For further information on the Integrated Rhine Programme,
please visit our website at
www.irp-bw.de
Comprehensive information is also available there
for download or order.

These measures are co-financed by the
Federal Republic of Germany.

Gefördert durch:
Bundesministerium
für Digitales
und Verkehr

Gefördert durch:
Bundesministerium
für Ernährung
und Landwirtschaft
aufgrund eines Beschlusses
des Deutschen Bundestages

Gefördert durch:
Bundesministerium
für Umwelt, Naturschutz, nukleare Sicherheit
und Verbraucherschutz
aufgrund eines Beschlusses
des Deutschen Bundestages

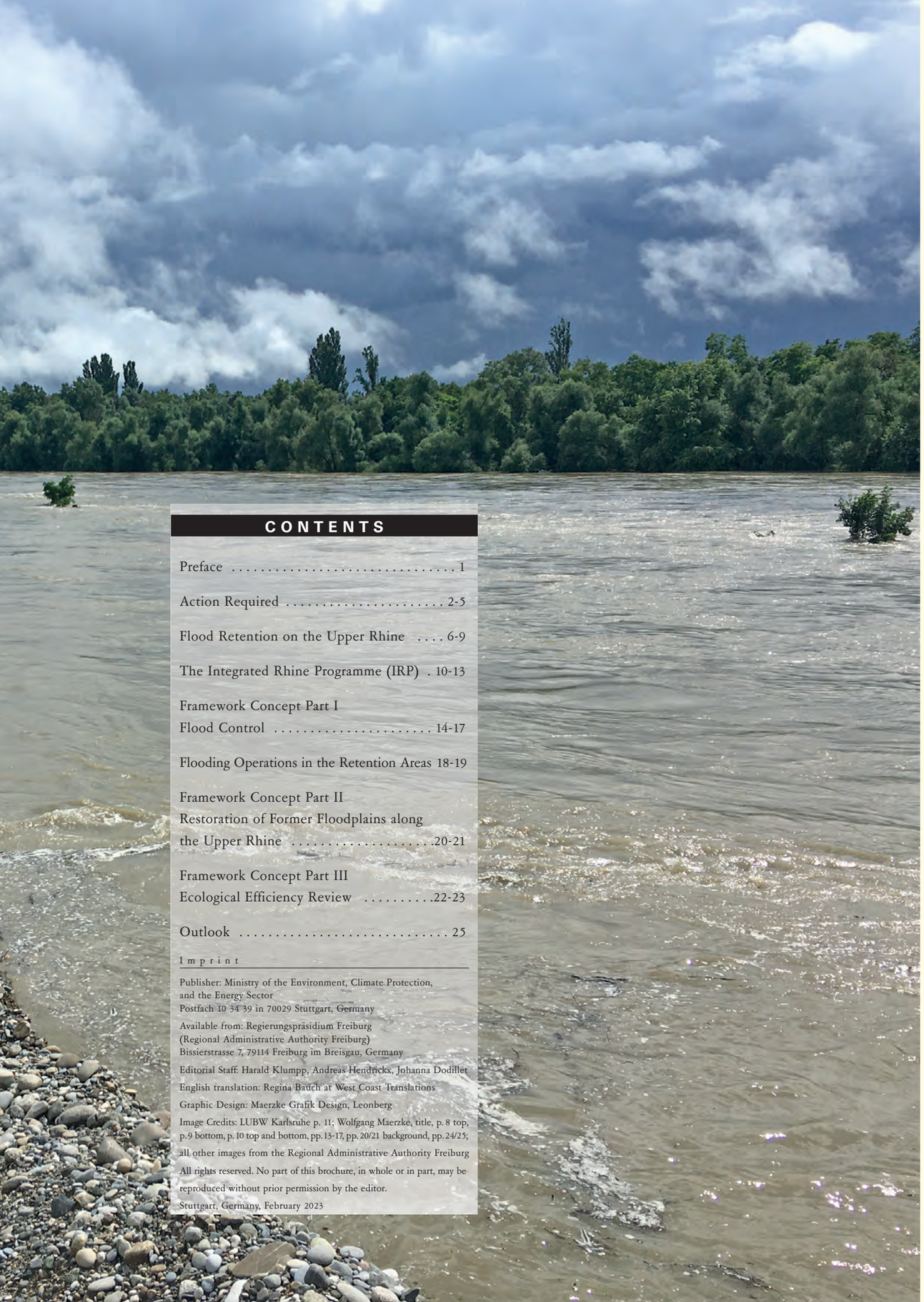
mit Mitteln aus dem Sonderrahmenplan „Maßnahmen des präventiven Hochwasserschutzes“ der Gemeinschaftsaufgabe zur Verbesserung der Agrarstruktur und des Küstenschutzes zur Umsetzung des Nationalen Hochwasserschutzprogramms (NHWSP).

Baden-Württemberg
MINISTERIUM FÜR UMWELT, KLIMA UND ENERGIEWIRTSCHAFT

The Integrated Rhine Programme

Flood control and restoration of former floodplains along the Upper Rhine

Baden-Württemberg
MINISTERIUM FÜR UMWELT, KLIMA UND ENERGIEWIRTSCHAFT



CONTENTS

Imprint

Publisher: Ministry of the Environment, Climate Protection, and the Energy Sector
Postfach 10 34 39 in 70029 Stuttgart, Germany

Available from: Regierungspräsidium Freiburg
(Regional Administrative Authority Freiburg)
Bissierstrasse 7, 79114 Freiburg im Breisgau, Germany

Editorial Staff: Harald Klumpp, Andreas Hendrickx, Johanna Dodillet

English translation: Regina Bauch at West Coast Translations

Graphic Design: Maerzke Grafik Design, Leonberg

Image Credits: LUBW Karlsruhe p. 11; Wolfgang Maerzke, title, p. 8 top, p. 9 bottom, p. 10 top and bottom, pp. 13-17, pp. 20/21 background, pp. 24/25; all other images from the Regional Administrative Authority Freiburg

Stuttgart, Germany, February 2023

Dear citizens,

In view of the dramatic events in recent years, we are once again reminded of how important measures for preventing and managing flood events are. Technical structures alone cannot provide protection against extreme flood events. Instead, we must take further means to reduce the devastating consequences of flooding facing us, our environment, culture, and economy. Based on our experiences, the State of Baden-Württemberg has developed an updated strategy for reducing flood risk which also incorporates the Integrated Rhine Programme (IRP) adopted by the state government in 1996.

Quelle: UM/Regenscheit

The IRP aims to provide flood protection while also preserving and restoring floodplains along the Upper Rhine. With the construction of 13 flood retention areas along the Rhine in Baden-Württemberg, this will be a generational task and a major challenge. From the start, numerous stakeholders have been involved in all implementation phases – from the planning and approval procedures to the construction of the respective retention areas.

