is an important prerequisite for harmonised water protection in international river basin districts (IRBD). In many sections, the rivers Rhine, Moselle and Saar are border rivers the water bodies of which are to be classified by two states.

For the Europe-wide comparison of natural water bodies, the national biological assessment procedures (with the exception of fish fauna in large rivers) were aligned in the process of intercalibration with regard to their "good/ fair" boundary. The criteria and environmental quality standards for the chemical-physical assessment of ecological status however remain a matter for the member states.

Most of the water bodies in the main stream of the Rhine and its tributaries with a catchment > 2,500 km² have been classified as "heavily modified" (HMWB). Thus, the good ecological potential (GEP) applies as environmental target.

As part of a harmonisation of the assessment of heavily modified water bodies, the EU Commission has drawn up guidance with the Member States on the derivation of the GEP¹⁶². In contrast to the intercalibration of the biological assessment methods, the mitigation measures are compared in relation to the different uses. EU guidance documents on mitigation measures with regard to water storage¹⁶³, land drainage¹⁶⁴ and flood protection¹⁶⁵ have been published; a workshop on mitigation measures for inland navigation was held in June 2017. As this is a harmonisation and not an intercalibration of the procedures for deriving the GEP, it remains important that there is a common understanding in the RBD about the GEP.

There are two methods for determining the ecological potential: The biological derivation (CIS reference approach) and the measure-based approach (Prague approach), which has been recognised by the EU Commission as an alternative to the biological derivation. The starting point is the definition of the highest ecological potential (HEP) as state of a water body resulting from the implementation of all technically feasible measures aimed at an ecological enhancement of a water body without significant effects on specified uses or the environment at large (according to WFD Art. 4 (3)). The GEP is understood as a gradation, as all measures with little ecological effects were subtracted from the HEP.

For the third Management Plan, the states of the IRBD Rhine have further developed their assessment procedures, but have not fundamentally changed them.

The common features and differences of the procedures are relevant with respect to the harmonization of classification results at border water bodies and have been intensively discussed within the IRBD Rhine.

As before, the HEP (in F also the GEP) is defined by the implementation of all technically feasible measures for the ecological enhancement of a water body without significant negative impacts on the specified uses or the wider environment (according to Art. 4 (3) WFD) (cf. Figure 36). In the Netherlands, Luxembourg and Germany, this information is ultimately transformed into numerical biological information (in EQR units of ecological potential for invertebrates and fish; in NL additionally for macrophytes; in LUX only for fish) that takes into account the ecological effects of the measures. In Luxembourg, by establishing the HEP and GEP for the biological quality elements fish and macroinvertebrates within the framework of investigative monitoring for each of the eight heavily modified water bodies, the approach of the measure will in future be completely replaced by the reference approach. France uses a complementary approach that does not focus on the positive effects of measures, but classifies the degree of hydro-

¹⁶² <u>cf. Common Implementation Strategy for the Water Framework Directive (2000/60/EC), 2012, Steps for</u> <u>defining and assessing ecological potential for improving comparability of Heavily Modified Water Bodies,</u> <u>Guidance Document No. 37</u>

¹⁶³ http://publications.jrc.ec.europa.eu/repository/bitstream/JRC103830/kj-na-28413-en-n.pdf

¹⁶⁴ http://publications.jrc.ec.europa.eu/repository/bitstream/JRC110959/jrc110959 jrc110959 final online.pdf
¹⁶⁵ http://publications.jrc.ec.europa.eu/repository/handle/JRC110957

morphological stress. The transformation to the organism groups affected by the morphological changes is thus not necessary.

As also confirmed by the work at EU level on harmonising the assessment of heavily modified water bodies, the direct comparability of all four procedures is only given at the level of the measures to be implemented (<u>Guidance Document No.37–2019: Steps for</u> <u>defining and assessing ecological potential for improving comparability of Heavily</u> <u>Modified Water Bodies</u>). However, the methods are not comparable for the overall assessment of the ecological potential.



Figure 36: Scheme for deriving the good or highest ecological potential (GEP or HEP, respectively)

National measures implemented in the EU Member States aimed at improving the ecological status resp. potential are described in Chapter 7.1

Annex 11: Results of the biological quality elements and the monitoring of waterfowl populations

Phytoplankton¹⁶⁶

Plankton are mostly microscopic small organisms floating in the water. Apart from the phytobenthos and the rest of the aquatic flora, the phytoplankton belongs to the important primary producers. In large rivers, phytoplankton can develop the well-known eutrophication symptoms and cause increased turbidity and oxygen depletion during the subsequent decomposition of the biomass. However, not all states have determined targets for phytoplankton according to WFD. The reason is that the residence time of phytoplankton in rivers is comparatively short. Excessive algal bloom is a good eutrophication indicator. However, if no excessive algal bloom occurs, this does not necessarily mean that there is no eutrophication. In waters which come to a standstill and in which the residence time increases, there is an increased probability of eutrophication, for example in cut-off river branches, in lakes, in coastal and transitional waters.

While a typical spring algal bloom in 2018 was only observed on the Lower Rhine at the Bimmen monitoring site, a pronounced summer algal bloom developed along the flow in August 2018, in contrast to previous annual cycles. This formed with two spikes first as a diatom bloom and directly afterwards as a green algae bloom. In places, it reached very high chlorophyll concentrations, the likes of which had not been measured since the beginning of the 1990s.

In 2018, the number and biomass of animal plankton (zooplankton), for which phytoplankton serves as a food source, were also low. This very low number was surprising because during the low water phase there were strong phytoplankton blooms, which provided a lot of food for rotifers (Rotatoria). However, it is possible that these phytoplankton blooms were too short, so that the rotatoria with their longer generation times could not react to them. The number of free-swimming mussel larvae was also very low.

