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European Flood Risk
Management Research***

**2nd ERA-NET CRUE Research Funding Initiative
Flood Resilient Communities – Managing the Consequences of Flooding
Final Report**

CRUE Final Report II-5

RISK MAP

Improving Flood Risk Maps as a Means to Foster Public Participation and
Raising Flood Risk Awareness: Toward Flood Resilient Communities

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Second Era-Net CRUE Funding Initiative: Flood resilient communities – managing the consequences of flooding

CRUE Final Report

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CRUE Final Report

RISK MAP

Improving Flood Risk Maps as a Means to Foster Public Participation and Raising Flood Risk Awareness: Toward Flood Resilient Communities

The project **RISK MAP** is part of the Era-Net CRUE Funding Initiative on Flood Resilient Communities.

ERA-Net CRUE was funded within the Sixth EU Framework Programme and introduced structure within the area of European research on flood risk management (FRM). Its vision was to support and develop an extensive co-ordination and integration of regional, national, and European research programmes, projects and policies in the field of Flood Risk Management. Within the CRUE ERA-Net two funding initiatives were introduced.

The second ERA-Net CRUE Research Funding Initiative **“Flood Resilient Communities – Managing the Consequences of Flooding”** was launched in support of the EU Floods Directive 2007/60/EC, which was introduced as a result of several severe flood events causing loss of life and property. Within this initiative seven joint research projects with test sites all over Europe are funded and focus on a broad spectrum of issues related to the enhancement of resilience. Besides, the scientific coordination project CORE CRUE is funded within this second call, to support the implement of the call and to disseminate its results.

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A project fact sheet can be found at the end of this document.

Summary for Decision-Makers

The central objective of RISK MAP was to improve the content and visualisation of flood maps through a participatory process but equally to test whether flood mapping is an effective means and process through which to facilitate participation. By following this objective we asked whether the content and visualisation of existing flood maps really fulfils the expectations and needs of different end-user groups. Based on our project findings (cf. Section 9), we can give recommendations regarding the following points:

1. How should stakeholders be involved in the mapping process (creation and updating of flood maps) and what are appropriate participatory processes?
2. Which contents should be included in flood maps for which user-group?
3. How should flood maps be visualised in order to produce user-friendly and understandable maps?

Before giving an overall summary of the project findings we outline the empirical basis of our study as well as the methodological design. Our findings and recommendations are based on research done in five different European case studies: Two small Austrian torrent catchments; the Lower Thames River area in England; a section of the Vereinigte Mulde River in the Federal State of Saxony, Germany; the Rivers Vils and Rott in the Federal State of Bavaria, Germany; and the City of Tours at the Loire River in France.

In each of the case studies the current practices of risk mapping, legal frameworks and existing flood maps were firstly analysed. Interviews and workshops were carried out with stakeholders in order to identify shortcomings of existing maps and the specific needs of different stakeholder groups. Improved maps were created based on these needs and tested by means of eye-tracking tests, i.e. the reading behaviour of stakeholders was recorded and analysed. Maps were further adjusted according to the findings of these tests and were discussed again with stakeholders in order to come to case-study specific but also overall recommendation for flood mapping. Furthermore, a risk mapping software tool has been developed which facilitates an integration of stakeholder knowledge and preferences into the final map product.

The results of our research underline the value and relevance of participation in mapping. Participation in mapping enables and facilitates a two-way learning process, network building and improved understanding of maps and their interpretation both on the side of producers as well as users. The main user-groups considered in RISK MAP are members from the group of strategic planners, emergency managers and the public. In the following we give an overview about the most important insights along the structure previously presented, namely aspects that relate to participation, content as well as visualisation.

How should stakeholders be involved in the mapping process and what is an appropriate participatory processes? There is not one single best way of conducting a participatory mapping process. Within the case studies the participatory process was conducted by partners in different locations, in institutional and cultural contexts and was hence adapted to the specific requirements and contextual conditions. However, as an overall finding we conclude that the appropriateness depends largely on the purpose of the participatory process. Defining the purpose is hence an important matter that should ideally be clarified at the beginning of any participatory process. In a general sense we propose to distinguish in a rather *substantive* and a rather *instrumental* rationale. If a participatory process follows a *substantive* rationale it aims at increasing the breadth and depth of knowledge contributing to the final product as attempts to include more contextualised forms of knowledge that cannot simply be reproduced by modelling. The *instrumental* rationale aims at building trust between actors from the public and administrative sphere. It may also attempt to contribute to raising people's awareness and motivation for taking actions to mitigate the impacts of hazards. In this sense, the answer to the question "What should be achieved by the participatory process?" is decisive as it has implications for the choice of actors to be

involved during the process, the intensity of the process as well as the outcome of the entire process. More specific recommendations are provided in section 10.3.