Thanks to the consistent financial provisions by the state and federal governments, we have already made good progress and can quickly implement the additional IRP retention areas.

These large retention areas can only be planned, built, and operated with the broad-based support of the people living and working along the Rhine. With this brochure, we hope to provide you with an overview of the IRP and its goals. More detailed information, especially on the planning and implementation status of each local retention area, is available on the websites of the Regional Administrative Authorities of Freiburg and Karlsruhe.

It is my hope that together, with your support, we will be able to swiftly implement the Integrated Rhine Programme. To do so, we must reconcile a multitude of very different interests, only succeeding if we manage to establish a broad consensus on a social and political level. Although it may not always be easy, I am asking for your constructive support and cooperation with the tasks ahead.

Sincerely,

Thekla Walker

Thekla Walker MdL (Member of the Landtag)
Minister of the Environment, Climate Protection, and the Energy Sector
of the State of Baden-Württemberg

Flood event on the Elbe River in Germany, 2013: Railway dyke for the Berlin-Chemnitz line with railway bridge over the Elbe (image top) and the Port of Riesa (image bottom)

Action Required

Many flood areas on the southern Upper Rhine were lost to the construction of barrages between Kembs and Iffezheim (1928 to 1977). This, in turn, exacerbated flood conditions on the northern stretch of the Upper Rhine. Against the background of the effects of climate change, the flood events of recent years, particularly on the Oder, Elbe, and Danube rivers, show that establishing retention measures is becoming more important than ever. As early as 1996, the State of Baden-Württemberg therefore adopted the Integrated Rhine Programme.

Fortifying a dyke along the Oder River during a flood, 1997

Since the Upper Rhine's systematic development and the construction of barrages, floodwater volumes downstream of the barrage-regulated section past Iffezheim are too large to be absorbed by the limited flood retention areas. This means, the conurbations of Karlsruhe, Mannheim/Ludwigshafen, and Worms will face considerable damages when the river overtops its embankments and inundates the areas behind the dykes.

Not only are housing estates, industrial zones, and infrastructure at risk, but human lives and nature are threatened. In the event of a major flood, the potential economic damages incurred in Baden-Württemberg, Rhineland-Palatinate, and Hesse alone are estimated to amount to roughly 41 billion euros (as of 2021).

As early as 1978, the International Commission on the Hydrology of the Rhine, comprised of representatives from France, Switzerland, Austria, and Germany, examined the impact of the systematic development of the Upper Rhine. The commission findings underlined the need for restoring the level of flood protection that existed prior to the systematic development of the Upper Rhine.

As exemplified by the Rhine, the strategy for years was to build ever higher dykes in an attempt to separate and therefore protect land that would otherwise be subjected to the river's flooding regimes. Today it is clear that these measures tremendously exacerbate the flood hazards for areas downstream of them.

Therefore, raising the dykes along the vulnerable section of the Upper Rhine beyond their current height is no longer a potential solution to the problem. To mitigate critical flood peaks, the only feasible solution is to reintroduce the floodplains back into the river system.

Flooding along the Upper Rhine poses a threat to 95 towns and municipalities, including
- an approx. total population of 700,000
- approx. 350,000 jobs
- a surface area of approx. 1,000 km² (as of 2021)

Photo: WWA Deggendorf

Flood on the Danube River, 2013

There are numerous sites along the Upper Rhine where this option is still feasible. Prior to the construction of the barrages, these areas were always subject to inundation; today, they are mainly used for forestry and, to a lesser extent, for agriculture. Many of these areas still contain remnants of the typical floodplain landscape that used to exist along the Upper Rhine. By reactivating these areas for flood protection and thereby encouraging the development of semi-natural floodplains, the Integrated Rhine Programme (IRP) of Baden-Württemberg aims to ensure flood control while also restoring former floodplain habitats along the Upper Rhine.

Kunstmuseum Basel

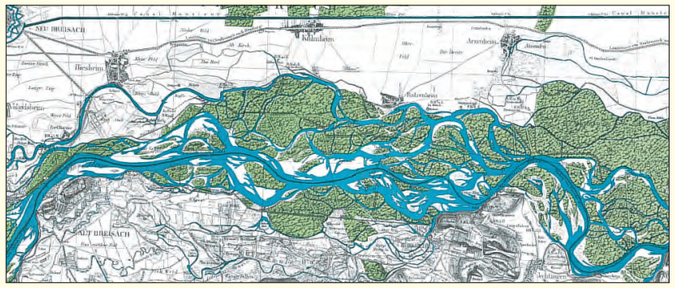
View of the historical southern Upper Rhine bifurcation zone from the Isteiner Klotz (painting by Peter Birmann)

SYSTEMATICALLY DEVELOPING THE LANDSCAPE ALONG THE UPPER RHINE

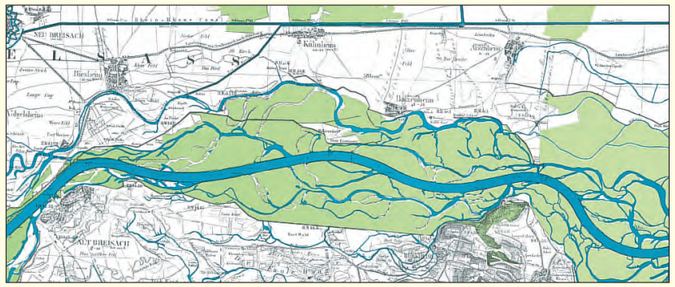
Around 200 years ago, the Rhine was still a wild river. The main channel of the Rhine between Basel and Lauterbourg forked and braided into countless, ever-shifting side arms, called the bifurcation zone. Each flood altered the course of these shallow channels, shifting them inland at times or towards the main Rhine channel at others. In so doing, the Rhine floodplains stretched two to three kilometres wide on either side of the braided channels.

Controlled, ecological flooding in Polder Altenheim

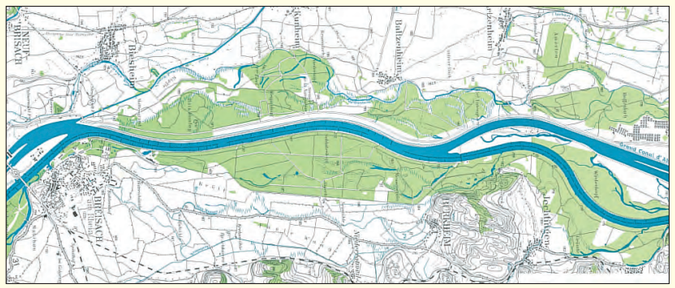
The next section of the river between the confluence of the Lauter River and the city of Worms was shaped by a shallow gradient. Here, the Rhine's course swung in wide loops, known as the meander zone, through the Upper Rhine plain in a near cohesive riverbed. This particular section of the floodplain was 10 to 12 kilometres wide, and floodwaters inundated the terrain mostly unhindered. The natural alluvial floodplains with their great diversity of flora and fauna were still largely intact. For the people living near the Rhine at the time, however, the river posed many threats. Consistent, recurring floods repeatedly engulfed entire settlements, often submerging vital agricultural lands for weeks at a time.



