LAWA

**German Working Group on Water Issues of the Federal States and the Federal Government**

# Recommendations for the Establishment of Flood Hazard Maps and Flood Risk Maps

Adopted at the 139th LAWA General Meeting in Dresden on 25/26 March 2010

LAWA Permanent Committee on Flood Protection and Hydrology (LAWA-AH)

German Working Group on Water Issues of the Federal States and the Federal Government (LAWA)
LAWA Permanent Committee on Flood Protection and Hydrology (LAWA-AH)

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**List of Abbreviations**

| | |
|---|---|
| BauGB | Federal Building Code |
| FRM plan | Flood risk management plan |
| FRMD | Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (Flood Risk Management Directive) |
| IPPC Directive | Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control |
| LAWA | German Working Group on Water Issues of the Federal States and the Federal Government |
| ROG | Federal Regional Planning Act (*Raumordnungsgesetz*) |
| WFD | Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive) |
| WHG | Federal Water Act (*Gesetz zur Ordnung des Wasserhaushalts – Wasserhaushaltsgesetz*) |
| INSPIRE | Infrastructure for Spatial Information in the European Community |
| 1D | 1-dimensional |
| 2D | 2-dimensional |
| DTM | Digital terrain model |
| DLM | Digital landscape model |
| ATKIS | Official Topographic-Cartographic Information System |
| ALK | Automated Property Map |
| ALKIS | Cadastre Information System |
| Corine Land Cover | Coordinated Information on the European Environment |
| EEA | European Environment Agency |
| GIS | Geographic Information System |
| Habitats Directive | Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora |
| RGB colours | Red, green and blue colour model: an additive colour model in which these basic colours are added together in various ways to reproduce a broad array of colours. |
| CMYK colours | Cyan, Magenta, Yellow and Key Black. The CMYK colour model is a subtractive colour model which forms the technical basis for modern four-colour printing. |
| RR models | Rainfall-runoff models |

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## 1 Introduction

In its document *Instrumente und Handlungsempfehlungen zur Umsetzung der Leitlinien für einen zukunftsweisenden Hochwasserschutz* (Instruments and Policy Recommendations for the Implementation of the Guidelines for Forward-Looking Integrated Flood Protection) (LAWA 2004), published in 2004, the German Working Group on Water Issues of the Federal States and the Federal Government (LAWA) attaches considerable importance to flood hazard maps, noting that: “Every forward-looking flood protection strategy should include the preparation of flood hazard maps as an integral element of the requisite protection measures, for knowledge about potential hazards is essential for targeted preparedness for future flood events.” Some of Germany’s federal states (*Länder*) began as early as 1999 to produce flood hazard maps and relevant guidelines for their preparation (MUNLV 2003, MUV 2003, 2005), albeit with partly varying content and formats. This prompted LAWA to draw up its own joint Flood Hazard Map Guidelines, which were issued in 2006.

Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (FRMD) entered into force on 26 November 2007. The purpose of the Directive is to identify flood risks and improve preparedness for future flood events and flood risk management. The EU FRMD was transposed into German national law in 2009 by means of the amended Federal Water Act (*Gesetz zur Ordnung des Wasserhaushalts* (*Wasserhaushaltsgesetz*) – WHG), with the relevant provisions being identical to those of the Directive. References below to provisions of the FRMD therefore relate also to the binding provisions of the Federal Water Act as amended.

The FRMD requires the Member States to prepare flood hazard maps and flood risk maps. It contains binding provisions relating to the content of the maps, which must be completed and made available to the European Commission by the end of 2013. LAWA takes the view that the provisions of the FRMD are minimum requirements which must be fulfilled on a general basis.

The present Recommendations contain standards so that the process of establishing flood hazard maps and flood risk maps meets these minimum requirements set out in the FRMD. The aim is to ensure that the content and design of the maps are standardised as far as possible, thus ensuring that the set of maps produced has nationwide coherence. Some deviations may be necessary, however, in relation to the coordination process for international river basins.

Furthermore, there are numerous possible applications for flood hazard and flood risk maps, as is evident from the maps already produced in some of the federal states (*Länder*). The precise content of the maps depends on the intended use and is tailored to users’ requirements.

These Recommendations are a revised version of the Flood Hazard Map Guidelines issued by LAWA in 2006.

The Recommendations relate to flood caused by surface waters or influx of sea waters in coastal areas (as defined in Section 72 of the Federal Water Act (WHG)). They do not relate to the production of maps for other types of flood, such as inundation caused by heavy rainfall or rising groundwater, such as may be necessary for the implementation of the FRMD.

## 2 Provisions of the FRMD and its implementation in Germany

The FRMD requires the Member States to undertake a number of specific tasks, including the following actions, in accordance with various deadlines:

- To undertake a **preliminary flood risk assessment** in order to identify the areas/water bodies for which potential significant flood risks exist (risk areas). This assessment must be completed by the end of 2011.
- To produce **flood hazard maps and flood risk maps** for the risk areas. The maps provide information about the areas affected by flooding and the extent of the hazards and risks. These maps must be completed by the end of 2013.
- To establish **flood risk management plans** on the basis of the flood hazard maps and flood risk maps. They must be coordinated at the level of the river basin district or unit of management and must be completed by the end of 2015.

The FRMD requires implementation of the plans to be reviewed and if necessary updated every six years.

In order to comply with the provisions of the FRMD by the deadlines specified, it is recommended that each of Germany's federal states (*Länder*) designate a lead agency with responsibility for preparing the flood hazard and flood risk maps and initiating such preparation in a timely manner. The Directive's requirements concerning the content of the maps should be regarded initially as minimum requirements which must be fulfilled irrespective of potential users' other specific needs (see Chapter 6).

The flood hazard and flood risk maps and possible conclusions to be drawn from them will then also form part of the flood risk management (FRM) plans.

### 2.1 Flood hazard maps

The provisions of the FRMD relating to flood hazard maps are contained in Article 6(3) and (4) of the Directive:

Flood hazard maps must cover the geographical areas which could be flooded according to the following scenarios (paragraph 3):

- floods with a low probability, or extreme event scenarios,
- floods with a medium probability (likely return period ≥ 100 years),
- floods with a high probability, where appropriate.

For each scenario referred to, the following elements must be shown on the flood hazard maps (paragraph 4):

- the flood extent (area),
- water depths or water level, as appropriate,
- where appropriate, the flow velocity or the relevant water flow.

For coastal areas where an adequate level of protection is in place (paragraph 6) and for areas where flooding is from groundwater sources (paragraph 7), the preparation of flood hazard maps should be limited to the scenario with a low probability, or extreme event scenarios.

Flood events with a low probability are defined as events with a statistical return period much lower than 100 years.

Examples of **extreme event scenarios** include:

- failure of flood protection infrastructure,
- the joint occurrence of a flood event with a low probability of return in a coastal region (storm surge) and a fluvial flood event with a low probability of return, or
- the unfavourable combination of a flood event with a low probability of return in conjunction with a structural or other form of interference in the discharge, e.g. construction faults, bridge or outlet blockage scenarios, etc.

In coastal areas where adequate protection is in place, potentially adverse consequences are only to be anticipated in extreme event scenarios.

For the depiction of flood hazards, the following approach is recommended.

As frequent flood events can also have significant impacts, it is recommended that for inland waters, besides extreme flood scenarios and flood events with a return period of 100 years, a 10-year flood event (or similar event as agreed within the river basin district or unit of management) should be depicted. For each of these three scenarios, the flood hazard maps should show the water depth or level and, where appropriate based on the calculation procedure selected and the information yielded, the flow velocity (optional).