Comparison with the results of previous studies shows that current hydrological conditions and weather conditions override the long-term trend and promote seasonal algal blooms. During a spring with high runoff, as in 2009 and corresponding tendencies also in 2018, phytoplankton development is low. The influence of the weather was particularly evident during the summer low-water phase in 2018. Here, the phytoplankton benefited from extended flow times, higher water temperatures and reduced mussel activity. This allowed the phytoplankton in Koblenz and Bimmen to develop high concentrations. Consequently, despite the significantly decreased total P concentration, the Rhine still presents a potential for algal blooms.

The weather-related phytoplankton dynamics in 2018 make it clear that permanent monitoring of phytoplankton with relatively narrow temporal sampling grids is urgently needed to make management successes visible and to document long-term environmental changes (cf. Figure 37).

¹⁶⁶ ICPR technical report no. 273 (2020)



Figure 37: Development of the chlorophyll-a concentration at the Koblenz monitoring station since 1990. Data: Bundesanstalt für Gewässerkunde (BfG).

Phytoplankton in coastal and transitional waters

For the coastal and transitional waters, phytoplankton is the most important biological quality component indicating eutrophication and is being classified according to its biomass (as chlorophyll-a) and its taxa composition (only algae of the genus *Phaeocystis*)¹⁶⁷.

Even though the concentrations are in excess of the Dutch guidance value of 0.46 mg/DIN/I at a salinity of 30 (DIN = Dissolved Inorganic Nitrogen), in certain years, the phytoplankton achieved a (very) good status on the Dutch coast (see Table 14). On the Wadden Sea coast and in the Wadden Sea, the condition scores less highly in recent years. Depending on the location, the rating is good to unsatisfactory and moderate overall. As of 2019, the Phaeocytis bloom will no longer be used for assessment in the Netherlands, as research has shown that this is not a good indicator for assessing eutrophication.

the phytoplankton quality component based on the Dutch classification system. ¹⁶⁸												
Monitoring	Water body	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018

Table 14: Final classification (minimum of the average value (of Chl and *Phaeocystis*) and Chl) of

Monitoring station	Water body	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018
Noordwijk2	Dutch Coast	0.76	0.62	0.64	0.66	0.92	0.56	0.81	0.61	0.51	0.75	0.80
Terschelling4	Wadden Sea coast	0.71	0.39	0.68	0.46	0.68	0.57	0.60	0.54	0.56	0.64	0.53
Dantziggat	Wadden Sea east	0.48	0.54	0.44	0.50	0.48	0.33	0.49	0.43	0.37	0.52	0.53
Doove Balg west	Wadden Sea west			0.74	0.65	0.72	0.77	0.69	0.60	0.62	0.59	0.68
Marsdiep Noord	Wadden Sea west			0.68	0.56	0.74	0.40	0.68	0.57	0.67	0.52	0.61
	Wadden Sea total	0.48	0.54	0.62	0.57	0.65	0.46	0.59	0.51	0.52	0.54	0.59

¹⁶⁷ VAN DER MOLEN 2012: Referenties en maatlatten voor natuurlijke watertypen voor de Kaderrichtlijn Water 2015-2021. STOWA 2012-31

¹⁶⁸ Eutrophication is one of the descriptors of the "good status of the marine environment" of the Marine Strategy Framework Directive (MSFD). Within the OSPAR, the EU Member States with marine waters in the Northeast Atlantic and the European Commission have agreed upon a joint classification to serve as a basis for their national reporting obligations. With respect to the OSPAR indicator, the presence or not of extreme *Phaeocystis* bloom is applied as a classification criterion, while, for the requirements of the WFD, the period during which *Phaeocystis bloom* occurs is decisive. The OSPAR classification within the MSFD is planned for 2017.

Table 15: Comparison of the final assessment of the phytoplankton quality element for the year 2020 based on the Dutch assessment system according to Intercalibration Decision 2018¹⁶⁹ and Intercalibration Decision 2013¹⁷⁰.

Monitoring station	Water body	2020	2020
		Calculated according to intercalibration decision 2018	Calculated according to intercalibration decision 2013
Noordwijk2	Dutch Coast	0.84	0.78
Terschelling4	Wadden Sea coast	0.64	0.80
Dantziggat, Doove balg West and Marsdien Noord	Wadden Sea total	0.54	0.67

Key: Ecological status / ecological potential



In accordance with the 2018 intercalibration, the Netherlands has decided to carry out two assessments from 2020 on for the coastal waters concerned. Table 15 shows for phytoplankton in 2020 both the assessment result calculated according to the 2013 Intercalibration Decision and the assessment result calculated according to the 2018 Intercalibration Decision. For two out of three assessment results, this means a stricter assessment. In order to better understand the eutrophication status of waters belonging to the Wadden Sea type and to improve the assessment thresholds (e.g. for chlorophyll a) on the basis of this understanding, the INTERREG project Water Quality Wadden Sea was launched. A number of German and Dutch research institutes and authorities are participating. The project started in 2019 and will end in 2022 and is supported with funds from the INTERREG programme Ems-Region.

Satellite monitoring

For the North Sea, the current trend is to assess chlorophyll a using satellite monitoring. To this end, the European project JMP-EUNOSAT has made concrete proposals, including a proposal for evaluation criteria. This proposal presumably contains stricter assessment criteria for the Netherlands than the current ones. This proposal will be discussed in the framework of planned OSPAR meetings in 2020 and 2021. The results are therefore still uncertain. Similarly, it is uncertain what more stringent assessment criteria will mean for proposed measures, such as in WFD management plans. This is because the majority of the nutrients come from the river basins. Concerning the Netherlands, the Rhine and the Meuse have the greatest impact on the North Sea.