Topographic map dated 1828. Detail of the so-called "Rheingränzkarte" (Rhine border map). Prior to Tulla's regulation of the Rhine, the river channel was wild and uncontrolled, changing its course and flowing in various streams and meanders in the so-called bifurcation zone while shaping countless islets and gravel banks.



Topographic map dated 1872. Tulla's regulation of the Rhine River joined the braided river arms to form a channelled riverbed 200 metres wide. In so doing, the volume of water flowing in the channel, known as river discharge, doubled during average flow conditions. During larger discharge events, the river overtopped its banks and inundated the alluvial forests, where inland flood control dykes kept it from flowing farther.



Topographic map from 1963. The systematic development of the Upper Rhine entailed the construction of the Grand Canal of Alsace up to Breisach, where the so-called "loop solution" was built. The Marckolsheim Barrage and the dykes flush again the riverbed were built to divert water into the canal loop near Burkheim. As a consequence, floodwaters can no longer inundate the riparian forest between Breisach and Burkheim.

The standard water conditions at Polder Altenheim

The first regulation of the Rhine River was carried out between 1817 and 1880 according to plans by Johann Gottfried Tulla, engineer and lieutenant colonel in the former Grand Duchy of Baden. Thereby, many of the braided channels in the bifurcation zone were connected to form one main narrow riverbed spanning 200 to 240 metres wide, and several wide meander loops were cut off from the main flow of water. The construction shaped the course of the Rhine riverbed that we see today. Not only was the section of the Rhine between Basel and Worms shortened from 354 to 273 kilometres, but floods were engineered to only inundate an area about one to two kilometres wide.

The Rhine was a wild, natural flowing river until J.G. Tulla's plans to straighten the Upper Rhine began to shape the landscape in 1817.

By regulating the course of the Rhine, Tulla created areas for settlement and transformed the marshy Upper Rhine plain into land suitable for agriculture and forestry. Plus, people living in the immediate proximity of the Rhine were more protected against floods. In 1906, Max Honsell continued Tulla's work in his capacity as Director of the Grand Ducal Building Authority in Karlsruhe. His construction of groynes with stone rip-rap along several riverbanks restricted the cross-sectional flow of water in the channel, thereby further concentrating the current into the main river channel. And with the creation of this continuous, navigable channel, which was two metres deep and 75 to 100 metres wide, shipping and travel to Basel became possible year round.

The 1919 Treaty of Versailles ultimately constituted the basis for further substantial changes along the Upper Rhine. In Article 358, France was granted the right to divert water from the Upper Rhine in order to harness the water power for generating electricity. Between 1928 and 1977, ten barrages were constructed along the Upper Rhine in three developmental phases. First, with the construction of the Grand Canal of Alsace (Grand Canal d'Alsace) between Märkt and Breisach, the Kembs, Ottmarsheim, Fessenheim, and Vogelgrün barrages were built. Between 1957 and 1970, development along the Upper Rhine continued with four "loop solutions" between Breisach and Strasbourg, which required the erection of barrages near Marckolsheim, Rhinau, Gerstheim, and Strasbourg. By 1977, the Gambsheim and Iffezheim barrages constructed directly in the river current marked the last of the planned measures

© EnBW Daniel Meier-Gerber

Iffezheim Barrage on the Rhine with a view of an open stretch of river

The construction of dykes along the Rhine separates the floodplain from the river and its flood regimes, as pictured here in the Elzmündung retention area

CONSEQUENCES OF FLOOD SAFETY

Overall, major natural flood areas were lost to the changes made to the Upper Rhine, and spaces bordering the river experienced the inundation of floodwaters less frequently. The dyke construction between Märkt (near Basel) to Karlsruhe alone resulted in the loss of 660 square kilometres of floodplain. Increased erosion of the Rhine in the south caused the loss of another 80 square kilometres of floodplain. Floodplain species and communities dependent on regular flooding disappeared. However, despite these adverse changes at the time of these initial construction phases, the floodplain landscape on the Upper Rhine was still largely in a semi-natural state and biotopes were better interconnected than they are today.

The systematic development of the Upper Rhine resulted in a loss of 130 square kilometres of previously flooded wetlands which, in turn, meant important habitats that sheltered rare animals, like kingfishers, beavers, and black storks, were also lost. Although the semi-natural habitats typical of floodplains did not completely disappear, the flood-inundated areas became subject to more and more human management, and instead of a continuous band of various alluvial biotopes shaping a large-scale river network, only small, isolated remnants of the Rhine's former natural floodplains currently remain.

Aerial view of the Rhine River near Mannheim

Photo: Ralph-Dieter Görnert

Rhine floodwaters near Leopoldshafen, 2021

As a direct consequence of the construction of the barrages, the risk of flooding has increased considerably along the developed stretch of the Rhine downstream of Iffezheim. The loss of natural floodplains means floodwaters now peak significantly higher today. Moreover, since the river was shortened, the Rhine's peak heights coincide with the floodwater volumes of its tributaries, like those flowing in from the Neckar and Main rivers.

© Struktur- und Genehmigungsdirektion Süd

Karlsruhe Rhine harbour during the January 2018 flood

Flood operation in the Kulturwehr Kehl/Strasbourg retention area, 2013

Flood Retention on the Upper Rhine

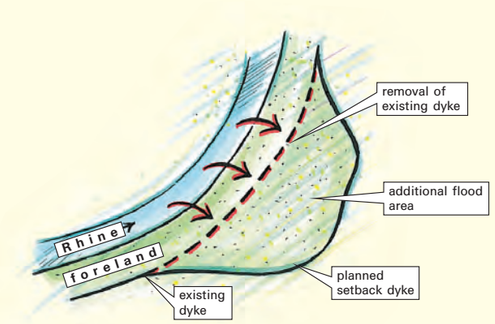
Floods on the Upper Rhine can be contained by setting back dykes, lowering and controlling retention areas, building barrages, and implementing emergency operations of Rhine power stations. The type of flood retention necessary for a given area depends on the local situation and on the required effects demanded of the overall system.

Flood retention options	Controllable during a flood?
Setting back dykes	no
Lowering the shores	no
Controlled retention areas	yes
Barrages	yes
Emergency operation of the Rhine power stations	yes

Semi-natural

SETTING BACK DYKES

By setting back dykes, floodwaters can once again overtop the riverbanks unhindered and reconnect larger natural flood areas to the Rhine River. As water levels in the river rise, water inundates the area and flows back into the Rhine with a time lag as floodwaters recede. This flood control measure reduces the mounting flood levels at an early stage before discharge volumes become critical.