In areas of overlap between potential hazards from storm surge events and/or fluvial flood events, separate identification and joint depiction of the inundation areas are recommended for all scenarios. For these coastal areas, the flood scenarios with a medium probability (likely return period ≥ 100 years) and a high probability (10 years) should only be shown in relation to inland flood protection. For adequately protected coastal areas, the scenarios should be shown for information purposes.

The flood hazard maps depict the scenarios that could occur under current conditions. The use of up-to-date hydrological data means that climate change impacts which have already occurred are incorporated into the maps. Future trends, as far as they can be predicted, can be considered in the flood risk management plans.

## 2.2 Flood risk maps

Flood risk maps are prepared for the same flood scenarios on the basis of the flood hazard maps. They should show not only the flood hazards (extent of flooding) but also adverse consequences of flooding. The required information is specified in Article 6(5) of the FRMD:

- the indicative number of inhabitants potentially affected;
- type of economic activity of the area potentially affected;

- installations as referred to in Annex I to Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control which might cause accidental pollution in case of flooding and potentially affected protected areas identified in Annex IV(1)(i), (iii) and (v) to Directive 2000/60/EC;
- other information which the Member State considers useful such as the indication of areas where floods with a high content of transported sediments and debris floods can occur and information on other significant sources of pollution;
- optional: Article 6(5) of the FRMD makes no reference to the potential adverse consequences, identified in the preliminary flood risk assessment and flood risk management plans, for the cultural heritage. However, as these consequences are addressed in the flood risk management plan, it may be useful to include them in the flood risk maps.

More detailed specifications as to the map content are provided below, with minimum standards recommended for the basic data and a more differentiated approach to presentation.

### 2.3 Exchange of information

Pursuant to Article 6(2) of the FRMD, the preparation of flood hazard maps and flood risk maps for areas which are shared with other Member States is subject to prior exchange of information between the Member States concerned.

### 2.4 Publication

Pursuant to Article 10(1) of the FRMD, Member States are required to make the flood hazard maps and the flood risk maps available to the public. Publication of the maps is essential in order to raise flood awareness and ensure that measures to prepare for flood events are effective.

### 2.5 Reporting

Pursuant to Article 15(1) of the FRMD, Member States are required to make available the flood hazard maps and flood risk maps to the Commission for the first time by 22 March 2014. The “reporting sheets” being prepared at European level will determine the scope and format for this process. Based on experience with reporting under the Water Framework Directive (WFD), there are plans to set up a joint standardised data storage system that is compatible with INSPIRE as part of the “WasserBLICK” information and communication platform.

# 3 Recommendations for map production

## 3.1 Prerequisites for flood hazard map production

In order for flood hazard maps and the flood risk maps that are based on them to be successfully produced, certain technical and organisational criteria must be met. Technical criteria concern the development and compilation of data (hydrology, topography, roughness) that form the basis for the production of the maps, the choice and development of the computational model (1D, 2D or combinations) and data management arrangements. Recommendations relating to the organisational process (project management) for the production of the maps can be found in **Annex 2**.

### 3.1.1 Hydrology

For watercourses for which flood hazards are to be determined, flood discharges should be calculated and classified according to their probability. Discharges can be determined based on the available water depth and water velocity data, or on specific regional data. Thanks to the greater availability in recent years of basic hydrological data in digital format, rainfall-runoff models are coming into increasing use for flood discharge calculations. In this approach, discrete flood events and precipitation scenarios can be simulated on the basis of the available data and models, or long-term simulations with subsequent statistical analyses of extreme values can be carried out.

As up-to-date hydrological statistics are used for the flood hazard maps, climate change impacts that have taken effect to date are included in the data. Future trends will be taken into account in map revisions.

A specific “climate change” scenario is not included in the flood hazard maps. It may be useful to take possible future climatic changes into account in relation to specific engineering structures with a long life-cycle, but this requires case-by-case assessment and will not be shown on the maps. Climate change is generally factored into the depictions of extreme scenarios.

Flood discharges/storm surge levels should be determined and/or specified for the various probabilities /scenarios listed in **Section 2.1**.

For coastal areas in which flood hazards are to be depicted, storm surge levels should be determined through the evaluation of gauge levels and, if necessary, by using hydrodynamic models. For coastal areas where an adequate level of protection is in place, a maximal observation is all that is required in relation to an extreme event scenario.

In areas where fluvial flood events could potentially occur simultaneously with storm surge events, however, it may be necessary, when considering an extreme event, to include the impacts of such a joint occurrence in the marginal conditions of watercourse modelling.

### 3.1.2 Topography

For high-quality hydraulic calculation of flood hazard areas for inland waters, precise imaging of the topography of the watercourse bed (flux line) and embankment, including relevant engineering structures, is required. As a rule, digital terrain models (DTMs) should be used for the embankment, and ground surveying for the watercourse and engineering structures. All images should be clearly georeferenced.

Watercourse cross-sections, produced by means of ground surveying, are used to depict the flux line. They extend along the entire river bed and include embankments and sufficiently broad stretches of riverbank. Connecting points for the DTM must be available within the open terrain. The distance between the cross-sections should be selected in such a way as to ensure that changes of direction in the watercourse and significant changes in channel geometry are encompassed by the hydraulic calculations with sufficient accuracy, and should not exceed 200 m. The distance between the measuring points in the cross-section should be selected in such a way that the geometry of the watercourse bed can be shown with sufficient accuracy. It is recommended that a low-lying point or central point in the watercourse also be imaged. The imaging should generally take place using a tachymeter. In the case of smaller watercourses, a level may also be used. For very large or deep watercourses, an echosounder is often used.

In additional, hydraulically relevant engineering structures (weirs, bridges etc.) in and along the watercourse and large outlets (culverts) must undergo ground surveying. If dikes and walls cannot achieve sufficiently good resolution in the DTM, these structures must also undergo ground surveying.

Bank lines or upper edges of embankments are required to act as the interface between the embankment and flux line DTM. They can be represented together with the ground surveying of the cross-sections or can be derived from the cross-section data. It is also possible to derive the bank lines/upper edges of embankments from orthophotos or a DTM.

For the embankment and the coastal areas, a high-resolution DTM is required. The accuracy of the DTM has key influence on the results of watercourse hydraulics and the determination of the water depths in coastal areas. In recent years, the terrain models have generally been obtained using laser scanning overflights. However, they can also be produced from photogrammetric analysis of aerial photographs. The quality of the photos depends on mean altitude and position error. If possible, it is recommended that for the purposes of the DTM, a grid size of 2 m or less is used in order to achieve sufficient resolution in the representation of narrow linear terrain structures. Other hydraulically relevant terrain features or edges can be surveyed, in addition, as breaking edges.

### 3.1.3 Land cover

The roughness of the terrain surface crucially influences flow dynamics. Information on surface roughness is generally obtained from data on land cover, backed by accompanying statistics from relevant specialist literature. Pre-classified data can be obtained, for example, from the Official Topographic-Cartographic Information System (ATKIS) or the CORINE Land Cover data set available from the European Environment Agency (EEA). In embankment areas in particular, manual augmentation with orthophotos (widely available) is advisable. In general, the roughnesses should be adapted to local conditions, and in difficult areas, site inspections are essential. When using two-dimensional (2D) modelling, the building outlines can be integrated into the model, or depicted as roughnesses in the model.