Macrophytes¹⁷¹

Aquatic **macrophytes** (aquatic plants) may equally be used to assess the nutrient pollution of flowing waters; however, they also react distinctly to interferences with the flow regime (for example impoundment) and reflect the structural conditions of a water body (substrate diversity and substrate dynamics, degree of cover establishment of the river bank and the river bottom). Within the Rhine Monitoring Programme Biology, the partial component macrophytes was considered independently of the algal growth (phytobenthos). So far, no reference for aquatic water plant communities of the Rhine can be described, so that no classification in conformity with the WFD is possible. The

¹⁶⁹ Decision 2018/229 of the EU Commission of 12 February 2018: <u>https://eur-lex.europa.eu/legal-content/DE/TXT/HTML/?uri=CELEX:32018D0229&from=EN</u>

¹⁷⁰ Decision 2013/480 of the EU Commission of 8 October 2013: <u>https://eur-lex.europa.eu/legal-content/DE/TXT/HTML/?uri=CELEX:32013D0480&from=EN</u>

¹⁷¹ ICPR technical report no. 274 (2020)

evaluating statements are based on an **initial expertise** of individual monitoring stations taking into account the number of species and growth forms, the occurrence of quality indicators and the degree of vegetation cover.

In 2018/2019, 55 aquatic macrophyte species were detected at 50 monitoring stations in the main stream of the Rhine: 33 higher plants, 18 mosses and 4 stoneworts. *Potamogeton pectinatus* (fennel pondweed, 32, see Figure 38) was most common, followed by *Myriophyllum spicatum* (Spiked water-milfoil, 29) and *Fontinalis antipyretica* (common water moss, 26). Some species which were still observed in 2012/2013 could no longer be detected. 18 species were recorded for the first time. Comparison is made difficult by the fact that the number of monitoring sites has increased significantly - from 36 monitoring sites in 2012/2013 to 50 in 2018/2019. The Nuttall's waterweed *(Elodea nuttallii)*, a neophyte that has spread rapidly in Central Europe since the middle of the last century, was detected in 2018/2019 in all sections with the exception of the Alpine Rhine and the Lower Rhine, in each case at several survey sites.

In the lower reaches of the **Alpine Rhine**, aquatic mosses dominate the colonisation pattern, which shows a pronounced development especially in the permanently wetted areas. The macrophyte population was "well developed".

In 2018/2019, the survey sites in the **High Rhine** were characterised by low or medium cover of aquatic vegetation (< 2% and 2-5%, respectively), which is rich in growth forms compared to 2012/2013. In 2012/2013, all survey sites in the High Rhine showed only a low cover of aquatic vegetation (below 2 %). Two survey sites each were classified as having "slight deficits" and "significant deficits".

In the **Upper and Middle Rhine**, most study sites showed cover values of below 2%, in 2012/2013 mostly cover values of above 2% were recorded. In both reporting periods, however, there were also individual survey sites that had medium or high covers of aquatic vegetation (3 sites with 5-25% and one site with over 25%).

In the **Upper Rhine**, the stock of macrophytes is heterogenous; some show considerable deficits, other are "well developed". The 3 sample sites in the **Middle Rhine** cover the range from "well developed", with "slight deficits" to "clear deficits" and are rich in species as well as growth forms.

In the **Lower Rhine**, aquatic macrophytes were completely absent at all survey sites in 2018/2019, which classifies them as presenting "very strong deficits". In 2012/2013, macrophytes with very low cover were present at least at some survey sites. Possible reasons for the lack of macrophytes on the Lower Rhine are the structural poverty with anthropogenically shaped river morphology and the higher turbidity, which may be caused by increasing navigation, among other things. Comparatively high chlorophyll concentrations also occur on the Lower Rhine, which can additionally lead to limited availability of light.

In the **Delta Rhine**, apart from one site, no aquatic plants were detected in 2012/2013. In 2018/2019, the vegetation cover was very heterogeneous; some survey sites show "very strong deficits", others are "well developed". In addition to sites without vegetation, there were also sites with low, medium and strong vegetation. The sampling sites Bacharach (Middle Rhine, km 541), Speyer (Upper Rhine, km 389) and Oude Maas (Delta Rhine, km 957-985) show the best developed macrophyte populations in the entire course of the Rhine during the study period with 14 and 16 species, respectively.

The observed heterogeneous spreading of macrophytes in space and time in the Rhine (see Figure 39) may be explained by (a) a difficult representative recording, (b) variations of the discharge situations during the monitoring years and (c) local design of favourable river bank structures (for example protected groynes with favourable substrate).





Links: Fennel pondweed (*Potamogeton pectinatus*). In 2006/2007, the fennel pondweed was still detected in all sections of the Rhine (from the High Rhine to the Delta Rhine). In 2013, the species only occurred in the Upper and Middle Rhine. In 2018/2019, *Potamogeton pectinatus* was found in all sections with the exception of the Alpine Rhine and the Lower Rhine at survey sites each. Right: Perfoliate pondweed (*Potamogeton perfoliatus*). The species occurs in the Upper and Middle Rhine. It disappears during more intensive eutrophication. The species was detected at all survey sites of the High Rhine, as well as at one survey site of the Delta Rhine in 2018/2019 (photos: K. van de Weyer).



Figure 39: Species numbers of aquatic macrophytes in the course of the Rhine main stream with indication of Rhine kilometres in the survey periods 2012/2013 and 2018/2019 (Rhine sections: AP: 88.5; HR: 64-158; OR: 199-512; MR: 541-618; NR: 758-855; DR: 968-933/957)

Phytobenthos¹⁷²

Phytobenthos (above all benthic diatoms = Bacillariophyta) reacts to changes in water quality with characteristic shifts of species composition and species frequency, and indicates nutrient and salt pollution, saprobity and the state of acidity in the water body. During 2018/2019, 340 species of benthic diatoms were detected at the 41 analysed sites. This corresponds to a considerable species diversity even for a big river such as the Rhine. However, many species only occur at few monitoring stations, while a comparatively low number of species (25) occurs at over 50 % of the sampled sites. Figure 40 shows the abundance, that is the number of species of 5 common benthic diatoms in the Rhine in one sample (see also photos in Figure 41).