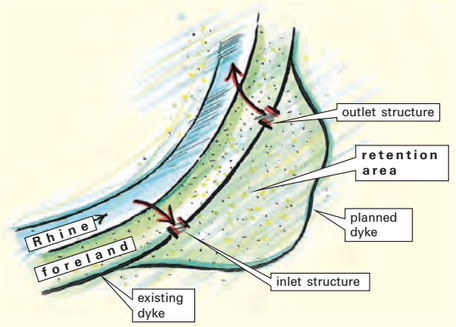
Setting back dykes

Aerial view of the future Elisabethenwört retention area, which will be created by setting back the dyke

The Weil-Breisach retention area was lowered prior to the 2013 flood pictured here

LOWERING THE SHORES OF THE RHINE

Like setting back dykes, lowering the Rhine shores also reconnects floodplains with the river. As a result of straightening the Rhine, the riverbed is currently 7 to 12 metres deeper between Weil am Rhein and Breisach than it was before the construction. Consequently, the high shores of the Rhine hinder floodwaters from entering the areas below them, creating dry meadows. By lowering shorelines in this section to roughly Rhine level, floodwaters can flow into these lowered areas, and within a short time, willows, poplars, and many other trees take root on the initial gravel areas, establishing a semi-natural alluvial forest. These trees then form a natural resistance against the water current. In combination with extending floodplain areas, slowing down river discharge greatly improves the effectiveness of flood retention.



Controlled retention area

Central inlet structure at the Elzmündung retention area

CONTROLLED RETENTION AREAS

In the event of a flood, controlled retention areas are flooded via inlet structures according to precise regulations. Floodwaters are controlled to continually flow through the retention area and back into the Rhine through an outlet structure with a time delay. It is estimated that these structures will be put into use every ten years or less. Building this kind of flood control structure in predominantly forested areas under nature conservation law, stipulates that regular ecological flooding must take place in the years between actual flood control operations.

This kind of regular flooding largely replicates natural conditions, creating habitats and conditions similar to natural floodplains.

Aerial view of the retention area near the Kehl/Strasbourg irrigation barrage

BARRAGES

In accordance with a stipulated set of rules and regulations, barrages in the Rhine control the water level in the river channel and floodplains upstream of the respective barrage.

Floodwaters are initially held back by the structure until water levels rise upstream and the flow is allowed to spill into the adjacent floodplains. When the barrage gates are opened, water empties out of the retention area.

Irrigation barrage near Kehl/Strasbourg during a flood

EMERGENCY OPERATION OF THE RHINE POWER STATIONS

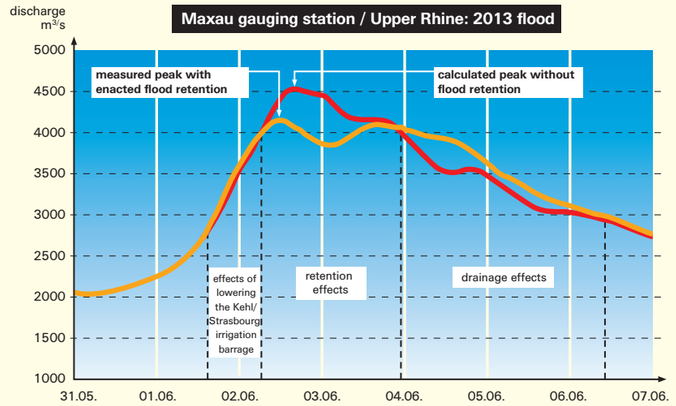
Along the systematically developed stretch of the Rhine between Basel and Strasbourg, the river is divided and channelled into the loops that hold the power station canals, the Grand Canal of Alsace and the old Rhine riverbed. In the event of a flood, the Rhine power stations initiate emergency operations, reducing the water levels in the loops to a minimum to channel the Rhine's entire discharge volume through the old riverbed, where water levels are allowed to rise. Here, the floodwaters can overtop the banks of the old river, freely inundating the adjacent floodplains.

Brugger Luftbild, Stuttgart

Rhinau loop with the Taubergiessen Nature Reserve

EFFECTIVENESS

A hydrological/hydraulic flood discharge model was used to verify whether the measures defined in Part I of the IRP Framework Concept – in conjunction with the measures taken in France and Rhineland-Palatinate – would provide effective flood protection. This evidence is updated as appropriate. According to a report by the Standing Committee, "The calculation results show that with the retention measures already in place and those scheduled, the flood protection that existed prior to the systematic developments along the Upper Rhine can be restored according to the objective of the Franco-German Agreement of 1982" (Sub-Working Group, Proof of Effectiveness, Report 2020). Therefore, to achieve this flood protection objective with its high retention efficiency, it is necessary to re-incorporate all former floodplain areas, creating retention areas as designated in Part I of the IRP's Framework Concept.



The graph shows the flood wave and the effect of the retention measures during flood operations in 2013. The orange line represents the discharge volumes measured at the Maxau gauging station. At that time, the following flood control structures were put into use: the Strasbourg barrage and Erstein retention area on the French side as well as the Polder Altenheim and retention area near the Kehl/Strasbourg irrigation barrage in Baden-Württemberg. Without these measures, the flood wave would have been significantly higher (red line).

VARYING EFFECTIVENESS OF UNCONTROLLED AND CONTROLLED RETENTION AREAS

Since floods immediately fill uncontrolled retention areas, like set-back dykes and lowered forelands, these areas are already largely under water when floods peak.

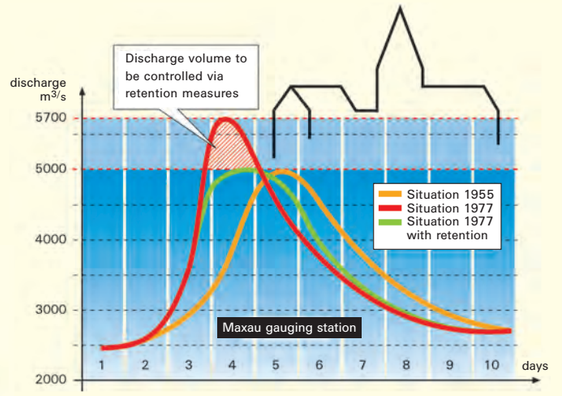
Therefore, these kinds of retention systems help, first and foremost, to temporally delay the river discharge. The controlled retention areas, on the other hand, are only flooded when critical water levels are exceeded. Their targeted use helps to reduce flood peaks.

Inlet structure at the Elzmündung retention area

What is a polder?

