Update on the identification of potential significant flood risk areas in the international river basin district Rhine

Second cycle of the FD
December 2018

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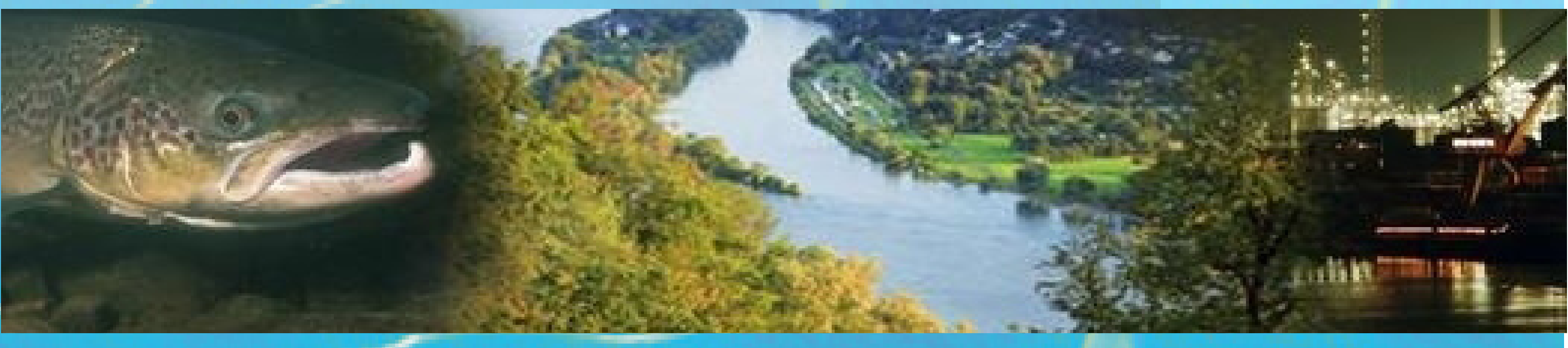

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Second cycle of the FD – December 2018

Foreword

According to Article 4 of the Directive 2007/60/EC[1] of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (in the following "FD") the **EU member states** proceeded to a **preliminary flood risk assessment** for the first cycle by 22 December 2011. Until end 2010 they were equally able to make use of the transitional measures according to FD Article 13. According to FD Article 5, EU Member States are required to identify areas presenting a potential significant flood risk. The preliminary flood risk assessment according to FD Article 4 and the identification of potential significant flood risk areas according to FD Article 5 jointly coordinated at the level of the IRBD Rhine are part of a first report[2] of the EU states in the IRBD Rhine. Furthermore, within the first cycle according to FD Chapter III and IV, the identification of flood risk areas was used for drafting flood hazard and flood risk maps and the first Flood Risk Management Plan (FRMP) for the IRBD Rhine[3].

Within the second cycle of the implementation of the FD and according to FD Article 14, the preliminary flood risk assessment or the assessment and decisions referring to Article 13, par. 1 are to be reviewed, and if necessary updated, by 22 December 2018. Further reviews will follow every six years. According to FD Article 14, the likely impact of climate change on the occurrence of floods are to be taken into account as of the second cycle.

In the Conference of Rhine Ministers of 18 October 2007 the International Commission for the Protection of the Rhine (ICPR) was charged to support the coordination required within the implementation of the FD between EU Member States and Switzerland in the Rhine catchment in a comparable manner to what is done for the Water Framework Directive (WFD).

As non EU members, Switzerland and Liechtenstein are not obliged to implement the FD. As is the case within the implementation of the WFD, and based on national law, Switzerland and Liechtenstein have supported the coordination of the EU Member States with respect to implementing the FD.

The EU Member States are in charge of reporting on the state of implementation of the FD to the EU Commission.

The reporting of the EU member states to the EU Commission followed the provisions of the "Guidance for Reporting under the Floods Directive (2007/60/EC)[4]" (2013).

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32007L0060
[2] https://www.iksr.org/en/floods-directive/preliminary-flood-risk-assessment/
[3] https://www.iksr.org/en/floods-directive/
[4] See Guidance Doc. No. 29 "A compilation of reporting sheets adopted by WD CIS for the WFD (2000/60/EC)", Technical Report – 071", 2013. Link: http://ec.europa.eu/environment/water/flood_risk/implem.htm

The report at hand and the jointly drafted survey map in Chapter 3.2 serves the EU states
(1) as a documentation for applying FD Article 4 (preliminary flood risk assessment) and FD Article 14 in the IRBD Rhine (part A, catchment > 2,500 km²)
(2) as a proof for the exchange of information required according to FD Article 4, par. 3
(3) as a proof for the coordination in the IRBD Rhine required according to FD Article 5, par. 2 or in management units (sub-basins) shared with other member states and covered by the reporting obligation.

The general and comprehensive description of the IRBD Rhine with maps representing the boundaries of the catchment, the sub-basins, the coastal areas and topography as well as land use is included in the management plan of the IRBD Rhine[5] according to WFD. Further details on the flood risk management are found in the FRMP according to the FD[6].

1. Historical flood events, potential future significant adverse consequences and impacts of climate change

1.1. Types of floods

The jointly coordinated assessment of flood risk in the IRBD Rhine focusses on **fluvial floods.** However, coastal floods on the Dutch coast and locally occurring floods caused by a sudden rise of the groundwater table, heavy rainfall, flash floods and mudslides may also cause great damage. The coastal area of the Rhine catchment is entirely located within the frontiers of the Netherlands and the influence of marine water levels including a rise of the sea level on the Rhine is limited to the Netherlands. Therefore, this report does not take into account coastal floods. Other flood sources than fluvial floods are described in the national reports on the PRFRA (Preliminary Flood Risk Assessment). A summary on the consideration of the flood types at a national level is to be found in Chapter 2.1 and the links in Chapter 3.3 as well as Annex 2.