The bioceonosis of diatoms occurring in the Rhine with certain indicative characteristics (so-called guilds) reflect decreasing flow velocity and in parallel increasing nutrient contents and organic substances: The species composition of the **High Rhine** is typical of running waters with few nutrients and organic substances. From the **Upper Rhine until the delta**, species typical of nutrient-rich habitats represent a considerable share. In addition, planktonic and halophile (salt-loving) species occur in the **Rhine delta**.

The benthic diatoms have been studied in the Rhine monitoring programme since 2006/2007. A good succession of diatom communities can be observed with decreasing flow velocity and simultaneous increase in nutrient supply from the upper to the lower reaches of the Rhine. Most of the course of the Rhine is thus characterised by taxa that prefer a medium nutrient supply and by a dominance of taxa that are characteristic of a high and moderate oxygen supply.



Figure 40: Average abundance of 5 aspect-forming species of benthic diatoms in the sections of the Rhine

Achnanthidium minutissum sensu lato is a pollution-sensitive species, which occurs in the High Rhine in a high density of individuals and only sporadically in other sections of the Rhine.

Amphora pediculus was recorded in all sections of the Rhine, but occurs in greater abundance on the Lower Rhine. The low abundance in the Middle Rhine is a special feature compared to the 2012/2013 inventory. It is considered euryecious and ubiquitous, i.e. the species prefers

ADMI: Achnanthidium minutissimum (Kützing) Czarnecki sensu lato; APED: Amphora pediculus (Kützing) Grunow; MVAR: Melosira Varians (Agardh); NPAL: Nitzschia palea (Kützing) W.Smith; SKSS: Skeletonema subsalsum (Cleve-Euler) Bethge.

¹⁷² ICPR technical report no. 275 (2020)

moderately nutrient-rich waters and tolerates different habitat conditions. It is a pioneer species in habitats with strong biofilm grazing (e.g. by invertebrates or fish).

The average abundance of *Melosira varians* and *Nitzschia palea* increases in the downstream direction. *Melosira varians* is a benthic tychoplankton species which means that it is typical of eutrophic (nutrient-rich) standing waters and represents a large share in the samples from the lower river section. The gradual increase in the average abundance of the very pollution-insensitive taxon *Nitzschia palea* can be linked to the organic influx and thus the gradual increase in organic and trophic load in the Rhine. Its disappearance from the Rhine delta is probably due to the highly lenitic conditions, which are rather unfavourable for the taxon, rather than to an improvement in water quality.

Skeletonema subsalsum is typical for the Rhine delta. The special, very lenitic conditions of this section favour strong sedimentation and explain the very abundant occurrence of this plankton species in the benthos.



Figure 41: Photos of 4 aspect-forming species of benthic diatoms in the sections of the Rhine. *1-2: Melosira varians* top view (1) and side view (2); 3- 4: *Achanthidium minutissimum* sensu lato in lateral view (3) and top view (4); 5: *Amphora pediculus;* 6: *Nitzschia palea;* photos D. Heudre.

Macrozoobenthos¹⁷³

Species composition, dominance relationships and the presence of invasive species (originating from other regions) of the **macrozoobenthos** (invertebrates living on the river bottom) serve as an indicator for water quality and structural conditions in the water body. All in all, more than 500 **macrozoobenthos species** were detected in the Rhine between the Alps and the North Sea. Above all molluscs (Mollusca), oligochaeta, crustaceans, insects, freshwater spunges and bryozoa make up the aspect. The macrozoobenthos composition in the Rhine was closely related to the pollution of the river water. Until the beginning of the 1970ies, the number of species typical for the Rhine drastically diminished as the pollution of the Rhine with wastewater rose. From the middle of the 1980er and in the 1990s many characteristic river species returned as oxygen contents improved due to the construction of wastewater treatment plants (Figure 42). Since 2000, however, the aquatic insect fauna in particular has declined again. According to discussions, a possible reason might be the now increased spreading of **invasive species** in the Rhine. These invasive species, which, since 1992 have above all been introduced into the Rhine via the Main-Danube Canal settle in the main stream

¹⁷³ ICPR technical report no. 276 (2020)

and the tributaries, often in great biomasses and, attached to ship even spread upstream – and often the indigenous fauna pays the toll.



Figure 42: Historical development of the biocoenosis of the Rhine between Basel and the German-Dutch border related to the average oxygen content of the Rhine at Bimmen (selected fauna groups).

In the **Anterior and Posterior Rhine** and in **the Alpine Rhine** rheophile insect species, i.e. larvae of mayflies, stone flies and trichoptera typical for the system of the Alpine Rhine are dominant. The macrozoobenthos of the investigated sections of the Alpine Rhine is heavily influenced by structural and hydrological deficits. Hydro-peaking of hydropower plants in the Alpine Rhine considerably impact the species number, species composition and abundance of individuals. Nevertheless, different rare species occur along the investigated section of the Rhine and none of the invasive species which have been introduced into the other sections of the Rhine have so far been able to invade the lower section of the Alpine Rhine.

Lake Constance being a still water has its own fauna composition distinctly different from that of the Rhine. Neozoic species such as the killer shrimp, Limnomysis benedeni, the spinycheek crayfish and the basket clam occur in high population densities. In 2016, the quagga mussel was detected for the first time and is spreading rapidly, displacing the triangular mussel.