### 3.1.4 Watercourse hydraulics

Hydraulic models are used to calculate water levels and flooding for discharges that are determined on the basis of hydrological calculations, as well as various possible models, depending on topography and watercourse type. One of the key model selection criteria is valley characteristics, i.e. the valley width and slope that are used to categorise the watercourse. In this regard, a basic distinction can be made between the following: (a) watercourses in high mountains, low mountains, and plains; (b) tidal estuaries; and (c) whether the watercourse is an open system without any flood control structures or a closed system with a flood control structure (dikes, flood protection walls, etc.).

The flooding models that are used for hydraulic simulations can be differentiated according to whether they are one dimensional/multidimensional, or steady/unsteady.

Flood hazard in open systems is largely determined by the watercourse level in situations where voluminous flood waves occur in relatively narrow valleys. Water velocity is also a factor, depending on watercourse descent and topographical slope. Conditions such as these mainly occur in high and low mountain regions, for which steady one-dimensional (1D) models are more suitable. In scenarios characterised by wider valleys and less steeply inclined slopes, as well as for the estuaries of larger watercourses, it must be determined whether (in view of the more complex flow characteristics involved such as meandering, and extensive embankments with substantial water velocity variation) a steady or unsteady 2D model will yield more useful results. For closed systems, i.e. those with a flood control structure, possible failure of flood protection systems, at several sites if appropriate, can be shown.

For the calibration of the models, it is essential to establish the peak water levels in past flood events, in order to ensure that the computations yield high-quality results. It is also helpful to check the (modelled) water levels against recorded gauge levels.

### 3.1.5 Hydraulics in coastal areas

Along watercourses, rainfall and valley characteristics, together with roughness, determine the inundation areas and water depths, whereas in coastal areas, the storm surge level and hence the potential inundation areas and water depths are determined by the storm event, the sequence of tides, surface water discharge in the estuaries, and the topography of the coastal foreland. In particular, low-lying areas along the North Sea coast are protected by flood control structures offering a high level of security. For these coastal areas where an adequate level of protection is in place, extreme event scenarios must be considered.

Depiction of an extreme event scenario is based on a maximal observation, e.g. by projecting the maximum water level occurring on the landward side of the flood control structure in the coastal area. Alternatively, appropriate hydrodynamic flood models can be used to determine projected water levels.

### 3.2 Prerequisites for flood risk map production

Flood risk maps should not only include flood hazard data, incorporated from the flood hazard maps; the required information specified in **Section 2.2** and described in more detail below should also be obtained and incorporated:

#### 3.2.1 Number of inhabitants potentially affected

The basic data are:

- number of inhabitants in each municipality (statistical data);
- land use data (ATKIS-DLM or ALK/ALKIS).

As a general rule, inhabitants' affectedness can be taken as a given if the inundation area overlaps with an area of housing or mixed use.

The indicative number of inhabitants potentially affected can be determined by assuming that the inhabitants of a municipality are evenly distributed throughout the specified areas. For those areas which overlap with inundation areas, the affected proportion of the total inhabitants within the municipality can then be calculated.

If detailed data are available on the number of inhabitants in the inundation areas, these data should be used in preference to the approximate method described above.

#### 3.2.2 Type of economic activity

The type of economic activity can be derived from the ATKIS-Basis-DLM object types. Its differentiation between land use types cannot usefully be replicated in full, so the individual areas, groups and types of object must be summarised in categories. Five categories are recommended, in addition to areas of water:

- housing and mixed use:
  These are areas where the residential population is concentrated (high monetary damage potential, considerable threat to life and limb);
- industrial and commercial areas, areas of a special functional character:
  These are areas where the working population is concentrated and where sensitive industrial and commercial objects are located (high monetary damage potential);
- all types of object of relevance to transport:
  These are areas of relevance to the transport infrastructure (major significance as emergency and evacuation routes);
- agriculture, forestry:
  These are areas used for agriculture and forestry in the broadest sense (low monetary damage potential);
- all other object types:
  Case-by-case assessment may be required (e.g. particularly high-value recreational facilities);

- all water-related object types:
  these are the objects from which the hazard emanates.

If available, data from the Automated Property Map/Cadastre Information System (ALK/ALKIS data) can also be used, offering greater accuracy. New land use data should only be incorporated in individual cases as necessary.

Flood damage potential is not determined or shown on the maps.

#### 3.2.3 Installations pursuant to Annex I of Council Directive 96/61/EC (IPPC Directive)

Installations of the types listed in Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control (IPPC Directive) that are located in inundation areas should be included on the maps. As the locations of IPPC sites are generally available as point data, case-by-case evaluation of affectedness is required for installations located close to the periphery of the inundation area.

#### 3.2.4 Protected areas identified in Annex IV(1)(i), (iii) and (v) to Directive 2000/60/EC

These are the bodies of water which, pursuant to Article 7 of the Water Framework Directive (WFD), are used for the abstraction of water intended for human consumption, bodies of water designated as recreational waters, including areas designated as bathing waters, and protected areas under the Habitats Directive and bird sanctuaries.

#### 3.2.5 Other information pursuant to Article 6(5d) of the FRMD

The inclusion of sites of particular cultural relevance in the flood risk maps is not a requirement of the FRMD. Such inclusion may, however, take place to the extent that objectives and measures to reduce adverse impact of flooding on the cultural heritage are to be specified in the flood risk management plans.

Other information which is considered useful, such as the indication of areas where floods with a high content of transported sediments and debris floods can occur and information on other significant sources of pollution, may also be included in the flood risk maps.

The information content of the flood risk maps can be expanded in accordance with local needs. For example, significant individual objects which may be at risk can be shown in more detail. Examples are hospitals, schools, infrastructure etc., as well as flood control structures, areas at risk from flooding, and bridges.

# 4 Recommendations for map design

The following recommendations are intended to facilitate the standardised design of the flood hazard maps and flood risk maps throughout Germany and should be followed unless the federal states (*Länder*) apply different procedures.

## 4.1 Data processing and map structure

Geographic Information Systems (GIS) should be used to collect, customise and update basic flood hazard and flood risk map data, as well as to produce the maps. These systems allow for the storage of vector, grid and other data, as well as joint management of spatial data and attributes. These data are to be archived without map sheet divisions or administrative boundaries and as far as possible are to be described in terms of the relevant meta-data, namely source, accuracy, scale, and date of last update.

In the interests of producing printed flood hazard maps that are easy to handle, DIN A0 should be the largest format used. Each map should meet basic cartographic standards and integrate the following elements, although the order may vary according to the federal states' own systems and layout:

- map title indicating the map content and its geographic region, preferably at the upper left;
- a legend in the upper right hand corner;
- scale and scale bar;
- a map overview, if possible;
- the following publication information: publisher, publication date, date of last update, author(s), copyright, map sources, and map approval.

Flood hazard maps in web-based cartographic information systems should be designed and realised without map sheet divisions of any kind, and should support continuous panning and zooming as well as displaying and hiding specific types of information, including specific scales. A maximum zoom-in percentage should be defined so as to avoid a false implication of accuracy. The basic information shown on the map's background should be to scale, and the map's publication information and legend should be shown in separate boxes.

There are now various examples of print-on-demand solutions which allow the user to select the map content, scale and size and then obtain a pdf version by e-mail which they can print out themselves.

## 4.2 Content design

### 4.2.1 Flood hazard map

In line with the provisions of the FRMD pertaining to flood hazard maps (see **Section 2.1**), it is recommended that for each scenario, the flood extent (area), water depths and where appropriate, the flow velocity or the relevant water flow each be shown in a separate map.

It is recommended that water depth be represented using the five-tone colour intensity scales shown in **Figure 1**, with variable colour tone and brightness. These scales allow for clear differentiation, both on paper and on screen, between the various depth categories, as well as between map and legend elements.