1.2. Flood generation

In the Rhine catchment, different discharge regimes (see Fig. 1) with different flood characteristics overlap one another.

- The Alpine and High Rhine (gauge Basel) with glacial-nival regime components of the high mountain range (floods mainly during the summer);
- Waters draining the Central Upland region (Neckar, Main, Nahe, Lahn, Moselle, etc.; Trier gauging station) are characterised by a pluvial runoff (dominated by winter floods);
- As these two regimes overlap, the downstream discharge distribution over the year ("combined regime", Cologne gauging station) is increasingly uniform (dominated by spring and winter floods).

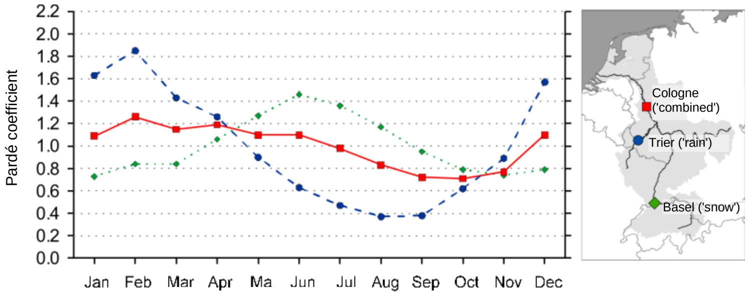


Figure 1: Typical discharge regime in the Rhine catchment according to Pardé[7]; reference period 1961-1990

Furthermore and due to watercourse realignments/regulation since the 19th century until way into the 20th century (1977) (among others regulation of the Alpine Rhine, correction of water courses in the Jura, training of the Upper Rhine, weir-regulated tributaries), floods are also influenced by man. Depending on the river section concerned, this may lead to increased flood protection or downstream of trained sections and due to

[5] https://www.iksr.org/en/water-framework-directive/river-basin-management-plan-2015/
[6] https://www.iksr.org/en/floods-directive/flood-risk-management-plan/
[7] Pardé coefficient = ratio of multi-year monthly discharge to multi-year annual discharge.

less alluvial areas and a shorter water course (speeding up of waves) this may lead to increased flood risk.

1.3. Historical flood events

If floods occur in several sub-basins and/or river sections, this may lead to exceptional large-scale events in the Rhine. The Table below (ICPR, 2012)[8] lists representative historical/past floods of the Rhine between 1882 and 2003 with different generation and of different regional importance. Further floods occurred in 2007, 2011, 2013 and 2018. Due to their different characteristics, historical floods of the Alpine Rhine and Lake Constance are listed separately: 1817, 1888, 1927, 1954, 1987, 1999 and 2005[9]. Coastal floods on the Dutch coast are described in Dutch national reports.

Table 1: Representative historical floods of the Rhine at the different gauges with flood peak discharges and probabilities (ICPR, 2012)

Run-off probabilities *(Status 1977, without retention measures)*	Gauge **Basel** [m³/s]	Gauge **Maxau** [m³/s]	Gauge **Worms** [m³/s]	Gauge **Mainz** [m³/s]	Gauge **Kaub** [m³/s]	Gauge **Andernach** [m³/s]	Gauge **Cologne** [m³/s]	Gauge **Lobith** [m³/s]
HQ_{10}	*3980*	*4100*	*4750*	*5700*	*5800*	*8850*	*9010*	*9459*
HQ_{100}	*4780*	*5300*	*6300*	*7900*	*8000*	*12200*	*12000*	*12675*
$HQ_{extreme}$	*5480*	*6500*	*7600*	*10300*	*10400*	*15250*	*15300*	*16000*
Discharge peaks								
Flood 1882/1883**	4100	6260	7520	9668	9653	12470	12886	10690 *
Flood 1918/1919	3850	4480	4710	5163	5047	6680	6748	6896
Flood 1919/1920**	3,160	4520	5380	7235	7365	10849	10951	11394
Floods 1925/1926***	2150	3260	4234	5923	5992	10394	11021	11694
Flood 01 1955**	3240	4560	6160	6836	6832	10340	10324	10328
Flood 02 1957	3340	4140	4590	5606	5634	7530	7580	7807
Flood 02/03 1970**	3190	4200	4990	4823	7105	9340	10137	10780
Flood 05 1978	3000	4180	5270	5800	5857	6339	6401	6656
Flood 02 1980**	3370	4160	4763	5939	6010	8666	9084	9630
Flood 04 1983**	2249	4110	4990	6178	6318	9736	9888	9817
Flood 05 1983**	3078	4260	5250	5967	6227	9768	9953	10043
Flood 03 1988**	3273	4090	5270	7161	7240	10029	10022	10852
Flood 12 1993	2109	3020	4765	5567	6493	10600	10800	11039
Flood 01 1995**	3485	4080	4245	5935	6670	10200	10940	11885
Flood 10 1998	2818	3320	3675	4881	5454	8360	8989	9487
Flood 02 1999	3833	4490	4945	5597	6022	7778	8082	7974
Flood 05 1999****	5085	4720	4577	4455	4662	4643	4671	4516
Flood 01 2003	2036	2810	3522	5060	5540	8722	9329	9451

* Discharge reductions between the gauges Cologne and Lobith, presumably due to the flooding of dikes
**: Continuous extreme floods (classification according to Schwandt & Hübner 2009 in UNDINE, BfG 2018)
***: Extreme floods in sections (classification according to Schwandt & Hübner 2009 in UNDINE, BfG 2018)
****: Additional discharge value for the Basel gauge (FOEN, 2018) The differences compared to discharge values downstream are explained by the flood generation (flood events 1999 on the High Rhine and the Upper Rhine), limited inflows from the Black Forest and R. Neckar, the use of retention areas and natural retention in the river and the flooded foreshores (information given by the ICPR Expert Group HVAL, 2018).