Downstream of Basel, the natural longitudinal segmentation of the Rhine is impacted by anthropogenic interferences. In the navigable and trained Rhine (Upper, Middle, Lower and Delta Rhine), the benthic fauna is largely uniform and is – apart from invasive species – dominated by common and frequent colonisers of bigger rivers and streams with little demands on their habitats (ubiquists). Elements of the original fauna are partly found in connected oxbow lakes and loops of the original course of the Rhine.

In the **Middle Rhine**, the proportion of neozoa is decreasing and that of some ancestral Rhine species is increasing. Apparently, this is also due re-colonizing of indigenous species from refuges in the tributaries.

In the further course of the **Lower Rhine**, widespread species can also be found. Sessile species, such as bryozoans and freshwater sponges are characteristic, which contribute to the self-purification of the river.

The sandy substrate of the **Delta Rhine** is above all colonized by chironomidae, oligochaetes and mussels while, on hard substrates, a biocoenosis similar to that of the

Lower Rhine is found. In the Delta Rhine near the coast the fauna is composed of brackish and marine water species.

Invasive species

Invasive species are ecdemic animal species from other regions. In particular after the accomplishment of the Main-Danube-Canal in 1992 organisms from the Lower Danube area and the Black Sea immigrated into the Rhine. In the Rhine, they even spread against the current when attached to ships. In the 1990s, this entailed a re-structuration of the biocoenosis. With respect to dominance (= relative abundance of a species compared to the other species and with respect to a certain size of habitat) and constancy (= relative distribution of a species compared to the other species and with respect to a certain size of habitat) invasive species moved into the front positions. Original Rhine species (e.g. *Hydropsyche* sp.) or old invasive species (e.g. *Gammarus tigrinus*) have been replaced.

The list of invasive species among the invertebrates detected in the Rhine between 2001 and 2018 has been completed by some brackish water species, resp. marine species from the Delta Rhine to include 49 species, 24 of which are crustaceans.

The four invasive mussel species in the Rhine have been thoroughly investigated. Since 2006, the quagga mussel *Dreissena rostriformis bugensis* originating from the northwest of the Black Sea and its tributaries is increasingly spreading in the Rhine area and locally achieves an abundance of far more than 1000 individuals/m². The strategies concerning habitat, feeding elements and reproduction of zebra mussel *D. polymorpha* occurring in the Rhine for more than 100 years and that of the quagga mussel are similar. Parallel to the spreading of the quagga mussel there are less occurrences of the zebra mussel.

Already Lauterborn (1916-1918) described the widespread occurrence of the river nerite *Theodoxus fluviatilis* in the Upper Rhine and Middle Rhine. While the species disappeared, when the pollution of the Rhine reached its peaks, it was again detected in several sections of the Rhine between 1988 and 1992, partly with great abundance¹⁷⁴. After 1995, the river nerite largely disappeared from the Rhine – probably under the influence of the heavily increasing dominance of invasive species, in particular of the omnivorous crustacean *Dikerogammarus villosus*. In May 2006, *T. fluviatilis* was again detected downstream the mouth of the Rhine between Worms and Koblenz, while it was individually detected at Basel. In 2018, the Rhine is almost completely populated (cf. Figure 43).



Figure 43: Spreading of the river nerite *Theodoxus fluviatilis* in the navigable Rhine (Westermann et al. 2007, complemented), without taking into account the occurrence in side waters

 $^{^{174}}$ <u>ICPR technical report no. 74 (1996)</u>: The Macrozoobenthos of the Rhine 1990-1995. - Editor Franz Schöll (BfG), ICPR report of the WG Ecology, 27 p + Annex.

The assumption that the recolonization of the Rhine originates from the stable stocks of the river nerite in the Danube has now been substantiated by genetic analysis: The form occurring in the Black Sea is genetically different from the form originally occurring in the Rhine and may thus be designated as "cryptic invasive species". But, from an ecological point of view, there is no reason to classify the "new" species in the Rhine different than the "old" one, as it belongs to the same type of life form.

The movement of alien species through coastal ports and canals by shipping is a widely described phenomenon. The potential of inland vessels as a vector for the spreading of alien species had not been investigated in detail so far (SCHWARTZ & SCHÖLL 2018). The investigation showed that all hulls were covered with vegetation, but that the amount of vegetation and the number of species varied (cf. Figure 44). Remarkable is the evidence of a barnacle colony (*Balanus improvisus*) that reached the port of Duisburg in the Rhine. Furthermore, most ships used ballast water, which can promote the introduction and spread of neobiota. On canals, the proportion of ships with ballast water is significantly higher (75%) than on the other waterways (54%), which is related to the reduction of the ship's height above the water level when passing through low bridges.



Figure 44: Fouling of various inland vessels (A) Faint vegetation cover with green algae. (B) Patchy vegetation with the barnacle *Balanus improvisus*. (C) Micro fouling covering the entire area with scattered mussels and insect larvae. (D) Cover of mussels(*Dreissena rostriformis bugensis*) in sea chest. (E) Cover of *D. rostriformis bugensis* and sponges in ballast water pumping hole. (F) Extensive cover of *D. rostriformis bugensis*, associated with other species (SCHWARTZ & SCHÖLL 2018).

Fish175

Species composition, abundance and age structure of fish indicate structures of large areas, river continuity, modifications of discharge (for example impoundment, water intake, diversion) and thermal pollution. All in all, today there are 70 fish species (including cyclostomata such as river and sea lamprey, see Figure 45) in the Rhine, which corresponds to a considerable species diversity in the Rhine. Apart from the European Sturgeon, all historically proven species were again detected during the fish-stock survey conducted in 2018/2019. In many places, results of electro fishing are dominated by invasive goby species, above all the round goby which above all prefers the armourstones reinforcing river banks.¹⁷⁶ Furthermore, mostly ecologically euryoecious species such as roach, bream, chub (see Figure 45), perch and bleak are found.