In the past, the term polder was used synonymously in the IRP for controlled flood retention areas. Over time, the term developed into a proper name in some cases, like Polder Altenheim, Polder Söllingen/Greffern, and Polder Bellenkopf/Rappenwört.

View of the Polder Altenheim looking north



In order to attain the same level of flood protection that existed prior to the systematic development of the Upper Rhine (until 1977), the flood peaks at the Maxau gauging station must be reduced by 700 m3/s, which can be achieved with the IRP retention measures.

The Integrated Rhine Programme (IRP)

The goals of the Integrated Rhine Programme include providing efficient flood control as well as preserving and restoring the Upper Rhine floodplains. To achieve these goals, the IRP will create 13 retention areas on former alluvial floodplains along the shores of the Rhine River in Baden-Württemberg, and in doing so, it will extensively preserve and restore floodplains along the Upper Rhine.

The primary goal focuses on improving flood control on the undeveloped stretch of the Rhine between Iffezheim and Worms, specifically enhancing protection of the conurbations of Karlsruhe and Mannheim/Ludwigshafen. This entails restoring the level of flood protection that existed prior to the construction of the barrages. For flood control structures to be approved under nature conservation law and thereby be environmentally compatible, semi-natural floodplain landscapes must be created for the preservation of their characteristic plant and animal communities.

A channel of the old Rhine in the Polder Altenheim

THE FRANCO-GERMAN AGREEMENT

As early as 1978, the International Commission on the Hydrology of the Rhine called for the restoration of flood protection as it existed before the systematic development of the Upper Rhine. This requirement was incorporated into the Franco-German Agreement concluded in 1982. This agreement on the development of the Rhine River between Kehl/Strasbourg and Neuburgweier/Lauterburg listed measures for building emergency operation power stations in Germany, including a barrage at Rhine kilometre 220.5, the irrigation barrage at Breisach and Kehl, the Polders Altenheim and Söllingen/Greffern as well as further polders downstream of the French-German border. Under this agreement, France is committed to the restoration of flood protection by maintaining its emergency power station and the Moder and Erstein polders.

Ecology and technology working hand in hand: flood retention area at the Breisach irrigation barrage with inlet structure and fish ladder

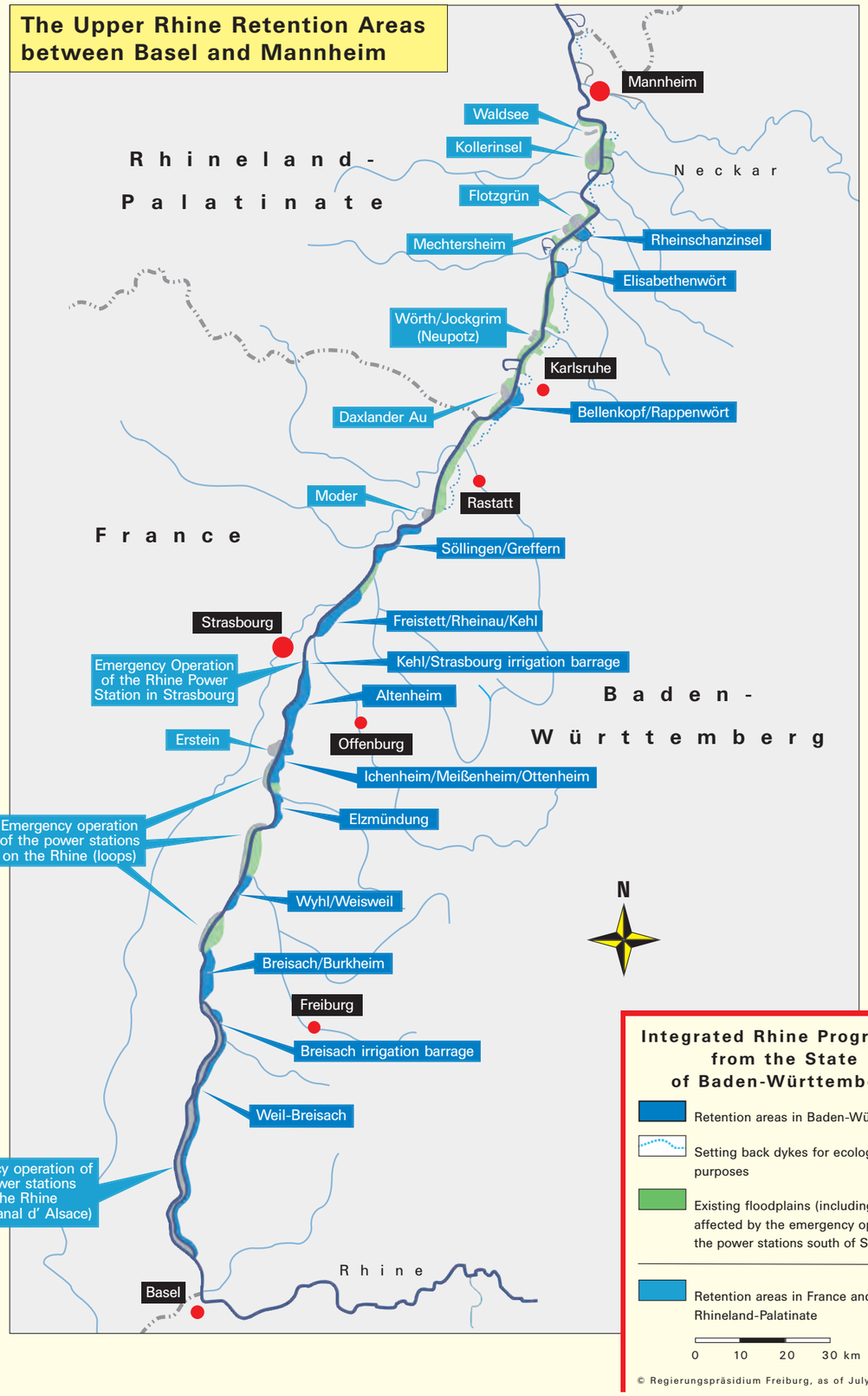
IMPLEMENTATION USING FRAMEWORK CONCEPTS I THROUGH III

During the planning stage, it became apparent that the flood control measures could not be implemented as originally conceptualised. On the one hand, there were technical issues with the implementation. On the other hand, environmental impact assessments showed new ecological insights and concerns that needed to be addressed in order to suffice nature conservation law.

The State of Baden-Württemberg responded by commissioning the then Ministry of the Environment to develop concepts for restoring flood protection (Framework Concept Part I), restoring the floodplains along the Upper Rhine (Framework Concept Part II), and for reviewing ecological efficiency (Framework Concept Part III). Therewith, the State of Baden-Württemberg approved the implementation of the Integrated Rhine Programme in 1996.