[8] https://www.iksr.org/en/documentsarchive/technical-reports/reports-and-brochures-individual-presentation/news/detail/News/200-and-199-balance-on-the-implementation-of-the-action-plan-on-floods-between-1995-and-2010/
[9] Sources: http://alpenrhein.net/; http://www.planat.ch/; https://de.wikipedia.org/wiki/Alpenrhein

Furthermore, the following Table is a simplified illustration of historical floods in selected tributaries to the Rhine[10].

Table 2: Representative historical flood events on Rhine tributaries

Selected flood events in tributaries of the Rhine (PFRA Rhine basin 2011, BfG Undine, PLANAT, Wikipedia, 2018)			
Moselle	**Mayn**	**Neckar**	**Aare**
Februari/March 1784	Juli 1342	Februari/March 1784	1480
October 1824	Januari 1682	October/November 1824	1651
Februari/March 1844	Januari 1764	December 1882 / Januari 1883	1852
March/April 1845	Februari/March 1784	December 1919	1876
Januari/Februari 1850	March/April 1845	May 1931	1999
November/December 1882	Februari 1862	December 1947 / Januari 1948	2005
December 1919/Januari 1920	Februari 1876	Februari/March 1956	2007
December 1925/Januari 1926	November/December 1882 / Januari 1883	Februari 1970	
December 1947/Januari 1948	Februari 1909	December 1993	
Januari 1955	Januari 1920		
April/May 1983	December 1947 / Januari 1948		
December 1993	Februari 1970		
Januari/Februari 1995	March 1988		
	Januari/Februari 1995		
	Januari 2003		

1.4. Concrete examples for adverse effects and damages

Autumn and winter flood 1882/83

The flood caused catastrophic damages (dike breaches, deterioration of traffic ways, damage to buildings, damage to crops, soil erosion, sand coverage, loss of supplies, ...) in big cities as in smaller places along the Rhine and its tributaries. The number of casualties is not known. In order to repair the damages, authorities as well as private donors had to partly provide considerable financial aid. (Source: UNDINE)

Winter flood 1925/26

There were no considerable damages in the southern Rhine catchment including R. Main. Downstream, a considerable share of the total damages was in particular due to building damages (e.g. in Cologne with 72,000 persons concerned) and to damages in agriculture (loss of field crops and crop supplies, soil erosion, sand coverage, ...). Hydro-engineering installations were damaged. There were no reports of flood victims. (Source: UNDINE)

Winter flood 1993 and 1995

The big flood events in 1993 and 1995 developed from extremely high inflows into the Rhine downstream of Koblenz, in particular from the Moselle area and caused extensive damage on the Lower Rhine and in the Delta Rhine in Germany and in the Netherlands (1993: 1.4 billion Euro and 1995: 2.6 billion Euro). There were several casualties. In the beginning of February 1995, feared dike breaches caused the evacuation of some 250,000 Persons in the Rhine delta. (Source: UNDINE)

1.5. Potentially significant detrimental consequences

ICPR calculations concerning the four assets (objects) according to the FD (ICPR, 2016[11]) based on information taken from the national flood risk maps in the ICPR Rhine Atlas 2015[12] summarize to the following theoretical damages resp. potentially significant adverse consequences:

- **Human health**: some 42,000 people live in flood prone areas along the Rhine with a high probability of floods, some 1.5 million live in areas with a medium flood probability and some 8.9 million in areas with low flood probability (i.e. extreme floods).
- **Cultural heritage:** Along the Rhine, there are about 20,000 cultural heritage objects potentially at risk of floods.
- **Environment:** There are about 1,400 IPPC/IED or SEVESO plants potentially threatened by floods along the Rhine. In the Rhine catchment, there are 386 bird protection areas, 1,335 flora-fauna-habitat areas and 9,016 water protection areas

[10] Sources: http://undine.bafg.de/rhein/extremereignisse/rhein_extremereignisse.html; http://bdhi.fr/; EPRI Bassin du Rhin 2011; http://www.planat.ch/; https://de.wikipedia.org/wiki/Aare
[11] https://www.iksr.org/fileadmin/user_upload/DKDM/Dokumente/Fachberichte/EN/rp_En_0236.pdf
[12] https://www.iksr.org/en/documentsarchive/rhine-atlas/

(Management Plan, 2015) which will normally profit from floods but may suffer detrimental consequences if polluted.

- **Economic activities:** The potential economic damages, calculated on the basis of different types of land use (Corine Land Cover) and damage functions related to water level and taking into account flood prevention measures carried out amount to some 53 billion Euro for an extreme event along the entire main stream of the Rhine.

1.6. Consideration of the likely impact of climate change on the occurrence of floods

According to the FD[13], the review of the preliminary assessment of flood risk (first review by 22 December 2018) shall take into account the likely impact of climate change on the occurrence of floods.

Altogether ICPR studies at hand (2011, 2015)[14] indicate that climate change and rising temperatures in the Rhine catchment might lead to the following modifications in precipitation and discharge by 2050 and 2100 (trends are even more evident for the remote future until 2100)[15].

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
- More 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.

As charged by the 15th conference of Rhine Ministers, the ICPR has drafted a Strategy for the IRBD Rhine for adapting to climate change which was published in 2015[16]. To this end the ICPR states agreed upon different climate scenarios and possible fields of action within flood prevention. In Annex 1 the report at hand includes a Table taken from the Strategy for adapting to Climate Change (updated by data of 2017[17]) indicating the agreed "sensitivity guidance values", i.e. bandwidths (scenarios) of possible discharge modifications (until 2050) for different hydrological flood parameters and Rhine gauges[18]. Scenarios are considered in the context of other hydrological parameters in order to enable an estimate of possible effects of climate change on flood risk.

Further effects on flood discharge and thus on flood risk management will have to be reckoned with in future. By now, the states in the Rhine catchment have implemented many of the measures convened in 1998 within the Action Plan on Floods (AFD) and are presently implementing the first FRMP for the IRBD Rhine. A major part of measures implemented or planned may be considered as so-called win-win and no-regret measures for flood prevention, water quality and ecology. They contribute to reducing possible adverse effects of climate change.