The greatest number of fish species is found in the **Upper Rhine** and the **Delta Rhine**. On the one hand, this result is due to the high density of sampling stations, on the other hand it is due to the special make-up of the biocoenosis in these sections. In the Upper Rhine, the alluvial areas of the Rhine rich in water plants contribute to this result, in the Delta Rhine the brackish water habitats and Lake IJssel. In particular along the Upper Rhine and the Middle Rhine (above all in the oxbow lakes and the groynes of the main stream) the vegetation of macrophoytes has considerably increased. This development furthers the reproduction of rheophile species. Juvenile fish habitats are thus available for many further species.

So far, 23 fish species have been detected in the **Alpine Rhine** (3 of them alien species). Streamer now dominate the fish population by far, and bullheads, brown trout and rainbow trout are not uncommon.

29 species have been inventoried in the **High Rhine**. Barbel and chub dominate. Spirlin, round goby and bleak are also rather common. The 2017/2018 data obtained as part of the FOEN juvenile fish monitoring show relative abundances that deviate from this. The juvenile numbers of chub, barbel, nase and dace have increased, as well as those of the round goby, which had only reached the High Rhine in a few specimens in 2012.

¹⁷⁵ ICPR technical report no. 279 (2021)

¹⁷⁶ ICPR technical report no. 208 (2013)

36 species are detected in the **southern Upper Rhine**. The dominance of invasive round goby begins here already. It accounts for more than a third of the individuals caught. The Kessler goby, on the other hand, is in sharp decline. The roach is currently the second most common species, closely followed by the bleak and the chub. As a special feature, the single catch of a *Cobitis bilineata* near Kembs should be mentioned, which is otherwise only known for the High Rhine. In the undersluices pockets there are no habitats for rheophile species such as the nase which rarely occurs. Despite potentially available habitats, especially in the Old Rhine, anadromous migratory fish are extremely rare in this area, since ecological river continuity has not yet been restored for the sections of the Rhine from Rhinau further upstream.

The return of the bitterling to the Rhine is encouraging. This species is above all continuously spreading in the **northern Upper Rhine**. Even the formerly rare spined loach is again regularly found in the Upper Rhine. With 41% frequency of occurrence among individuals caught, the round goby here reaches its highest dominance. Roach and bleak follow. All in all, 29 species have been detected in this section of the Rhine. Flow velocity increases in the breakthrough valley of the **Middle Rhine**, offering good conditions for rheophile species. All in all, 35 species have been recorded, but again 38% of the catches are round gobies. The composition of the remaining species is similar to that in the northern Upper Rhine, with the nose accounting for 16% of the individuals caught and the eel also being somewhat more common in the Middle Rhine, where it accounts for 6%.

In the **Lower Rhine**, 22 species were detected. Here, too, the majority of catches were round gobies. Apart from that, the bleak dominates with 19%. The sub-dominant fraction consists of the species bleak, nase and eel. Together, the **Delta Rhine and Lake IJssel** have the highest density of individuals and species of all Rhine sections. Here, the perch is by far the most common species, which can possibly only be attributed to an exceptionally good reproductive year for this species. It is followed by roach, round goby, ruffe, bream and gudgeon. All in all, 41 species were registered.

Generally speaking, the **fish density** has greatly diminished since the 1980s and is almost stable since 1993 (data from the Lower Rhine and from the fyke-net Moselle/Koblenz). This is presumably to be seen in connection with the improved water quality of the Rhine and its tributaries already before the WFD entered into force and to reduced organic substances, thus the food supply during 1984 to 1993. Often, the density of the fish stock in the Rhine itself varies considerably, even within one and the same year. Since the last fish monitoring in 2012/2013, no further statements can be made about a renewed change in fish density in the Rhine. Also, dominance varies considerably, in particular among very frequent fish species such as roach, bream, barbel and chub. All the same and compared to earlier surveys, considerable changes in dominance have been registered. This is a consequence of the spatial spreading and the increase in the stock of the invasive gobies registered since the stock-taking in the Rhine carried out by the ICPR in 2006/2007. At the ICPR sampling sites, the round goby alone on average represented 28% of the individuals; on the Upper Rhine, the relative frequency locally reached more than 90%. Presumably, this will lead to crowding out indigenous species. As an example, the stock of the regularly detected ruffe is particularly declining at locations where armourstones reinforcing riverbanks predominate which are ideal structures for goby species and offer good possibilities for high abundance. Furthermore, gobies represent a new food source for fish predating species such as pike-perch, barbel, catfish and bleak. In future, that might lead to considerable changes in the food web which, on the long run, may again lead to reduced goby stocks.



Figure 45: Left: Sea lamprey (*Petromyzon marinus*); right: Chub (*Squalius cephalus*). Photos: J. Schneider

As is shown in Figure 46, and as in previous years, the species diversity in the Rhine is very high.

As a matter of principle, it can be stated that the Rhine is a water body with a considerable change in its fish stocks during the past 25 years. Following the great improvement of its water quality, some species are today again settling in the Rhine or have spread. Additionally, many goby species from the Ponto-Caspian regions have immigrated and further increased the species number. Therefore, the species number itself may not be considered as a criterion for an ecological improvement of the Rhine, as an increase in the species number may also indicate an interference, as is shown with the occurrence of invasive goby species.

Thus, the increased number of detected species is also due to more ample available data. More intensive investigations within WFD monitoring, the construction of further control stations at upstream fish migration passages at great hydro power plants, special investigations and new recording techniques contribute to enhance knowledge on the Rhine fish fauna. This is very clearly shown by the comparison of the species numbers of the five ICPR survey campaigns between 1995 and 2019 (see Figure 46). The decrease of the species number in the Delta Rhine in 2013 is not really a decrease but a consequence of the ban on fishing eel following the high dioxin contents in 2011. As a consequence, the monitoring of by-catches in the fyke-nets of professional fishermen is lacking.