Which contents should be included in flood maps for which user-group? RISK MAP confirms the finding that for a target-oriented communication the contents of flood maps need to be adjusted to the end-user needs, since different end-user groups have different requirements on the contents of flood maps.

Strategic planners require a maps that shows where areas of high risk are, i.e. where there is a need for risk mitigation efforts. Maps serve also as an intermediate product for economic appraisal of flood risk mitigation measures. With regard to hazard information especially detailed information on inundation depth is required for events with different probabilities. Regarding information on the consequences of flooding the following contents are of importance: Information on the consequences of specific events should be shown, but also maps showing the annual average damage as a basis for economic appraisals. Furthermore, not only information on the economic damages should be displayed but also information on social, cultural and environmental risks in order to show a complete picture of possible consequences. This should also include critical infrastructure, like bridges, power plants, hospitals etc. An aggregation of these different social, economic and environmental risks by means of a multicriteria risk map may be supportive to show overall risk hot spots.

Emergency managers, on the other hand, need easy accessible maps in case of emergency to have quick access to information on affected areas, people to be evacuated, critical infrastructure to be protected, evacuation routes etc. With regard to the consequences of flooding the following information is most important for emergency management: The number of people at risk from a certain event, i.e. the number of people to be evacuated in case of emergency; critical infrastructure which have to be protected, secured or evacuated (i.e. hospitals, energy or water supply facilities, relevant or blocked roads and bridges). Apart from traditional hazard and risk information also information on emergency management itself should be included, like gathering points, evacuation routes, hospitals, gauging stations etc. Again, information should be included at which level of flooding these emergency facilities are itself at risk, i.e. when certain evacuation routes are not usable any more.

The public also require easily understandable and accessible maps, but with a lower complexity of information, including only the most crucial information: Information on the extent and depth for events with different probabilities (with links to the associated alarm stages) and the buildings and roads in the area and which of them will be affected in case of a specific event. Furthermore, the most relevant information in case of emergency (evacuation routes, shelter, assembly points) should be included.

More detailed recommendations for the different user-groups but also some more general recommendations on contents will be given in section 10.4

How should flood maps be visualised in order to produce user-friendly and understandable maps?

Similar as argued before, multiple topics dedicated to different user groups should not be shown in the same map. E.g. evacuation information (which is necessary for emergency managers) should not be mixed with information on economic impacts (which is more relevant for strategic planning). A map should rather be easy accessible, not overloaded with information and high in contrast with regard to the choice of colours and brightness. This implies, for instance, that areas at risk should be clearly visually differentiated from areas not at risk. Furthermore, the research showed that the use of self-explanatory icons or symbols to highlight e.g. major risks or the direction of evacuation routes can facilitate a quick access to the relevant contents. Also text should be used within the maps in order to better and faster transmit important information, e.g. information on the number of people to be evacuated. The legend should be sufficiently large, preferably on the right side of the central element of the map, with a limited number of information (not more than five discrete classes) comprised from one range in colour only and arranged in decreasing values. The topics in the legend should be organized in a way that it really helps comprehension: Firstly hazard information, secondly major risks, then secondary risks, finally background information. More specific recommendations will be given in section 10.5.

Contents

Era-Net CRUE Funding Initiative	3
Summary for Decision-Makers	5
Contents	7
1 Introduction	13
1.1 Background and objective	13
1.2 Structure of the project and of this report	14
2 Status quo of risk mapping	17
2.1 Summary of legal frameworks for participation	17
2.2 Current practices of flood mapping in the case studies	19
2.2.1 Flood maps, defined target groups and public participation in flood mapping	19
2.2.2 Flood hazard / flood risk	21
2.2.3 Form of presentation and obligation of public availability	23
2.2.4 Existing mapping reviews and guidelines	24
3 Methodology for improving risk maps	25
3.1 Theory & methods of participation	25
3.1.1 Literature review on participation in hazard mapping	25
3.1.2 Participation framework	32
3.1.3 The RISK MAP process	38
3.2 Description of the participative multicriteria risk mapping tool (FloodCalc)	45
3.3 Methods of visualisation & and the approach of Experimental Graphic Semiology (EGS)	50
3.3.1 Compilation of risk maps	51
3.3.2 Visual strategies and method of eye-tracking	52
3.3.3 Method of visualisation	53
3.3.4 Experimental graphic semiology	55
3.3.5 Experimental protocol	58
4 Case study Austria	64
4.1 Case study Wartschenbach	64
4.1.1 Physical geography of the catchment	64
4.1.2 Human geography of the catchment	65
4.1.3 Previous flooding experienced	65
4.2 Case study Vorderbergerbach	66
4.2.1 Physical geography of the catchment	67
4.2.2 Human geography of the catchment	67
4.2.3 Previous flooding experienced	67
4.3 Background information	68
4.3.1 History of hazard mapping	68
4.3.2 Legislative context	71
4.3.3 Roles and responsibilities	73
4.4 Current flood mapping practices	75