The consideration of climate change is described more in detail in the national reports and methods (see Chapter 3.3).

[13] FD Art. 14
[14] ICPR Technical Report No. 188 (2011) and ICPR Technical Report No. 219 (2015); see here: https://www.iksr.org/en/topics/climate-change-in-the-rhine-catchment/
[15] OBS: Available climate models are subject to great uncertainty. Therefore, indications concerning the possible development of extreme precipitation values and flood situations depending on them so far show a great bandwidth.
[16] ICPR Technical Report No. 219 (2015); see here: https://www.iksr.org/topics/climate-change-in-the-rhine-catchment/
[17] Internal ICPR status report "2017 Update of knowledge on the effects of climate change in the Rhine catchment", SG(2)17-09-02.
[18] Bandwidths of changes by 2100 are included in the ICPR report on climate (report no. 188).

2. Exchange on methods and state of the preliminary flood risk assessment in the states of the IRBD Rhine according to FD Article 4, Par. 3

2.1 National method of the preliminary flood risk assessment

As required by FD Article 3, Par. 3, the authorities in charge in the member states of the IRBD Rhine have exchanged relevant information.

Due to differing legal and technical basis of flood protection in the different member states in the Rhine catchment there is no uniform approach to a preliminary flood risk assessment (PFRA).

In the following, the national method in the states of the IRBD Rhine is therefore described and exchanged.

Netherlands (Rhine):

For the 1st period under report, the Netherlands have applied the transitional regulation of the directive (FD Article 13, Par. 1b) and have drafted maps and plans for the entire territory. For the 2nd period under report, the Netherlands have made a preliminary flood risk assessment according to Article 4 of the directive. This preliminary assessment includes historical, as well as possible future floods. In the Netherlands, historical floods with significant effects have been inventoried. In order to detect possible adverse effects of future floods, model calculations and knowledge of water management have been made use of. This has been done for situations, in which protection systems (dunes, dams, sluices, impoundments, dikes) protect land against floods and for situations, in which water may unhindered flood land. For the 1st situation, there is a potentially significant flood risk for areas protected by primary protections systems against floods originating from the main water system (e.g. North Sea, Rhine and Maas). National standards apply to these protection works. Areas protected against floods by regional (secondary) protection works and for which the standards of the province apply are also prone to potentially significant flood risks. For the second situation there are a number of waters potentially exposed to a significant flood risk. Floods of regional transboundary waters belong to this group. With respect to the main stream of the Rhine and transboundary waters there has been coordination with Germany.
A first analysis of flood events which may result directly from heavy precipitation and without any contribution of surface waters has been made. Before drawing any conclusions from these investigations, further analysis is required. Flood events due to sewers and emerging groundwater do not represent any potentially significant flood risk.

Germany:

The recommendation developed by the German LAWA "Approach to the preliminary flood risk assessment according to the FD"[19] serves as common preliminary assessment basis in Germany. Following these recommendations, all available or easily obtainable relevant information has been used when concluding on potentially significant flood risks. Based on the results of the PFRA 2011, the approach harmonised by the LAWA for Germany is applied to the Rhine and its tributaries.

The review is based on the water network equally serving as a basis for the WFD (catchment > 10 km²), resp. waters which are known for floods in the past and which, from an expert point of view, may cause significantly adverse consequences in case of future floods. Due to this approach, all important main waters and tributaries were included. The banks of Lake Constance were equally included.

Within the preliminary risk assessment, and based on FD Article 2, Par. 2, the following different types of floods are considered as significant: Fluvial floods and flooding from groundwater in alluvial areas. Pluvial floods following heavy rainfall are not defined as significant, but as a general risk, as such events may occur anywhere and at any time. Flooding from Artificial Water-Bearing Infrastructure is not considered as significant.

[19] "Recommendation for reviewing the preliminary assessment of flood risk and flood areas according to the EU directive (2017)"

The entire process has been guided by experts and the plausibility of results was then checked.

France:

In 2011, the areas according to FD Article 4 were selected due to the estimated extent of potential floods (EAIP) and based on criteria for the importance of local action.
For the 2nd cycle of the Floods Directive the review of the preliminary flood risk assessment has led to a slight revision without any new EAIP-calculation. In addition to the floods along surface waters taken into account by the EAIP within the preliminary assessment of flood risk during the first assessment cycle, the preliminary flood assessment 2018 includes an informative map of the rise of groundwater.
The updated list of areas identified according to Article 5 is based on state expertise:

- concerning local knowledge, as far as available,
- concerning proposed amendments of parties involved in the implementation of the FD during the coordination.

At the end of this process, the amendment of the list of areas identified according to Article 5 is determined after the consultation of parties involved and those taking part in the FD implementation procedure.

Luxembourg:

The preliminary flood risk assessment in Luxembourg is based on Article 4 of the Floods Directive. The method takes into account the LAWA-requirements (Recommendation for reviewing the preliminary assessment of flood risk and flood areas according to the EU directive (2017))

All water bodies designated as areas at risk during the first cycle of the Flood Risk Management Plan are assessed. This assessment is based on earlier studies aimed at determining the flood risk for Luxembourg (FD Article 13, Par. 1a and Article 13, Par. 2). Furthermore, two more water bodies are included into the risk analysis.

The risk analysis is based on the inventory of potential assets (objects) within the flood areas (HQ10, HQ100 and HQextreme). The assets are split into different categories, such as "environment" or "people and damage to goods". If a predefined critical amount of assets is present within a flooding area, the water body is defined as area at risk.