Figure 46: Number of indigenous (above) and invasive (below) fish species detected in in the different sections in 1995 to 2019.

In the updated "Master Plan Migratory Fish Rhine"¹⁷⁷, the progress made in the conservation and reintroduction of migratory fish species until 2018 was comprehensively documented. Current information on migratory fish stocks can be found in Appendix 12.

Water fowl

Waterbirds have been systematically counted along certain sections of the Rhine since the 1950s. Since the 1980s, reliable data on the populations and distribution of wintering waterbirds have been available for the entire Rhine catchment. Now, for the third time, a summary overview for the international Rhine Valley has been published¹⁷⁸.

Monitoring of waterbird populations is important from a conservation perspective and is also needed for monitoring the EU Birds Directive and international conventions (e.g.

¹⁷⁷ ICPR technical report no. 247 (2018)

¹⁷⁸ ICPR technical report no. 277 (2020)

Ramsar Convention, African-Eurasian Waterbird Agreement) that require information on the conservation status of bird species. Furthermore, waterbirds are visible and good indicators of the ecological quality of their habitats, thus showing the general state and developments in the habitats they use.

On average, the Rhine Valley hosted over 1.1 million native waterbirds belonging to 70 species during the winters 2015/16 to 2017/18, of which 25 species were present in internationally important populations (i.e. > 1% of the biogeographical population).

Comparing the population figures of the water bodies or river sections, it becomes clear that the lake ecosystems of Lake Constance, IJsselmeer, Markermeer and Randmeren as well as the main stream of the Rhine, each harbour about half of the waterbirds. The seasonal occurrence of the individual species varies considerably, which is due to different wintering strategies and the different geographical locations of the individual parts of the Rhine. In general, the numbers are highest in the months of November until February. From February onwards, many waterbirds leave the international Rhine area again for their breeding grounds.

The study of changes between waterbird numbers as well as ecological changes in the Rhine valley revealed a strong increase in waterbirds feeding on aquatic plants based on the same food and habitat preferences. The number of species grazing on grassland is stable or has decreased. Waterbird species that mainly feed on freshwater mussels are declining. There is no clear trend in the larger, piscivorous species. Species that seek for food in shallow water have increased. These developments can be attributed to the improvement of the Rhine's water quality.

The current waterbird monitoring focuses on the occurrence of non-breeding waterbirds. In future, it should be examined whether data from the breeding season along the Rhine can also be merged.

Annex 12: Status of migratory fish populations

Due to progress made with respect to the restoration of accessibility resp. the continuity of reproduction waters during the last 25 years, the situation of the stock of longdistance migratory fish had improved for a while: Increasing numbers of returners of salmon and sea lamprey and distinctly increasing numbers of proofs of reproduction in accessible water bodies gave evidence of the success of measures until 2007. However, between 2008 and 2013, less such proofs concerning the great salmonids salmon and sea trout were registered. The reasons discussed for the joint migration corridor Rhine and/or the coastal area are fishery (illegal catches), high predation pressure on smolts by predatory fish and cormorants, high smolt mortality rates in hydro power plants. Furthermore, reduced survival rates in the marine life cycle are assumed. In the upper sections of the Rhine, the construction of a 5th turbine at the Iffezheim impoundment between April 2009 and October 2013 led to a reduction of the number of upstream migrating individuals of numerous fish species. During 2013 to 2019, the numbers of returnees have increased again, especially for salmon, sea lamprey and sea trout. This can certainly be explained by the completion of construction work on the Iffezheim and Gambsheim fish passes. The low numbers of returnees in 2018 are due to irregularities in monitoring (June) and work on the fish pass between August and November, as well as to the low water event on the Rhine between July and November 2018 (cf. table 16, figure 47).

On 12 October 2019, the first salmon was discovered in the fish pass in Kembs (Old Rhine/Restrhine), which is on its way to Switzerland (cf. figure 48). It probably reached there through ship locks.

The new programme "Rhine 2040", which was adopted in February 2020 within the framework of the 16th Conference of Rhine Ministers, sets concrete goals for the restoration of the river continuity in the Rhine catchment¹⁷⁹. The construction of the fish passes at the Upper Rhine barrages Rhinau, Marckolsheim and Vogelgrun as well as at the barrages in the High Rhine shall restore the continuity of the Rhine up to the Rhine Falls of Schaffhausen.

At the time being, and due to the few specimens registered, it is not possible to state whether a comparable trend as that of big salmonids exists for the **river lamprey**.

The reduced number of detected **sea lamprey** also seems to be caused by the construction measures between 2009 and 2013 and thus limited monitoring. The number of returnees continues to decline. Due to the past stocking exercises in Hesse and North Rhine-Westphalia, the number of returning **allice shad** should distinctly increase in the years to come. Counts at the Iffezheim fish passage confirm this assumption. There, a high number of upstream migrating allis shad (157) was documented for the first time in 2014 (cf. Figure 47). In addition, the detection of individual young allice shad in the Upper Rhine in 2013 and 2014 upstream of all stocking sites indicate a natural allice shad reproduction. In 2015, a relatively large number of allis shad were still documented, before records were found at a much lower level. But these numbers are many times higher than the isolated records before 2014. Moreover, in the entire Rhine system as well as at the control station Iffezheim, a slight increase in allis shad can be observed again in the years from 2017 onwards, despite the low water in 2018 and 2019 (cf. Table 16 and Figure 47).