The FRMD does not require differentiated representation of systems without a flood protection structure, and systems with such a structure. Due to the partial variations in the treatment of areas behind and in front of flood protection structures under water law, however, the following approach is recommended: water depth should be shown in blue colour tones in open, i.e. unprotected systems and in yellow and red colour tones in closed, i.e. protected systems.

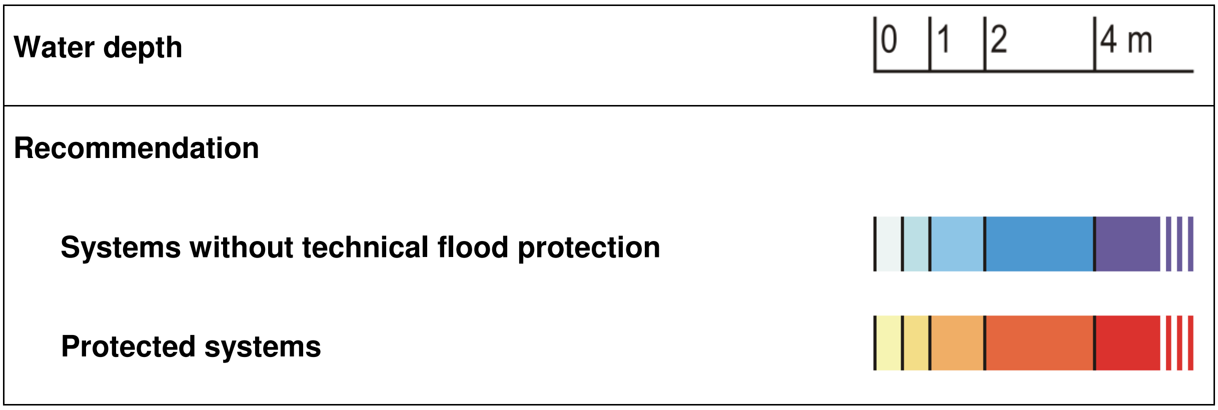



Figure1: Categories and colours for water depth intensity

The definition of category thresholds to show intensity is based on technical factors. The 0, 0.5, 1, 2, and 4 metre thresholds should be used to categorise water levels. More precisely defined categories may be useful in order to take account of regional characteristics, such as broad flat river meadows in valleys or extensive coastal lowland. Conversely, if steep slopes, dense concentrations of buildings, or high water velocities greatly limit the accuracy of water level calculations, less precisely defined categories can be used.

Besides water depth, water velocity (and direction) can also be shown. Depending on the intention, it is recommended that water velocities be shown using various sized arrows in up to three categories:

| | |
|---|---|
| < = 0.2 m/s | Not shown |
| > 0.2 - 0.5 m/s |  |
| > 0.5 - 2 m/s |  |
| > 2 m/s |  |

Figure 2: Depiction of water velocities

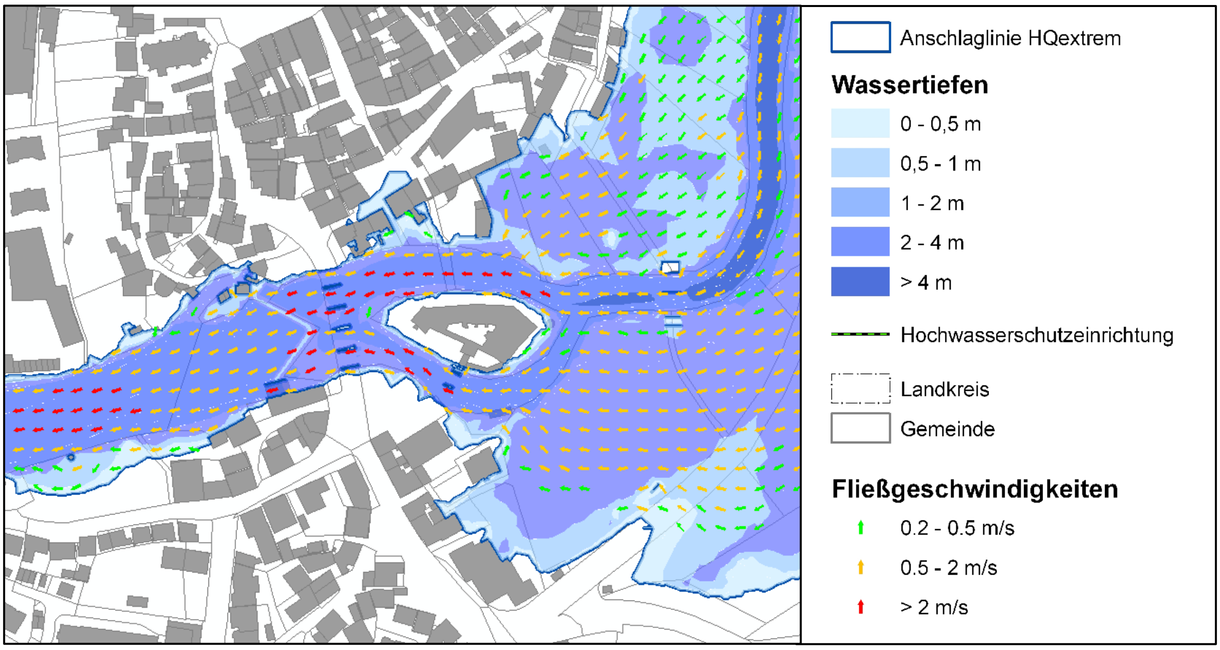



Figure 3: Map showing water velocity (excerpt)

In areas with flood control structures and in coastal areas, the flood protection systems should also be shown.

In order to ensure standardised presentation, the colour values to be used are specified in **Annex 1**.

### Example

The following example of a flood hazard map, whose layout is based on the above recommendations, meets the requirements of the FRMD:

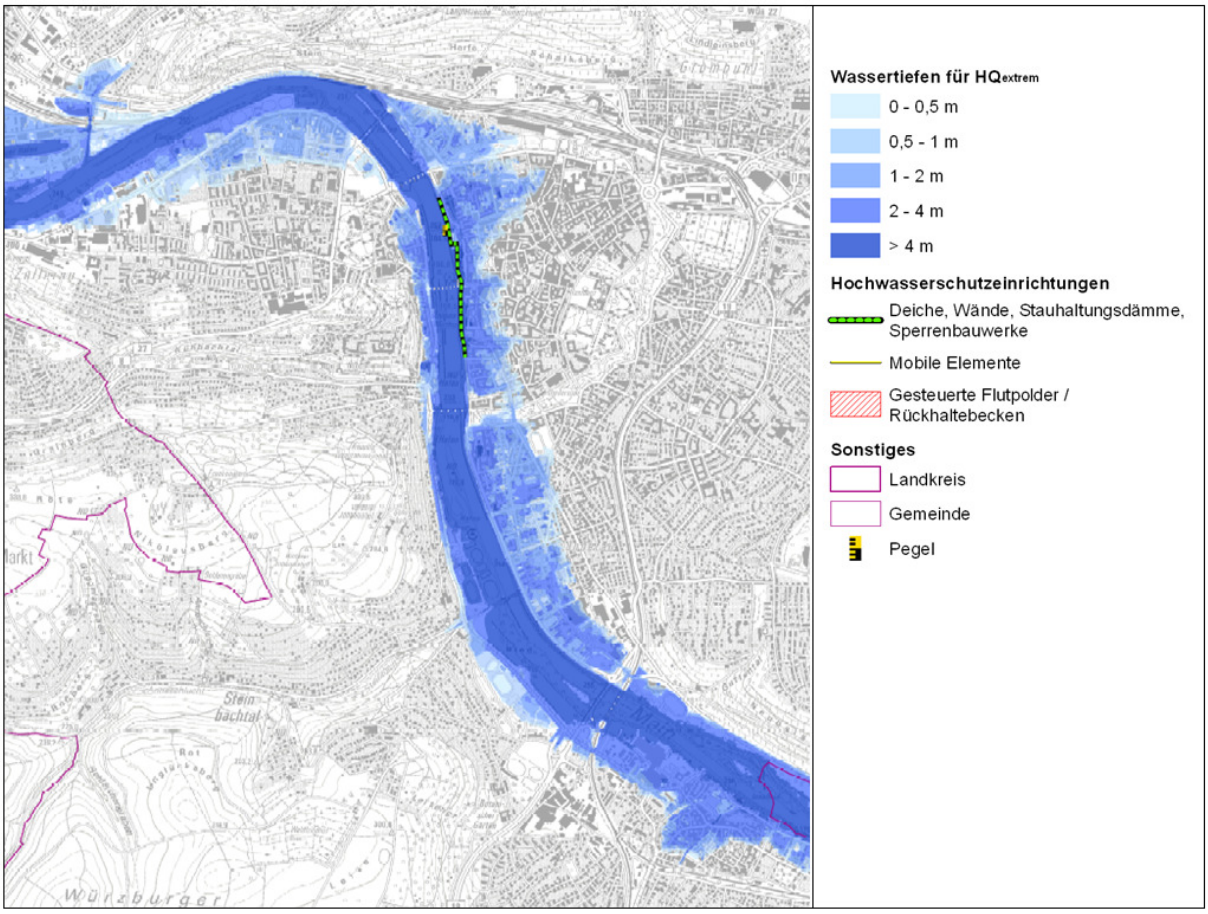



Figure 4: Example of a flood hazard map, $HQ_{extrem}$ (excerpt)

### 4.2.2 Flood risk maps

The flood risk maps include not only the extent of the inundation areas, incorporated from the flood hazard maps, but also other diverse area and point information. For each return period considered, the preparation of a separate flood risk map is recommended. Alternatively, all three scenarios can be depicted on one map. The following specific information should be included:

<u>Number of inhabitants potentially affected</u>

The number of inhabitants potentially affected is shown by means of a symbol, a numeral (rounded up or down) and the name of the municipality, or, in the case of greater spatial differentiation, the contiguous residential area. The number derived is then assigned to a category.

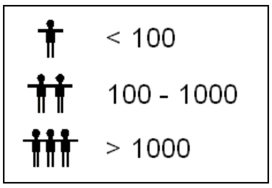



Figure 5: Symbol showing the number of inhabitants potentially affected.

Type of economic activity

The type of economic activity can be depicted using the available ATKIS or ALK/ALKIS data and the classification scheme outlined in **Figure 6**. The map should only show areas affected by flooding.

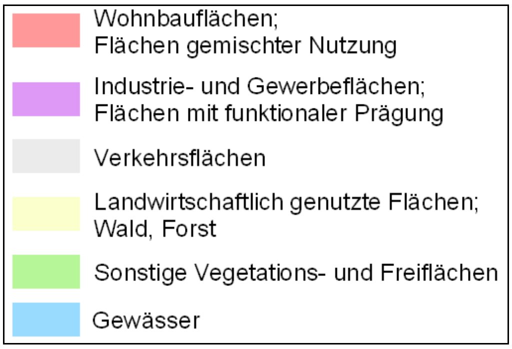



Figure 6: Scheme for the depiction of types of economic activity

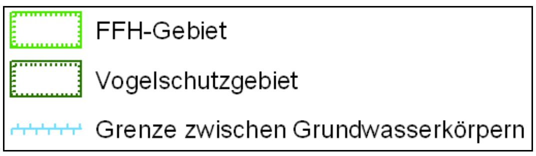
Installations as referred to in Annex I to Council Directive 96/61/EC

Locations of IPPC installations are shown using symbols. The map should only show installations affected by flooding.

Figure 7: Symbol used to depict an IPPC installation

Potentially affected protected areas

Protected areas (protected areas under the Habitats Directive, bird sanctuaries and the bodies of water specified in Article 7(1) of the Water Framework Directive) are shown by means of outlining in various colours. Potentially affected recreational waters and bathing waters should be highlighted when depicting the topography and clearly labelled. The depiction of the protected areas should include their full extent in order to improve the readability of the map, especially when the inundation areas are small in size.




Figures 8: Outlining should be used to show protected areas

Figure 9: Symbol to show bathing waters

<u>Cultural sites</u>

If sites of cultural relevance are to be shown, the following symbols may be used:

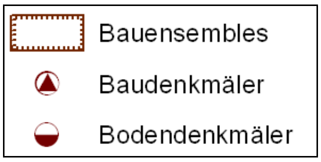



Figure 10: Symbols showing cultural sites

### Example

The following example of a flood risk map, whose layout is based on the above recommendations, meets the requirements of the FRMD:

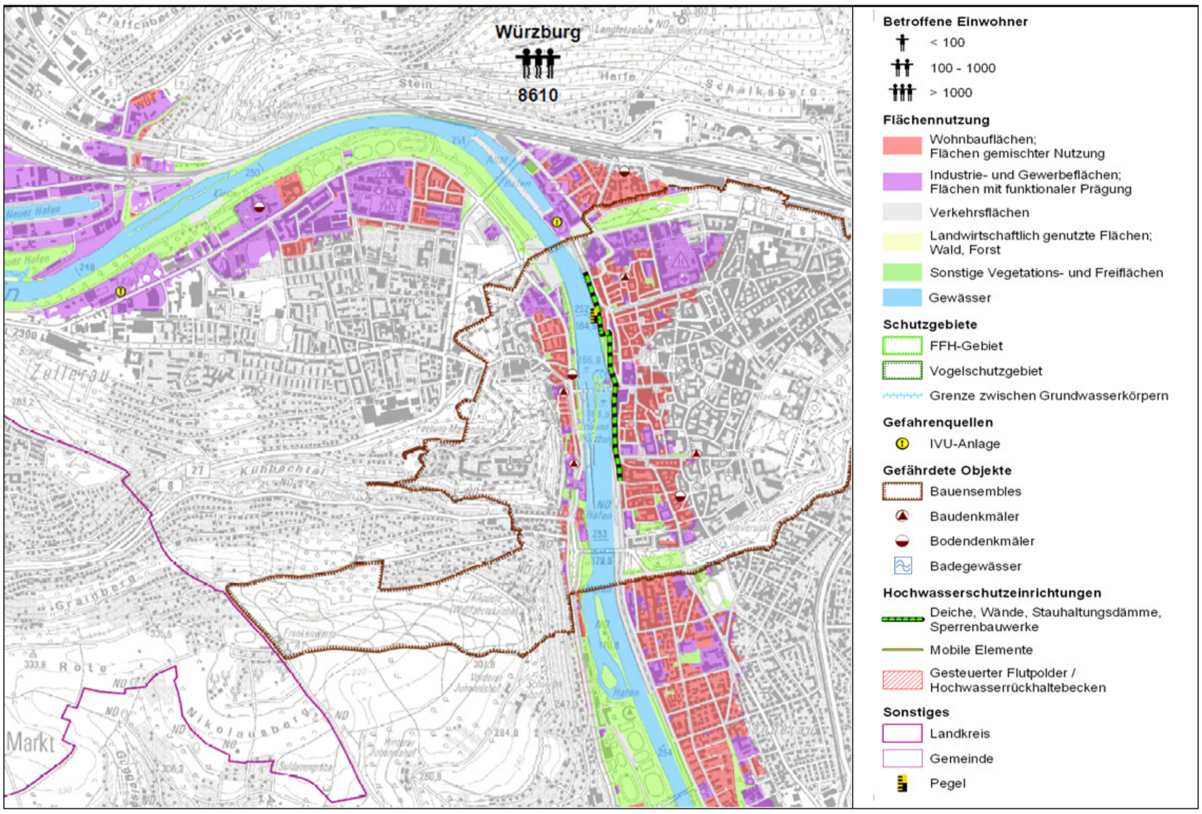



Figure 11: An example of a flood risk map $HQ_{extrem}$ (excerpt)

### 4.2.3 Map scales

Flood hazard maps and flood hazard zone maps should preferably be produced with a scale of 1:2,500 up to 1:10,000. An increase in scale above 1:25,000 is also possible with the inclusion of information from ALK/ALKIS.