Belgium (Wallonia):

Wallonia applied FD Article 13 for the first management cycle according to the FD, as, at that time, a flood risk map (1st issue 2007) already existed showing that the entire territory is prone to flood risk.
For the second cycle, Wallonia has made a preliminary assessment according to FD Article 4.
In this connection, historical floods with significant impact when occurring and which most probably will again occur in the future were selected. In this connection, Wallonia chose 1993 as pivotal year. Thus, all historic flood events which occurred before 1993 and are assessed as significant have been entered into a list together with their date of occurrence and a short description of the event and were included into the preliminary assessment. Historical floods after 1993 are described much more in detail, in particular, as far as the analysis of adverse consequences of these events are concerned. All in all, 12 flood events which occurred after 1993 were selected and analysed in detail.
Based on Article 4.2 (d) of the directive, Wallonia equally analysed future flood events and their potential consequences. As required by the directive, the effects of climate change and long-term spatial developments have been taken into account. For the analysis of potential adverse effects of future floods the map layer representing the extent of flooding areas for the scenario Qextreme has regionally been cross-matched with the sector plan, which is the most important tool for spatial planning in Wallonia[20].
The main objective of the sector plan is to determine land use at a scale 1/10,000, in order to secure a harmonic development of human activities and to avoid excessive use of space. Thus, long-term spatial development is comprehensively taken into account. As

[20] http://lampspw.wallonie.be/dgo4/site_amenagement/site/directions/dar/pds

already explained, the extreme scenario for flooding areas (Qextreme) takes into account climate change and is supposed to become the scenario for the 100 years return period by 2100. For surface runoff pathways on which discharge will concentrate, a 20 m buffer zone was applied.
The process leads to the following preliminary assessment for Wallonia: Since 1993, all 262 municipalities in the region Wallonia have experienced at least one flood event caused by floods along surface waters or by surface runoff. Thus, the 15 sub-basins in Wallonia are considered to be potential areas at risk.

Liechtenstein:

On the one hand, the assessment of flood risk is based on the national hazard mapping and the risk map derived thereof for inland waters and revised during 2015-2018, on the other it is based on the clarification of hazards related to the Alpine Rhine[21] initiated by the International Government Commission for the Alpine Rhine (IRKA).

Austria:

In Austria, the review and updating of the preliminary flood risk assessment for the 2nd cycle and the resulting identification of areas of potentially significant flood risk (APSFR) was accomplished in time. Apart from the linear identification of the APSFR, surface-related information is made available to the population based on the PFRA. In order to increase flood risk awareness, potentially affected persons in flood areas are represented for each municipality[22]. Apart from assessing fluvial floods leading to determining the APSFR, hazard indication maps were drafted for the process of pluvial floods (surface runoff) and published in order to create awareness. Based on improved data (run-off analysis, maps of hazard areas and register of buildings and housing), the number of APSFR rose from 391 (about 2700 km of water courses) to 416 (about 3000 km of water courses).

Switzerland:

Since 1991 there has been a legal obligation in Switzerland to draft a hazard mapping for floods (fluvial flooding, lake inundation), landslides, gravitational processes and avalanches (federal law and regulation on hydraulic engineering) and to take into account the resulting hazard maps in guidelines and land use planning as well as all related activities. Thus, basically all waters to be taken into account in the Rhine catchment area are to be classified as potential areas at risk except for those sections of water bodies which are in a natural state and along which damages can therefore not occur. This only applies to two comparatively short sections of the Anterior and Posterior Rhine in the canton Graubünden.
The report published in 2016, "Umgang mit Naturgefahren in der Schweiz" (Dealing with Natural Hazards in Switzerland) also includes information on the risk and damage potential with respect to floods determined on the basis of the risk and land use data available for Switzerland as a whole. About 20 % of the Swiss population is living in areas which might be flood prone. In these very areas, there are some 1.7 million or about 30 % of employments. In addition, about a quarter of the material assets (CHF 840 billion) are located in these areas. This confirms the former assessment that almost all municipalities in Switzerland are potentially affected by flood or debris flow hazards.

2.2. State of application of FD Article 4

In 2018, the following states or federal states have reviewed and if necessary updated the preliminary flood risk assessment carried out according to FD Article 4 in 2011 or the assessment and decisions according to Article 13, Par. 1 in the IRBD Rhine:

- The **Netherlands** have carried out the preliminary risk assessment for its entire territory in the Rhine river basin district for the first time.
- **Germany** has carried it out for its entire territory in the Rhine river basin district.
- **France** has carried it out for its entire territory in the Rhine river basin district.

[21] Hydrologie Alpenrhein, Juli 2000; Schadenrisiken und Schutzmaßnahmen im Alpenrheintal, Juli 2008
[22] https://www.bmnt.gv.at/wasser/wisa/fachinformation/hochwasserrisiko.html

- **Luxembourg** has carried it out for certain significant flood risk areas within its territory.
- **Belgium (Wallonia)** has carried it out for its entire territory in the Rhine river basin district**.**
- **Austria** has carried it out for its entire territory in the Rhine river basin district.
- **Liechtenstein** for its entire territory.
- **Switzerland:** Hazard maps are regularly reviewed within revisions of the guidelines and land use plans and are updated, if the hazard situation has considerably changed (e.g. due to protection measures or changes of the natural conditions).

3. Coordination based on FD Article 5, Par. 2 and identification of flood risk areas in the IRBD Rhine

3.1. State of Coordination and application of FD Article 5

The transboundary coordination of flood risk management is based on concrete work resulting from the international cooperation of the 9 states in the Rhine catchment. Some states of the Rhine catchment (France, Switzerland, Germany, Luxemburg and the Netherlands) are implementing the Action Plan on Floods (APF, 1995-2020)[23] which was adopted by the Conference of Rhine Ministers on 22 January 1998 and served as a model, when drafting the Floods Directive at EU level. Furthermore, by 22 December 2015, the first "Internationally coordinated Flood Risk Management Plan (part A: catchments > 2,500 km²) (FRMP) for the IRBD Rhine"[24] was drafted. As of 2016, the APF was further implemented within the first and eventually the second FRMP according to the Floods Directive and within the flood risk management plans of the states/federal states/regions. The FRMP of the IRBD Rhine describes the joint management of floods decided by the states in the IRBD Rhine in order to reduce eventual adverse consequences of floods on human health, the environment, cultural heritage and economic activities in the states.