Construction site of an inlet structure in the Breisach/Burkheim retention area

Gravel deposits in a section of the old Rhine – valuable structures typical of the Rhine River



A CROSS-BORDER PROJECT

Commissioned by the State of Baden-Württemberg, the Integrated Rhine Programme was drawn up by the state environmental administration in interdisciplinary cooperation with other departments and third-party experts. With the determination of the three Framework Concepts, the objectives and intended improvements for flood control will be planned and implemented incrementally. The Regional Administrative Authority Freiburg (Regierungspräsidium Freiburg) is managing the overall IRP project and its implementation in the Freiburg administrative district. Local implementation in the administrative district of Karlsruhe is ensured by the Regional Administrative Authority Karlsruhe (Regierungspräsidium Karlsruhe).

In conjunction with IRP projects, the restoration of flood control measures will also be implemented in Rhineland-Palatinate and France. French-German agreements regulate how this international cooperation is structured and organised. Various committees hold meetings several times a year to make decisions and to discuss current issues, tasks, and status reports.

Cross-border groundbreaking ceremony for the inlet structure of the Elzmündung retention area, 2015

Important Events:

1919 Treaty of Versailles

1928-77 Systematic development of the Upper Rhine

1968 Establishment of the International Commission on the Hydrology of the Rhine

1982 Franco-German Agreement on the systematic development of the Rhine

1987 The first retention areas become operational – Polder Altenheim and the irrigation barrage near Kehl/Strasbourg

1988 The State of Baden-Württemberg resolves to develop a framework concept

1996 The State of Baden-Württemberg approves the Framework Concept proposed for the implementation of the Integrated Rhine Programme

2002 The Landtag unanimously reaffirms its approval of the 13 sites designated to become retention areas in the Integrated Rhine Programme

2010 The Cabinet reaffirms and resolves to report regularly to the Landtag every 3 years

Construction of a new culvert in the Elzmündung retention area

Framework Concept Part I – Flood Control

The implementation of the IRP largely consists of building controlled retention areas. However, along an undeveloped stretch of the Rhine north of Iffezheim at Elisabethenwört, a dyke will be set back to create an uncontrolled retention area. The southern sections of the Weil-Breisach retention area will be lowered by dredging to increase water retention, which has a similar effect as setting back dykes.

Currently, investment costs for all 13 IRP retention areas total around 1.88 billion euros. The alternative, however, is potential, future flood damages estimated at roughly 41 billion euros in Baden-Württemberg, Rhineland-Palatinate, and Hesse alone (as of 2021). The measures are financed by the Federal Republic of Germany and the State of Baden-Württemberg. The most important aspects of flood control planning and implementation are presented in the following sub-sections.

Inlet structure of the Elzmündung retention area

ENVIRONMENTAL IMPACT

Nearly 70 percent of the IRP retention areas are forested, and many of them are located entirely in designated Natura 2000 sites. These spaces form a European network of protected areas for the conservation of important habitats and species. It is estimated that the retention areas will be put into use every ten years or less. In these rare instances, plant and animal communities unadapted to flooding are threatened. According to the Federal Nature Conservation Act, flood operations are interventions that affect nature and the landscape. (Bundesnaturschutzgesetz – BNatSchG). Therefore, years of planning and increased operational experiences have led to the development of ecological standards.

Ecological flooding in Polder Altenheim

ECOLOGICAL FLOODING

The dynamic stability of floodplains and their biotic communities can only develop with regular flooding. In controlled retention areas, these conditions are maintained by regular, intentional flooding, called ecological flooding. Ecological flooding is determined by the natural flooding regimes of the Rhine River. In so doing, the devastating effects on floodplain habitats that could occur when they are exposed to prolonged dry periods are avoided or mitigated as defined by nature conservation law. Plus, flood-tolerant communities can re-establish themselves in the retention areas, mimicking floodplain habitats with their characteristic plants and animals. These retention areas, therefore, develop into ecologically equivalent natural spaces with time. Forest management is also expected to adopt the concepts of mimicking floodplain conditions to avoid recurring damage to forest communities. For controlled retention areas to be approved, ecological flooding as a preventative measure is mandatory.

Together, administrations from nature conservation, forestry, water body management, the Institute for Landscape Ecology and Nature Conservation Bühl and the World Wildlife Fund Wetlands Institute developed a model called Floodplain Forest Stages for the area between Iffezheim and Karlsruhe. These model stages have been used as a consensual planning basis for the IRP retention areas in the Rhine floodplain to recreate conditions that are as close to natural processes as possible. The stages are subdivided into flood level and duration and are characterised by the occurrence of different plant and animal communities.

FLOOD LEVELS

In the IRP, the maximum flood level in the retention area is limited to 2.5 metres above mean ground level; this is not only based on the environmental impact study conducted in the three retention areas near Breisach, but surveys investigating the 1999 flood event also warrant this level. Forests in future IRP areas which have not been flooded for a long time will react more sensitively to water than forests grown under natural floodplain conditions. Also, since trees are more susceptible to damage when floodwaters reach a certain level, experts have mutually agreed on this flood level maximum.

FLOW CONDITIONS

The environmental impact study also showed that trees in slow-flowing or backwatered areas react much more sensitively to flooding than trees in well-flooded areas, meaning areas where the water flows more swiftly. Essentially, slow-flowing or stagnant water contains lower oxygen levels than quick-flowing water. Therefore, floodwaters in the retention areas will be regulated to achieve adequate flow conditions.

COMPENSATION

The areas of the IRP retention areas are currently used in various ways, including for agriculture, forestry, fishing, hunting, recreation, and gravel extraction. Each affected instance will be compensated individually.

Within the retention areas, basic compensation is paid for land use, which is secured by an easement in favour of the state. Forests damaged by the operation of a retention area are allotted a one-time compensation based on a model. Compensation for agricultural land affected by flooding is determined on a case-by-case basis by an appraiser.

RECREATIONAL USE

The retention areas, which are temporarily restricted by the IRP measures, are important local recreation areas for the people of the neighbouring municipalities. Therefore, concepts to improve the recreational use of the Rhine floodplains and their adjacent spaces are being developed for each retention area in cooperation with the affected municipalities. This also helps to encourage people's acceptance of the flood control measures. Several exemplary projects have already been developed in cooperation with municipalities.

For example, the Community Action Group to Combat the Infestation of Mosquitoes (Kommunale Aktionsgemeinschaft zur Bekämpfung der Schnakenplage, or KABS e.V.) has successfully helped to control mosquito populations in the Upper Rhine region for years. On behalf of the State of Baden-Württemberg, KABS carries out these proven control measures in the IRP retention areas after a flood.