If maps are reduced to a scale of 1:25,000 or less, a generalisation process must be carried out.

## 5 Publicity

In accordance with Article 10(1) of the FRMD, Member States are required to make the flood hazard maps and the flood risk maps available to the public. The Internet is a suitable medium for this purpose. Examples from the individual German federal states (*Länder*) can be accessed via the link to the information platform in Chapter 7.

However, not all population groups can be reached via the Internet, so other distribution channels must be identified. For various options for disseminating the maps, please refer to LAWA's document *Instrumente und Handlungsempfehlungen zur Umsetzung der Leitlinien für einen zukunftsweisenden Hochwasserschutz* (Instruments and Policy Recommendations for the Implementation of the Guidelines for Forward-Looking Integrated Flood Protection) (LAWA 2004). Traditional distributional channels, such the displaying of the flood hazard maps and flood risk maps in or at public buildings or at other locations much frequented by the public, should also be utilised.

Via flood partnerships and stakeholder forums (advisory councils etc.), a variety of topics can be brought to the attention of the various target groups at regular events on a river basin-specific basis. The introduction of the hazard and risk maps into the partnerships has proved its worth.

## 6 Potential flood hazard and flood risk map users

The flood hazard maps and the flood risk maps form part of the flood risk management plans to be produced under the FRMD. The conclusions drawn from the maps should serve as a basis for the formulation of appropriate objectives and measures.

In managing the impacts of flood events, solidarity-based cooperation between the various specialised disciplines has proved its worth. Similarly, this cooperation has a key role to play in the establishment and implementation of flood risk management plans.


Figure 12: Policy areas of relevance to flood risk management

The policy areas shown in Figure 12 are involved as relevant sectors and stakeholders in the establishment of the flood risk management plans:

### Water management

They raise awareness of flood hazards and flood risks in advance of a flood event and provide up-to-date flood information and forecasts. Depending on the specific arrangements in place in the federal states (*Länder*), these agencies are responsible for technical and infrastructural flood protection along watercourses as well as for developing, technical monitoring and, if appropriate, regulating measures to improve water retention in the catchment and floodplains.

The water management agencies of the federal states (*Länder*) use flood hazard maps and flood risk maps for a variety of purposes. They can, for example, be used as a basis for the following:

- developing and prioritising plans for flood protection and coastal protection,
- planning the reactivation of existing water retention areas,
- decisions in proceedings under water law,
- formulating the relevant policies,

- developing guidelines for handling substances that pose a risk to water resources, by mapping at-risk areas,
- identification of floodplains,
- answering questions from the general public.

**Spatial planning**

Within the framework of spatial planning, a key task is to keep inundation areas free from adverse types of use. In the regional spatial plans, areas for flood retention and flood protection (with prevention being one of the aims of regional planning) are designated as Priority and Reserve Areas (*Vorranggebiete und Vorbehaltsgebiete*) and mapped. Observance of these designations is mandatory for area development planning at municipal level (Section 1(4) of the Federal Building Code). Besides their function in flood retention and flood protection, these areas can also be assigned appropriate uses which are compatible and in no way conflict with flood protection.

The flood hazard maps can serve as the basis for the designation of the Priority Areas and Reserve Areas based on the information contained in the maps concerning:

- statistical probability of flooding*:* flooding recurrence/flood frequency, and
- intensity, as measured by water depth, water velocity etc.

**Building law/local planning**

By taking account of flood hazards, building planning law and building regulations and the local planning and decision-making based on them can make a key contribution to damage reduction. Rules on damage reduction can be introduced, in particular, by incorporating relevant criteria into area development plans and building regulations.

Flood hazard and flood risk maps can serve as a basis for the following within the framework of land use plans:

- best practices for urban development;
- land use management;
- protective measures for buildings.

Technical information from the water management sector should be factored into local planning processes. As far as possible, measures aimed at reducing and avoiding flood damage should be implemented.

The maps provide information that can enable communities and potentially affected persons, e.g. property owners and residents, businesses and other stakeholders, to do the following:

- identify and assess the relevant risks,
- implement safeguards against flooding, and
- take prompt and effective action in the event of flooding.

**Disaster and emergency planning**

These agencies are responsible for developing operational plans on the basis of strategies and for making the organisational and technical preparations to assist affected persons in the event of a flood, minimise the damage sustained by them, and protect the environment as far as possible. The resources required for this purpose must be kept at the ready and the emergency response practised.

Flood hazard maps provide information concerning flood conditions and extent (water depth, water velocity) in a specific area, and thus allow for effective planning and implementation of strategic action plans for specific scenarios. Specific analyses of data sets comprising an amalgamation of flood hazard map information and additional empirical data allow for the following:

- hazard identification,
- optimised use of human and material resources,
- identification and optimisation of evacuation routes,
- identification of the need for additional flood barriers (horizontal structures) and secondary lines of defence against floods so as to avoid or delay the inundation of other areas when primary flood barriers fail.

Flood hazard maps also provide emergency personnel with an overview of flood scenarios during scheduled flood/disaster control procedure exercises, and form the basis for the realisation of these exercises.

**Insurers**

Insurers need precise and accurate flood hazard and flood risk information in order to define realistic premiums for flood damage insurance. Flood hazard maps can be used to validate the flood hazard zone classification system (ZÜRS) as defined by the German insurance industry association *Gesamtverband der Versicherungswirtschaft* (GdV). Hazard maps that provide flood intensity information are a vast improvement over the simple zone maps used to date.

**Nature conservation**

With their planning, area conservation and other instruments and support programmes, nature conservation agencies can help to increase water retention in the catchment and in floodplains. Flood hazard maps provide relevant information here.

**Agriculture and forestry**

Adapted management of agricultural areas, e.g. by means of a conservative approach to soil cultivation or the creation of grassland instead of cropland, together with natural forest development and afforestation, can increase water retention in the catchment. Flood hazard maps provide relevant information here.

**Stakeholders affected by flooding**

Flood hazard and flood risk information is indispensable to determine which measures are needed for effective flood protection and to provide the general public and businesses with relevant information.

If flood hazard and flood risk maps are distributed efficiently, they can greatly improve awareness of flood risks. The information contained in the maps enables all stakeholders – from property owners and residents to corporate decision makers – to make sound decisions for construction planning, building protection, action plans and other precautionary measures. Flood hazard maps provide affected residents and businesses with the basis for the following:

- precautionary behaviour/flood preparedness (information channels, escape routes and evacuation),
- precautionary measures for buildings through adapted use and the use of construction materials in a manner that safeguards buildings against floods, and proper storage of water-hazardous substances,
- protection of buildings (e.g. use of door and window seals).