The exchange of information and coordination takes place among the EU Member States (Germany, France, Netherlands, Luxemburg, Austria, Belgium (Wallonia)) in the IRBD Rhine and includes Liechtenstein and Switzerland. Annex 2 gives a closer description of the existing further bilateral, trilateral or multilateral organs at a regional level.

The updated survey map below (Chapter 3.2) represents the results of the exchange of information according to FD Article 4, Par. 3 in 2018 and the resulting coordination in the IRBD Rhine for the reporting criteria required by FD Article 5, Par. 2. Furthermore, Chapter 3.3 includes links to further detailed national information on areas at risk.

The survey map represents the areas of potential significant flood risk (APSFR) identified by the states in the IRBD Rhine according to **FD Article 5**. It shows that, based on the preliminary assessment or existing knowledge (red) for the main stream of the Rhine and its most important tributaries in the IRBD Rhine, part A, catchments > 2,500 km² most river sections present a **potential significant flood risk**.

In France, the following "**areas with significant flood risks**" (territoires à risques importants d'inondation – TRI[25]) have been identified):

– "Greater Strasbourg" (3 watercourses: Bruche[26], Ill, Rhine; flood risk area of significant flood risk and with consequences at a national level)
– "Greater Mulhouse" (Ill ad Doller[26])
– "Thionville - Metz - Pont-à-Mousson" (along the Moselle between Blénod-les-Pont-à-Mousson and the French-German-Luxembourgian frontier)
– "Pont-Saint-Vincent" (Madon[26])
– "Nancy - Damelevières" (Meurthe)
– "Epinal" (Moselle)

[23] https://www.iksr.org/en/international-cooperation/rhine-2020/action-plan-on-floods/
[24] https://www.iksr.org/en/floods-directive/flood-risk-management-plan/
[25] See list of municipalities concerned in the prefectural regulation „Arrêté S.G.A.R. n° 2012- 527" of 18 December 2012" (see link in chapter 3.3).
[26] Catchments < 2.500 km²

- “Saint-Dié – Baccarat” (Meurthe)
- “Saargemünd” (Sarre and Blies[26] in the border area to the Saarland)

In the Netherlands, the following “**areas of potential significant flood risk**” are identified according to FD Article 5:

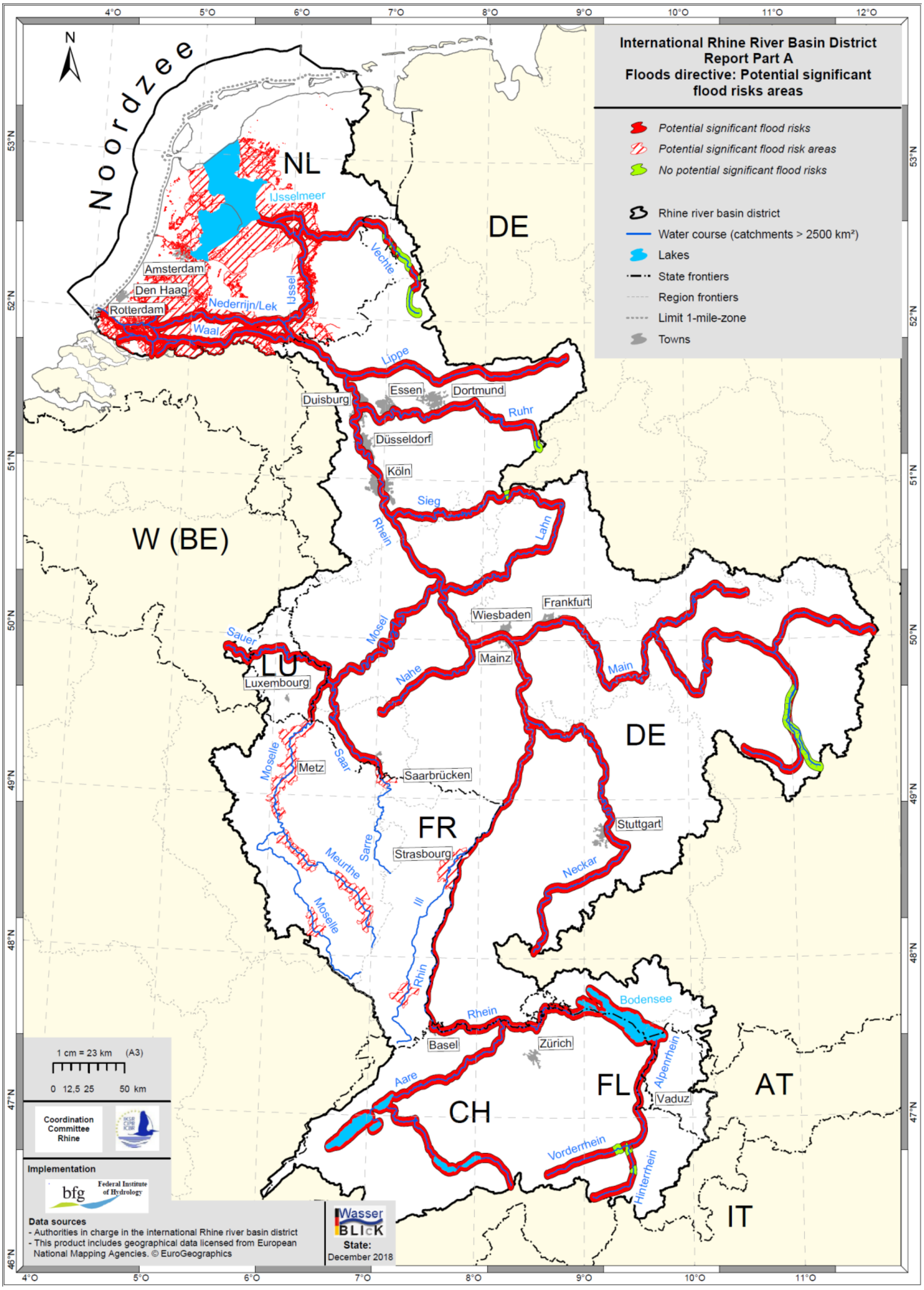
- Entire section of the main stream and its side arms in the delta (red)
- All areas protected against floods by (primary) protection structures which might be flooded by a flood of the main stream and its side arms or lakes connected to these ().