Wilderness trail in Polder Altenheim

Viewing platform in the Rhine Gardens near Neuenburg am Rhein

Wilderness trailhead in the Polder Altenheim during a flood

Protective measures surrounding the village Marlen near Kehl

LOCAL PROTECTIVE MEASURES

Throughout the year, groundwater levels fluctuate depending on precipitation and water levels in bodies of water. Even today, without the use of a retention area, groundwater levels in the Rhine Valley can rapidly increase after prolonged and heavy precipitation. However, when a retention area is flooded, this body of water is no longer able to absorb rising groundwater. Preventing any more water from entering the already full retention area leads to groundwater rising elsewhere.

Therefore, measures are in place to protect local communities from rising groundwater and the additional damages it can cause, like basement flooding. These measures include installing individual wells, well galleries, pumping stations, drainage ditches, underground drainage pipes, and creating ponds.

Drilling a well

Aspenrain Pond in Marlen near Kehl

Installing a well pipe in a well shaft

Flooding Operations in the Retention Areas

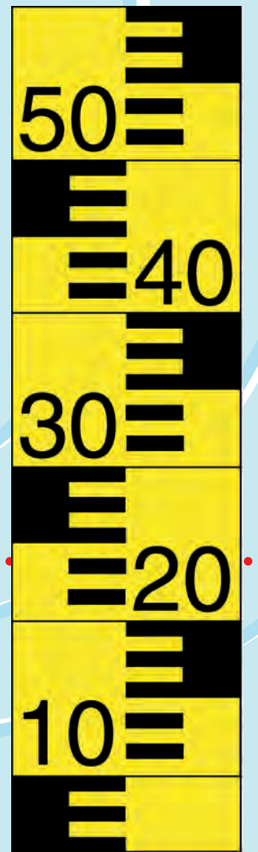
"And now, on to the weather: The warm spell will continue at higher altitudes while in southern Germany and Switzerland, sustained heavy rainfall, as we have seen the last few days, is expected. No changes are expected for the rest of the week." This type of message from the German Meteorological Service would mean flooding is expected in the Upper Rhine, signalling the use of the IRP's controlled retention areas for flood retention. Operations would proceed as follows:

Hochwasservorhersagezentrale der LUBW, Karlsruhe

Stage 1: Water levels in the Upper Rhine and Black Forest tributaries rise after heavy rainfall, triggering flood alert levels. The Central Flood Forecasting Office (Hochwasservorhersagezentrale – HVZ) of the State of Baden-Württemberg, which constantly monitors the discharge regimes of the state's key water bodies via a computer-controlled system, has already started its round-the-clock service. The HVZ computes hourly flood forecasts for the state's most important gauging stations based on measurement data of precipitation and water levels as well as on rain forecasts provided by the German Meteorological Service. These HVZ projections predict the occurrence of a major flood event along the Rhine River: Typically, rising discharge volumes at the Maxau gauging station in Karlsruhe trigger the operation of the IRP's controlled retention areas. This action is coordinated between French and German partners according to internationally agreed operating regulations which pertain to each individual retention area. At this point, the lowered areas of the Weil-Breisach retention area are already flooded. One after the other, the IRP retention areas go into operation. The HVZ, the French authorities, and the operators of the retention areas on the French and German sides in Baden-Württemberg and Rhineland-Palatinate continually send each other updated information.

Stage 2: The general public is notified of the flooding via loudspeaker announcements and are informed to leave the retention areas. The staff of the operating company, the workers of the municipal building control offices, the police, and the volunteer fire brigade are working around the clock. Within hours, the retention areas and their immediate vicinities are cordoned off with barriers and boom gates. For safety reasons, re-entering the retention areas is prohibited, giving animals a chance to retreat without being disturbed. Continuous monitoring and control of on-site operations are carried out from central control stations located near the Kehl/Strasbourg irrigation barrage.

Stage 3: When the operational criteria are exceeded, the retention areas are flooded in a controlled manner, channelling the Rhine floodwaters through inlet structures and culverts. Water levels continue to rise in the retention areas of the old Rhine channels and is allowed to inundate these areas. During flood operations, outlet structures are not completely closed, ensuring water flows continuously in the retention area.



Stage 4: In order to prevent any adverse impact caused by rising groundwater levels in the neighbouring localities, the pumping stations, protective wells, drainage ditches, and other measures are put into simultaneous operation along with the retention areas. During flood retention periods, the local fire brigade continually checks the barrages, and equipment and material are available for securing any seepages.

Stage 5: Retention areas can be in use for up to one week. As water levels in the Rhine recede, outlet structures are fully opened so retention areas can empty naturally, after which the operating company carries out the necessary clean-up operations.


Photo: Dr. V. Späth

The bank of the old Rhine, Altrhein Backofen, south of Mannheim has no towpath and consists of white willows through which floodwaters can flow unhindered.

Framework Concept Part II – Restoration of Former Floodplains along the Upper Rhine

Despite the multitude of changes made to the river dynamics, the Upper Rhine and its adjacent floodplains continue to be vital and valuable natural spaces. The floodplain ecosystem with its mosaic of habitat types, diversity of species and biotopes, as well as its plant and animal communities is of inestimable value. Therefore, Part II of the Framework Concept is primarily intended to advance floodplain restoration processes.

The measures focus on the Rhine foreland north of Iffezheim. In particular, parts of the old floodplain will be reconnected to the discharge regime of the Rhine, for example by setting back the dykes. Plus, the intensive use of agricultural areas will be downsized and forests will be cultivated or converted to tolerate more floods. At the same time, the objectives of the EU Water Framework Directive (Wasserrahmenrichtlinie – WRRL) will be implemented. The projects are nationally funded and, where applicable, subsidised by programmes like the Blaues Band Deutschland, which supports the creation of semi-natural river landscapes.

Along the Upper Rhine, there are still remnants of floodplain forests that are now protected, such as the Taubergiessen Nature Reserve. With the IRP, the fundamental principles and objectives of nature conservation are put into practice in the natural environment of the northern and southern Upper Rhine lowlands. These goals are in line with the provisions stated in the national and international agreements for the protection of these lowlands. Flora and fauna along the Upper Rhine are already benefiting from the IRP measures.

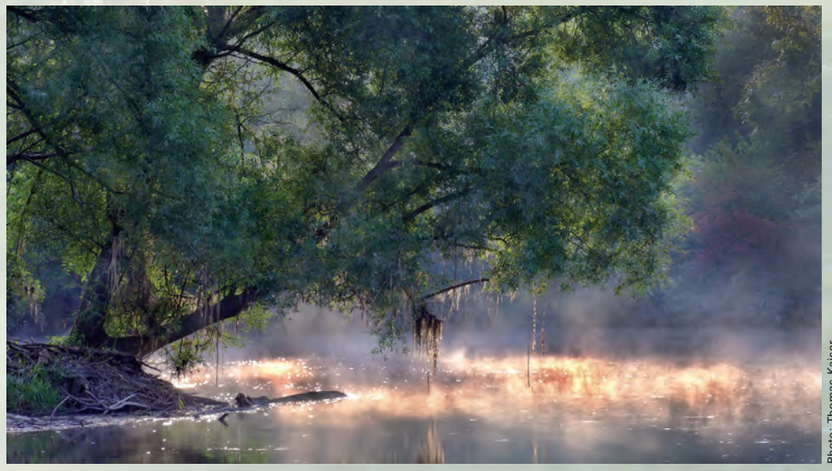


Photo: Thomas Kaiser

Measures


Photo: IUS Heidelberg

By setting back the artificial dykes, former floodplain areas will once again be inundated by floodwaters when discharge volumes of the Rhine increase. For example, in Mannheim-Kirschgartshausen around 75 hectares of former floodplain have been re-established, creating important nature conservation areas.