# 7 Link to the information platform with examples from the federal states (*Länder*)

The stage reached in the preparation of flood hazard and flood risk maps in the federal states (*Länder*) varies. The information platform

www.wasserblick.net

provides information about the approaches being adopted in the various federal states. The platform contains links to relevant Internet sites operated by the *Länder* which contain the flood hazard and flood risk maps, as well as to Internet map services.

## 8 References

Bund/Länderarbeitsgemeinschaft Wasser LAWA (2004): Instrumente und Handlungsempfehlungen zur Umsetzung der Leitlinien für einen zukunftsweisenden Hochwasserschutz, Düsseldorf

Empfehlungen der Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA) zur Aufstellung von Hochwasser-Gefahrenkarten, Mainz

Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA) (2008): Strategie zur Umsetzung der Hochwasserrisikomanagement-Richtlinie in Deutschland, Saarbrücken

Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA) (2009): Vorgehensweise bei der vorläufigen Bewertung des Hochwasserrisikos nach EU-HWRM-RL (unveröffentlicht), Saarbrücken

Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA) (2010): Strategiepapier „Auswirkungen des Klimawandels auf die Wasserwirtschaft" -- Bestandsaufnahme und Handlungsempfehlungen

Merz, B, und M. Gocht (2003): Karten für die Hochwasservorsorge und das Risikomanagement auf der lokalen Skala. Hydrologie und Wasserbewirtschaftung 47/2003 H. 5, S 186 - 194

Ministerium für Umwelt- und Naturschutz, Landwirtschaft und Verbraucherschutz des Landes Nordrhein-Westfalen MUNLV Hrsg. (2003): Leitfaden Hochwasser-Gefahrenkarten. Düsseldorf.

Ministerium für Umwelt und Verkehr, Innenministerium und Wirtschaftsministerium Baden-Württemberg (MUV) (2005): Hochwassergefahrenkarten in Baden-Württemberg. www.hochwasser.baden-wuerttemberg.de

## Annex 1

## Colour values for the realisation of standardised designs of flood hazard and flood hazard zone maps (recommended)

### Flood hazard maps

| RGB and CMYK colour values | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Topic** | **Element** | **Colour intensity** | **RGB colours** | | | **CMYK colours** | | | |
| | | | **R** | **G** | **B** | **C** | **M** | **Y** | **K** |
| Depth categories and colouration | Open systems | 0 – 0.5 m | 204 | 236 | 255 | 20 | 7 | 0 | 0 |
| | | 0.5 – 1 m | 153 | 204 | 255 | 40 | 20 | 0 | 0 |
| | | 1 – 2 m | 102 | 153 | 255 | 60 | 40 | 0 | 0 |
| | | 2 – 4 m | 61 | 102 | 255 | 76 | 60 | 0 | 0 |
| | | > 4 m | 0 | 51 | 204 | 100 | 80 | 20 | 0 |
| | Closed systems | 0 – 0.5 m | 255 | 255 | 150 | 0 | 0 | 41 | 0 |
| | | 0.5 – 1 m | 255 | 255 | 0 | 0 | 100 | 0 | 0 |
| | | 1 – 2 m | 255 | 198 | 28 | 0 | 22 | 89 | 0 |
| | | 2 – 4 m | 255 | 160 | 28 | 0 | 37 | 89 | 0 |
| | | > 4 m | 204 | 68 | 0 | 20 | 73 | 100 | 0 |
| Velocity categories and coloration | | 0.2 – 0.5 m/s | 0 | 255 | 0 | 100 | 0 | 100 | 0 |
| | | 0.5 – 2 m/s | 255 | 204 | 0 | 0 | 20 | 100 | 0 |
| | | > 2 m/s | 255 | 0 | 0 | 0 | 100 | 100 | 0 |

### Flood risk maps

| RGB and CMYK colour values | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Topic** | **Colour intensity** | **RGB colours** | | | **CMYK colours** | | | |
| | | **R** | **G** | **B** | **C** | **M** | **Y** | **K** |
| Type of economic activity | Housing … | 255 | 0 | 0 | 0 | 100 | 100 | 0 |
| | Industry … | 169 | 0 | 230 | 34 | 100 | 10 | 0 |
| | Transport | 204 | 204 | 204 | 0 | 0 | 0 | 20 |
| | Agriculture/Forestry | 244 | 255 | 128 | 4 | 0 | 50 | 0 |
| | Other | 118 | 255 | 0 | 54 | 0 | 100 | 0 |
| | Water bodies | 0 | 163 | 255 | 100 | 36 | 0 | 0 |
| Protected area | Habitats Directive | 76 | 223 | 0 | 70 | 13 | 100 | 0 |
| | Bird sanctuary | 38 | 115 | 0 | 85 | 55 | 100 | 0 |
| | Groundwater body | 115 | 223 | 255 | 55 | 13 | 0 | 0 |

## Annex 2

## Work process for the production of flood hazard und flood risk maps for inland waters

The compilation of flood hazard maps for multiple river basins or an entire federal state (*Land*) requires an efficient and professional project management team, which should be defined before the project gets under way and should assume responsibility for all project management and quality assurance processes.

It is recommended that flood hazard map projects be structured and implemented as described in the working steps below:

### Phase 1: Scenario definition / needs analysis

Define responsibilities in the water catchment

Plan public information measures, as well as ways to involve the public

Examine and evaluate existing maps and other documentation.

> Available data concerning watercourse networks, watercourse cross-sections, river basin studies (rainfall-runoff models), and water surface profiles should be used, provided that they are of sufficient quality and are up-to-date. Experience has shown that the incorporation of existing information – particularly survey data – can be an extremely complex process and may cause delays. In many cases, it is more beneficial to carry out new surveys which generate up-to-date data which can be incorporated into the overall project without further processing.

Define the relevant reaches of watercourses

> Flood hazard and flood risk maps are produced for those reaches of watercourses for which the preliminary flood risk assessment has identified potential significant flood risks (risk areas). It is also important to clarify whether flood hazard and or flood risk maps should be produced for other water bodies. As a general principle, it is sensible to produce hazard maps for entire water bodies/watercourse sections. However, for financial reasons, different levels of quality may apply. Flood hazard maps for the source areas of rivers are of little practical use since flood hazards are the main criteria for producing such maps. The farthest upstream point of the watercourse, or a minimum catchment area (e.g. 10 $km^2$), should be defined.

Identify data gaps

Determine the extent of the required data collection activities

Estimate cost and efforts for data collection

Draw up a description of project tasks.

Determine marginal conditions, such as the need to take account of freeboard at flood control structures or closed systems, and technical standards.

> These documents should then be integrated into the performance specifications for the subsequent project phases.

**Phase 2: Topography**

Create DTM

Create terrain models on the basis of photogrammetric analyses of aerial photographs, or using laser scanning data.

Carry out ground surveys

Produce performance specifications with a standardised data model

Ensure coordination between the surveyor and the hydraulic engineer. The hydraulic engineer and surveyor jointly define the number and location of cross-sections required for the hydraulic simulations.

Survey the watercourse, i.e. the watercourse cross-sections and banks, excluding embankment

Survey engineering structures in and on the watercourse

Submit the surveying data to the hydraulic engineer

Modify terrain models.

**Phase 3: Hydrology**

Describe basic approach, with topics such as:

Unsteady data,

Provision of basic data,

Consideration of existing flood retention basins,

Overlapping of flood probabilities at river mouths,

Detailed specifications for hydrological calculations,

Safeguarding comparability.