The map in Chapter 3.2 does not show the additionally designated areas which can exclusively be flooded from the sea in the coastal area of the Netherlands and by floods in regional water systems.

Only some rare sections of the Anterior and Posterior Rhine in Switzerland and shorter sections of Rhine tributaries do **not present any potential significant flood risk** (green).

3.2. Potentially significant flood risk areas

Survey map on the identification of potentially significant flood risk areas in the IRBD Rhine (part A, catchment > 2,500 km²)



3.3. Directory of detailed information on the preliminary flood risk assessment and identification of flood risk areas in the states[27] and federal states/regions

Netherlands
PFRA: https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/eu-richtlijn/voorlopige/
Maps: https://flamingo.bij12.nl/risicokaart-viewer/app/Risicokaart-openbaar
Plan: https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/eu-richtlijn/overstromingsgevaar/

Germany
LAWA: Recommendation for reviewing the preliminary evaluation of flood risk and flood areas according to the EU FD directive (as of the 2nd cycle)[28]:
http://www.lawa.de/documents/00_LAWA_Empfehlungen_vorl_Bewertung_HW_Risiko_a30.pdf
Baden-Württemberg
https://www.hochwasser.baden-wuerttemberg.de/gebiete-mit-signifikantem-hochwasserrisiko
Bavaria
http://www.lfu.bayern.de/wasser/hw_vorlaeufige_risikobewertung/index.htm
http://www.hopla-main.de
Hesse
http://hwrm.hessen.de/mapapps/resources/apps/hwrm/index.html?lang=de
Lower Saxony
http://www.hwrm-rl.niedersachsen.de
North Rhine-Westphalia
https://www.flussgebiete.nrw.de/vorlaeufige-bewertung-197
Rhineland-Palatinate
http://www.hochwassermanagement.rlp.de/servlet/is/391/
Saarland
http://www.saarland.de/74440.htm
Thuringia
http://www.thueringen.de/th8/tmlfun/umwelt/wasser/hochwasservorsorge/hochwasserrisiko_management/risikobewertung/

France
Preliminary assessment: http://www.grand-est.developpement-durable.gouv.fr/evaluation-preliminaire-des-risques-dinondation-r6726.html
Areas with significant flood risks: http://www.grand-est.developpement-durable.gouv.fr/les-12-tri-du-bassin-hydrographique-rhinmeuse-a15507.html

Luxembourg
http://www.waasser.lu; http://eau.geoportail.lu

Wallonia
Floods portal: http://environnement.wallonie.be/inondations/
Flood risk map: http://geoportail.wallonie.be/home.html

Austria
Publication of the implementation of the FD in Austria in the Water Information System Austria:
https://www.bmnt.gv.at/wasser/wisa/fachinformation/hochwasserrisiko.html
Vorarlberg / Report of the working area of Alpine Rhine / Lake Constance:
https://www.vorarlberg.at/pdf/koordinationsberichtbgalp.pdf

Liechtenstein
http://geodaten.llv.li/geoportal/naturgefahren.html
https://www.llv.li/#/12004/naturgefahren

Switzerland
www.bafu.admin.ch/gefahrenkarten; http://www.bafu.admin.ch/cartes-dangers;
http://www.bafu.admin.ch/carte-pericoli

[27] Since Switzerland and Liechtenstein are not members of the EU, they are not obliged to implement the Floods Directive.
[28] With a view to harmonising the approach within the "preliminary risk assessment" within Germany, a joint approach was coordinated in the LAWA. It is applied to the Rhine and its tributaries and is based on the results of the preliminary assessment 2011.

Annex 1 - "Guidance values for sensitivity" for floods (orientation values for possible adaptation measures)