¹⁷⁹ ICPR "Rhine 2040" Programme (2020)

Table 16: Results of fish counts at the Iffezheim impoundment since 2008. Due to construction works to integrate a 5th turbine at the Iffezheim impoundment the fish passage Iffezheim was partly not functioning between April 2009 and October 2013. June 2018: no monitoring; August - November 2018: Construction work at the fish pass

Fish species	Scientif. name	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Salmon	Salmo salar	86	52	18	50	22	4	87	228	145	171	106	72	203
Sea trout	Salmo trutta trutta	101	66	40	68	20	13	191	69	154	83	53	33	43
Sea lamprey	Petromyzon marinus	145	225	23	3	15	0	145	138	79	74	35	31	72
Allice shad	Alosa alosa	2	0	0	0	0	0	157	84	19	14	24	32	36
Eel	Anguilla anguilla	12,886	8,121	13,681	4,480	4,958	0	6,801	7,988	8,612	12,111	113,297	84,456	62,882
Nase	Chondrosto ma nasus	720	426	370	830	451	313	9,380	18,274	4,440	19,042	2,452	2,997	3,063
Barbel	Barbus barbus	2,064	1,833	1,383	1,034	2,056	333	5,356	5,176	4,940	3,955	1,985	1,954	1,019
Bleak	Alburnus alburnus	726	352	182	145	137	0	20,350	7,215	20,333	1,396	3,739	5,059	64
Asp	Aspius aspius	2,122	1,590	1,329	773	673	5	3,658	5,932	2,330	1,673	2,106	2,116	4,313
Bream	Abramis brama	2,941	2,433	3,326	1,517	1,144	5	1,928	2,076	3,476	1,897	3,445	6,587	2,496
Other species		439	383	801	415	722	182	4,013	3,208	2,819	1,922	1,457	2,249	1,000
Total		22,232	15,481	21,153	9,315	10,198	855	52,066	50,388	47,347	42,338	128,699	103,686	75,191



Figure 47: Results of fish counts of selected long distance migratory fish at the Iffezheim impoundment since 2000.



Figure 48: First salmon in the fish pass in Kembs on its way to Switzerland. Photo: EDF.

In the Alpine Rhine / Lake Constance sub-basin, the **Lake Constance lake trout** (*Salmo trutta lacustris*) is the only long-distance migratory fish. In the Lake Constance region, it is therefore also called "inland salmon". Just as the salmon downstream of the Rhine Falls it has an important role for achieving the water protection targets. The Lake Constance lake trout grows up in Lake Constance until it is mature to spawn, subsequently it migrates into the tributaries to Lake Constance to spawn. This migration may stretch over 130 km into the tributaries to the Alpine Rhine. Due to its complex habitat requirements self-sustaining lake trout populations are only able to settle in obstacle-free water systems with habitats for all stages of development permitting to conclude the entire life cycle of the species.

During the 1970ies, the yield of the lake trout continuously sank in Lake Constance in spite of stocking measures (see Figure 49). Looking back, the first lake trout programme of the "Lake Trout Working Group" was responsible for the survival of the lake trout in Lake Constance and that it may today again be used for commercial fishery. Saving the last spawning fish, the subsequent stocking measures and the gradual elimination of obstacles to migration in the spawning rivers figured among the decisive measures. In particular the construction of the fish passage at the Reichenau (Switzerland) hydropower plant in 2000 represented an important step towards reopening historical spawning waters. In order to sustainably secure the stock of fish, they must again have the possibility to develop self-sustaining populations. The long-term target is to reduce the present intensive stocking measures or to even be able to completely stop them.

Since 2010, both the professional fishermen's catches and the upstream numbers of Lake Constance lake trout at the control stations in the Alpine Rhine near Reichenau have been declining despite strict seasonal protective regulations. In order to understand this decline and to formulate countermeasures, an in-depth causal analysis is currently being carried out. The focus is on discharges and temperatures in the tributaries.

Since 2010, professional fishermen's catches have been declining again, both due to the designation of closed areas at the estuaries and due to an overall downward trend in fishing yields in Lake Constance. The number of upstream migrating specimen is no longer fully comparable due to the system changes in 2017, but a decline can be observed here as well.



Figure 49: Lake Constance lake trout catches by professional fishermen in Lake Constance-Obersee and number of fish migrating upstream at the Reichenau power plant (Switzerland): Spawning fishery (until 1999), trap control (from 2000), video counting (from 2007), system changeover 2017 (VAKI), limited operation 2019 (May-Dec.).

During the past decades, the stocks of the **European eel** have greatly diminished in almost its entire distribution area, including the Rhine and its tributaries¹⁸⁰. Since the beginning of the 1980s, only a few percent of the long-time average of glass eel numbers migrating upstream into the rivers return. Known causes include habitat changes, parasite infestation, the expansion of hydropower use for electricity production, overfishing of glass eel and silver eel stocks, pollutant loads in sediments as well as feeding pressure from the cormorant, etc. The glass eel index, which is calculated on the basis of the glass eels caught in April and May near the ship locks at Stellendam in the Haringvliet, has shown an overall decreasing trend since the 1980s with particularly low values since 2003¹⁸¹. An exception is the year 2019, when a very high number of eels was counted in Iffezheim (cf. table 16). In almost all water bodies of the Rhine catchment where eels occur, migration is impeded by transverse structures. This particularly applies to the Delta Rhine, the southern Upper Rhine and almost all Rhine tributaries. In particular, downstream migrating eels are at risk: Often, they get into the turbines of hydro power plants, intake structures, pumps, etc. Due to the length of their bodies they may suffer from grievous, mostly lethal injuries; the cumulated mortality may be considered substantial if several transverse constructions follow one another.

The **European sturgeon** (*Acipenser sturio*) died out in the Rhine catchment in the 1940/1950s and ranges among the worldwide most endangered species. Within a species protection programme under guidance of an NGO ("First Sturgeon Action Plan") some specimen are again being stocked into the Delta Rhine since 2012.

¹⁸⁰ ICPR technical report no. 264 (2019)

¹⁸¹ Griffioen et al. 2016