**Phase 4: Hydraulics**

Coordinate and check survey data

Append embankments from the digital terrain models to the watercourse cross-sections

Incorporate the available documentation

Revise DTM relating to the watercourses and hydraulically relevant structures that have not been imaged.

Carry out hydrological calculations as needed (see **Section 3.1.1**)

Carry out hydraulic calculations – water profiles – as needed (see **Section 3.1.4**)

If one-dimensional hydraulic models are used, intersect water profiles with terrain model

Determine water levels

Produce a plausible margin line and delete implausible islands

Hydraulic engineer produces and submits the defined data results.

Produce draft maps.

**Phase 5: Data collection for the flood risk maps**

Incorporate population figures (e.g. by municipality)

Incorporate and categorise land use types, with collection of new data/corrections in individual cases if necessary

Identify areas where inhabitants are concentrated

If necessary, determine mean population density (e.g. by municipality)

Identify flood risk areas where population is distributed

Calculate the number of inhabitants potentially affected by flooding

Remove risk areas from classified land uses

Incorporate locations of IPPC sites and exclude installations at risk of flooding

Incorporate protected areas

Produce maps

**Phase 6: Map production**

The production of flood hazard and flood risk maps requires not only extensive cartographical skills but also a sufficiently large infrastructure for the processing and presentation of geographical and specialist data and information. As the production of the maps is also subject to deadlines under the FRMD, as a rule, some map project work may have to be outsourced to specialised providers, with appropriate division of the process into phases (lots). Central project management is recommended.

This phase of work comprises:

The production of flood hazard maps according to the layout specifications (see Section 4)

Follow-up data storage and management.

**Phase 7: Publicity**

Initiate and implement the publicity measures defined jointly with the client, e.g. as part of the process to establish flood risk management plans.

In some of Germany's federal states, substantial experience has already been gained with work on flood hazard and flood risk maps. The information platform www.wasserblick.net provides up-to-date information and contact addresses, if required.

**Annex 3:**

**Glossary**

This glossary lists the key terms that are used in connection with flood hazard and flood risk mapping. An explanation of the the basic terminology can be found in the relevant statutory standards such as DIN 2425, Parts 5 and 6.

Closed system: Refers to an area with a protective structure such as a dike, fixed/mobile protective wall.

Coastal waters: The sea between the coastline at average high tide or the limit of above-ground water flowing towards the sea, and the borders of coastal waters; the German federal states (*Länder*) determine the limit of bodies of water that are above ground flowing towards the sea, and that are not inland waterways under the jurisdiction of the German Federal Government.

Flood: The temporary inundation of land not normally covered by water by surface waters or influx of sea waters in coastal areas (as defined in the Federal Water Act (*Gesetz zur Ordnung des Wasserhaushalts* (*Wasserhaushaltsgesetz*) – WHG).

Flood risk: The combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event (WHG).

Intensity: A neutral term that is used as required to describe various physical attributes of a destructive event. For flooding, these attributes are classified according to relevance as follows: water depth, water velocity, the arithmetic product of water level and velocity, duration, rate of rise, transport of sediment and pollutants (Merz and Gocht 2003).

Priority Areas are area categories that are used in regional planning and that form the basis for the definition of usage priorities for specific areas. Pursuant to § 7(4) and § 4(1) of the Regional Planning Act (ROG), Priority Areas constitute "regional planning objectives" and thus are no longer subject to assessment. Buildings or functions in flood control or disaster protection priority areas are prohibited by law, insofar as they could sustain flood damage or impair flood control measures.

Reserve Areas: Pursuant to § 7(4) and § 3, no. 3 of the Regional Planning Act (ROG), Reserve Area is a regional planning category that defines assessable requirements for future assessment or discretionary decisions made by government agencies in connection with land use planning and the attendant measures. In contrast to Priority Areas, in Reserve Areas land use measures can be implemented insofar as the attendant planning processes take flood control structures into account.

River basin district: The area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters, which is identified under Article 7(5), second sentence of the Federal Water Act (WHG) as the main unit for management of river basins.

Sub-basin: The area of land from which all surface run-off flows through a series of streams, rivers and, possibly, lakes to a particular point in a watercourse.

**<u>Code</u>**

**Figure 3** (see page 18)

Anschlaglinie = Inundation boundary

Wassertiefen = Water depths

0 – 0.5 m

0.5. – 1 m

1 – 2 m

2 – 4 m

>4 m

Hochwasserschutzeinrichtung = Flood control structure

Landkreis = Rural district

Gemeinde = Municipality

Fließgeschwindigkeiten = Flow velocities

0.2 – 0.5 m/s

0.5 – 2 m/s

> 2 m/s

**Figure 4** (see page 19)

Wassertiefen für = Water depths for ...

0 – 0.5 m

0.5. – 1 m

1 – 2 m

2 – 4 m

>4 m

Hochwasserschutzeinrichtungen = Flood control structures

Deiche, Wände usw. = Dikes, walls, dams, barrages

Mobile Elemente = Mobile elements

Gesteuerte Flutpolder, Rückhaltebecken = Managed polders, retention basins

Sonstiges = Other

Landkreis = Rural district

Gemeinde = Municipality

Pegel = Gauge

**Figure 6 (**see page 20)

Wohnbau ... = Areas of housing and mixed use
Industrie ... = Industrial and commercial areas, areas of a special functional character
Verkehrs ... = Objects of relevance to transport
Landwirtschaft ... = Agricultural areas, forestry
Sonstige ... = Other areas with vegetation, open spaces
Gewässer = Water bodies

**Figure 8** (see page 20)

FFH-Gebiet = Protected area under the Habitats Directive
Vogelschutzgebiet = Bird sanctuary
Grenze ... = Boundary between groundwater bodies

**Figure 10** (see page 21)

Bausensemble = Buildings
Baudenkmäler = Monuments
Bodendenkmäler = Archaeological site

**Figure 11** (see page 21)

Betroffene Einwohner = Number of inhabitants potentially affected
Flächennutzung = Land use
Wohnbau ... = Areas of housing and mixed use
Industrie ... = Industrial and commercial areas, areas of a special functional character
Verkehrs ... = Objects of relevance to transport
Landwirtschaft ... = Agricultural areas, forestry
Sonstige ... = Other areas with vegetation, open spaces
Gewässer = Water bodies
Schutzgebiete = Protected areas
FFH-Gebiet = Protected area under the Habitats Directive
Vogelschutzgebiet = Bird sanctuary
Grenze ... = Boundary between groundwater bodies
Gefahrenquelle = Source of hazard

IVU-Anlage = IPPC installation

Gefährdete Objekte = Objects at risk

Bauensemble = Buildings

Baudenkmäler = Monuments

Bodendenkmäler = Archaeological site

Badegewässer = Bathing waters

Hochwasserschutzeinrichtungen = Flood control structures

Deiche, Wände usw. = Dikes, walls, dams, barrages

Mobile Elemente = Mobile elements

Gesteuerte Flutpolder, Rückhaltebecken = Managed polders, retention basins

Sonstiges = Other

Landkreis = Rural district

Gemeinde = Municipality

Pegel = Gauge

**Figure 12** (see page 23)

Wasserwirtschaft = Water management agencies

Raumordnung = Regional/land use planning agencies

Kommunalplanung = Local planning agencies

Gefahrenabwehr/Katastrophenschutz = Disaster and emergency planning agencies

Versicherungswirtschaft = Insurers

Betroffene = Stakeholders affected by flooding

Naturschutz = Nature conservation agencies

Land-, Forstwirtschaft = Agriculture and forestry