Fields of action	Guidance value	Representative value	Relevant factor	Possible effects /scenarios (until 2050): Bandwidth (Basis for discussions on adaptation measures)
Flood risk management	**Level of protection/security**	**MHQ (in m^3/s)**	Lobith: 6,680 m^3/s (Dutch data)	+5% to +20%***
			Cologne: (MHQ year): 6,610 m^3/s MHQ (hydrological summer, May-Oct.): 4,000 m^3/s MHQ (hydrological winter, Nov. - Apr.): 6,510 m^3/s	0 to +20%
			Kaub: (MHQ year): 4,370 m^3/s MHQ (hydrological summer, May-Oct.): 3,240 m^3/s MHQ (hydrological winter, Nov. - Apr.): 4,260 m^3/s	-5 to +25%
			*Worms: (MHQ year): 3,480 m^3/s MHQ (hydrological summer, May-Oct.): 2,870 m^3/s MHQ (hydrological winter, Nov. - Apr.): 3,310 m^3/s	-4% to +8%***
			*Maxau: (MHQ year): 3,240 m^3/s MHQ (hydrological summer, May-Oct.): 2,850 m^3/s MHQ (hydrological winter, Nov. - Apr.): 2,980 m^3/s	-7% to +5%***
			*Basel: (MHQ year): 3,070 m^3/s MHQ (hydrological summer, May-Oct.): 2,880 m^3/s MHQ (hydrological winter, Nov. - Apr.): 2,520 m^3/s	-7% to +5%***
		HQ10 (in m^3/s)	Lobith: 9,500 m^3/s	+15% to +20%***
			Cologne: 8,870 m^3/s	-5% to +15%
			Kaub: 5,800 m^3/s	-15% to +15%
			Worms: 4,750 m^3/s	+7% (KLIWA)
			Maxau: 4,100 m^3/s	0% to +5% (KLIWA, 2014)
			Basel: 3,980 m^3/s	0% to +5% (KLIWA, 2014)
		HQ100 (in m^3/s)	Lobith: 12,700 m^3/s (BfG) - NL: 12,675 m^3/s	+15% to +20% (without submersion) and +10% (with submersion) (HQ100)
			Cologne: 12,000 m^3/s	0 to +20%
			Kaub: 8,000 m^3/s	-5 to +20%
			Worms: 6,000 m^3/s (without use of retention facilities: 6,300 m^3/s)	to +10% (KLIWA; for HQ 100 and HQ 200)***
			Maxau: 5,000 m^3/s (without use of retention facilities: 5,300 m^3/s)	+3% to +5% (KLIWA; for HQ 100 and HQ 200)***
			Basel: 4,780 m^3/s	+3% to +5% (KLIWA; for HQ 100 and HQ 200)***
		HQextreme (in m^3/s)	Lobith: 16,000 m^3/s	+15% to +20% (HQ1000) (without submersion) and +5% to +10% (HQ1000) (with submersion)***
			Cologne: 15,250 m^3/s (maximum consideration, no calculation value)	-5 to +25%
			Kaub: 10,400 m^3/s	-5 to +25%
			Worms: 7,600 m^3/s (maximum possible discharge without considering dike breaches)	-15% to +30% *(no KLIWA data available)* *
			*Maxau: 6,500 m^3/s (maximum possible discharge without considering dike breaches)	-20 to +35% *(no KLIWA data available)* *
			*Basel: 5,480 m^3/s (defined as HQ1000)	-20 to +35% *(no KLIWA data available)* *
	Navigation	**HSQ (in m^3/s) HSW (in cm or m)**	Lobith: 5,675 m^3/s	+15% to +20% (without submersion) and +10% (with submersion) (trends for HQ100)
			Cologne: 830 cm = 6,960 m^3/s	0 to +20% (trends for HQ100)
			Kaub: 640 cm = 5,100 m^3/s	'to +10% (KLIWA; for HQ 100 and HQ 200)***
			Worms: 650 cm = 4,310 m^3/s	to +10% (KLIWA; for HQ 100 and HQ 200)***
			Maxau: 750 cm = 2,800 m^3/s	+3% to +5% (KLIWA; for HQ 100 and HQ 200)***
			Basel to Rheinfelden: 2,500 m^3/s	+3% to +5% (KLIWA; for HQ 100 and HQ 200)***

Remark:
Luxemburg is not located along the main stream of the Rhine (no gauging stations indicated in the table above). All the same, certain adaptation measures have been carried out in water management.
NL (Lobith): HQextreme (in m^3/s) (according to Dutch statements, it is important to take HQextreme into consideration as a representative value): At Lobith, 6% are estimated for the increase of the relevant discharge by 2050.

*: For the gauges on the Upper Rhine at Basel, Maxau and Worms "no statement is possible" for possible climate effects on MHQ and HQextreme, as the bandwidth of modelling results is ≥ 50% and methodical deficits have been pointed out (see ICPR report no. 188, p. 17).
**: so far, the KLIWA project does not include any investigations for HQextrem
***: New data 2017 from KLIWA (DE + Basel) or KNMI14 2050 (NL) (see SG(2)17-09-02)

Legend:
HQ10: Flood discharges with a probability of occurrence once in 10 years (highly probable floods).
HQ100: Flood discharges with a probability of occurrence once in 100 years (floods with average probability of occurrence).
HQextreme: Discharge during extreme floods (floods with low probability of occurrence).
MHQ: Arithmetic average of the highest daily discharge values during homogenous periods of time (e.g. hydrological half-year periods) of the period under consideration.
HSW: highest water level (in m)
HSQ: Discharge during highest navigable water level

Sources:
Data for "Relevant factor": national data: Gauges in D: German delegation and BfG (Deutsches Gewässerkundliches Jahrbuch), Gauge in NL (Lobith): NL-Delegation, Gauge in CH (Basel): CH-Delegation

Data for "Possible effects /scenarios (until 2050)":
- ICPR report no. 188, 2011
- Results KLIWA project, state September 2014
- Results KLIWA project, state 2017 (DE + Basel) and KNMI14 2050 (NL) (see SG(2)17-09-02 and H(1)17-04-02)

Annex 2 - Collaboration and cooperation in sub-basins

The transboundary coordination in the sense of the FD is not only taking place within the ICPR (part A, catchments > 2,500 km²) but is also granted in sub-basins (parts B, C) based on bilateral/multilateral coordination and agreement. Specific reports describe how transboundary coordination was carried out in the sub-basins. The following organisations or commissions based on corresponding agreements confirm the long-lasting and close international cooperation - among others with respect to flood risk management - in the IRBD Rhine:

- Internationale Regierungskommission Alpenrhein (IRKA) (AT, CH, FL)
- Internationale Rheinregulierung (IRR) der gemeinsamen Rheinkommission (GRK) (AT, CH)
- Koordinierungsgruppe (Alpenrhein/Bodensee) der Internationale Gewässerschutzkommission für den Bodensee (IGKB) (AT, DE, CH, FL)
- Ständige Kommission für den Ausbau des Oberrheins zwischen Straßburg / Kehl und Lauterbourg / Neuburgweier (Permanent Commission of the Upper Rhine, The A-Committee is in charge of the sections upstream of Strasbourg) (FR, DE)
- Working Group Flood Protection and Hydrology (IH) of the International Commissions for the Protection of the Moselle and the Sarre (FR, DE, LU, Region Wallonia (BE))
- Permanent German-Dutch transborder river commission (DE, NL)
- German-Dutch Working Group Floods (DE, NL)
- International Working Group / Steering Group Delta Rhine (AGDR/SGDR) (DE, NL)