Photo: R. Deible

The discharge regime in the forelands of the Rhine River will be improved. Specific measures, including reconnecting old Rhine channels to the main river, will ensure water flows without impediment. Opposite the Lauterbourg harbour, a groyne field was redesigned and a branch of the old Rhine, the Illinger Altrhein, is now connected with the main channel.


With the construction of fish ladders, floodplain waters will be reconnected to the Rhine. This enables fish, like salmon, to reclaim their spawning grounds.


Photo: Dr. Volker Späth

Up to now, many riverbanks have been heavily obstructed, destroying the resting and spawning areas that many species depend on. However, the restoration of former riparian spaces, as pictured here in the northern floodplains near Rastatt, creates semi-natural habitats, like gravel banks for nesting waterfowl.

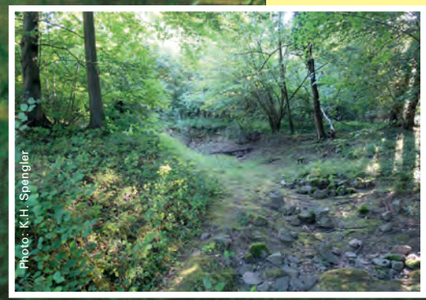


Photo: K.H. Spengler

The construction of fords, like in the floodplains near Rastatt, improves water flow through the old Rhine channels, slows the process of siltation, and creates dynamic steep banks, which benefit many species, such as the kingfisher.

Framework Concept Part III – Ecological Efficiency Review

The IRP measures are gradually transforming habitats, including their flora and fauna species. To document and monitor these developments brought about by flooding, the IRP Framework Concept III (Ecological Efficiency Review) was developed with appropriate and standardised monitoring methods.

Conducting a botanical survey in the Polder Altenheim

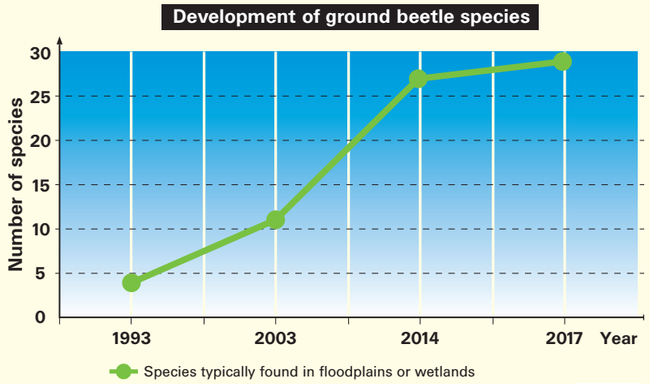
For years, scientists have been using bioindicators to record changes in an ecosystem. Suitable bioindicators for the IRP are fauna species or communities living near the surface of the soil that react quickly and distinctly to flooding, as ground beetle fauna do. This way, the development of flora and fauna in the retention areas that have been reconnected to the discharge regime of the Rhine River can be observed over several years. Since such changes occur comparatively slowly, the standards set in Part III of the Framework Concept ensure that the results in the various retention areas can be compared many years from now.

Spotted darter

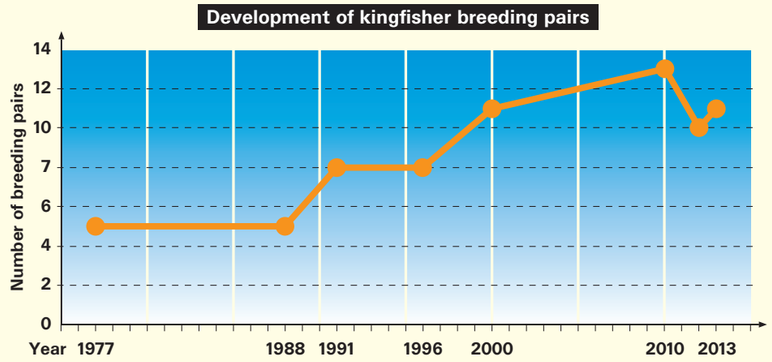
Desmoulin's whorl snail

Insects' survival strategy during a flood

Long-term outcomes from the Polder Altenheim show that, since 1989, species-rich communities of ground beetles adapted to the floodplains have been developing on frequently flooded areas. This example from Polder Altenheim proves that regular flooding creates and mimics the intended floodplain dynamics in retention areas while also gradually avoiding or mitigating habitat damage that would otherwise be caused by infrequent flood events.



The graph shows the number of ground beetle species on a frequently flooded area from 1993 to 2017. This monitoring plot in the Polder Altenheim shows a clear increase in flood-tolerant species.



The graph shows a positive increase in the kingfisher population based on the number of breeding pairs from 1977 to 2013. Over the course of monitoring, a stable population developed in the Polder Altenheim.

Kingfisher

Outlook

The Integrated Rhine Programme of the State of Baden-Württemberg plays a decisive role in flood control on the Upper Rhine. So far, the operational retention areas have been helping to significantly reduce flood hazards to people, the environment, the economy, and culture. The following retention areas are operational: the irrigation barrage near Kehl/Strasbourg, Polder Altenheim, Polder Söllingen/Greffern as well as the Polder Rheinschanzinsel. The southernmost section of the Weil-Breisach retention area, completed at the end of 2021, is now also providing flood protection.

However, the most powerful solution to mitigating the threat of centennial floods lies in the successful implementation of all 13 retention areas stated in the Integrated Rhine Programme. Given the complexity of these major projects, this is a massive challenge. For this reason, the solidarity of the people living and working along the Rhine and the support of all the stakeholders are vital.

But our efforts will be worthwhile. The retention areas will not only significantly reduce the risk of flooding, but in adapting its measures to the natural discharge regimes of the Rhine, the Integrated Rhine Programme will also create a mosaic of dynamic habitats that mirror a floodplain ecosystem. These structures will support a multitude of diverse plant and animal species, which will then revive and sustain the rare floodplain habitat. This, in turn, will be beneficial for both natural spaces and the people of the Upper Rhine.