4.5	Flood hazard and risk	76
4.5.1	Flood hazard	76
4.5.2	Flood risk	77
4.6	Risk analysis	80
4.6.1	Specific definitions of risk and method for assessment	80
4.6.2	Components of risk assessed	80
4.6.3	Aggregation method	80
4.7	Alternative mapping	81
4.7.1	Map scales	81
4.7.2	Colour schemes	81
4.7.3	Graphic map background	81
4.8	Interview findings	83
4.9	Findings from the workshops in Austria	84
4.9.1	First workshop	84
4.9.2	Second workshop & case-study specific recommendations	85
5	Case study England	87
5.1	History of flood mapping	87
5.2	Legislative context of flood risk mapping in England and Wales and the development of the current flood map and online information service	88
5.2.1	Roles and responsibilities for mapping and users of the flood map	88
5.2.2	Uses and users of the flood map	90
5.3	Current flood mapping practices	90
5.3.1	Outline flood map	92
5.3.2	Risk analysis and the National Flood Risk Assessment (NaFRA)	93
5.4	Map design	94
5.4.1	Map scales	95
5.4.2	Graphic map background	96
5.4.3	Colour schemes	97
5.4.4	Online presentation	97
5.4.5	Flood mapping issues	98
5.4.6	Recent changes to flood mapping, legislative developments and planned improvements for mapping	99
5.5	The case study area: Chertsey, Surrey	105
5.5.1	Physical geographic features	105
5.5.2	Human geographic features	107
5.5.3	Previous flooding experienced	108
5.5.4	Chertsey as represented by the Environment Agency Flood Map	108
5.5.5	Local Environment Agency mapping	110
5.6	Participation workshops	111
5.7	Exploratory workshops	112
5.7.1	Participants	112
5.7.2	Exploratory workshop design	113
5.7.3	Workshop activities	113
5.7.4	Exploratory workshop findings	114

5.8	Alternative mapping: Exploring mapping preferences with experimental graphic semiology	134
5.9	“Findings” workshop	137
5.9.1	Participants.....	137
5.9.2	Workshop design and activities.....	138
5.10	Case-study specific recommendations	145
5.10.1	Recommendations for mapped content and visualisation	145
5.10.2	Recommendations for participation in the Thames case study and England and Wales.....	148
6	Case study Saxony	150
6.1	The case study area	150
6.1.1	Physical geographic features	150
6.1.2	Human geographic features	153
6.2	Background information	154
6.2.1	History of flood hazard and risk maps.....	154
6.2.2	Relevant legislation, strategies and programmes	156
6.2.3	Flood risk management in Saxony: Actors, tasks & responsibilities	157
6.3	Current flood mapping practices (map types and their defined target groups).....	161
6.3.1	Saxony-wide map types	161
6.3.2	Maps in pilot sites, research projects, etc.	168
6.3.3	Software using and/or producing flood maps.....	172
6.3.4	Availability of maps and further publicly available information.....	174
6.4	Flood hazard and flood vulnerability	175
6.4.1	Data sources	175
6.4.2	Flood hazard	175
6.4.3	Flood vulnerability	176
6.5	Risk analysis	177
6.5.1	Specific definition of risk and methodology for its assessment.....	177
6.5.2	Components of risk assessed	177
6.5.3	Aggregation method	178
6.6	Map design.....	178
6.6.1	Map scales	179
6.6.2	Colour schemes	179
6.6.3	Graphic map background and additional map data	179
6.7	Results from interviews and workshops.....	180
6.7.1	The stakeholder involvement process in the case study	180
6.7.2	Alternative mapping: Exploring mapping preferences with experimental graphic semiology	188
6.7.3	Additional interviews and second workshop	193
6.7.4	Evaluation of the participatory process by the participants.....	198
6.8	Case study-specific recommendations	199
7	Case study Bavaria	203
7.1	Case study Lower Rott River	203
7.1.1	Case study area	203

7.1.2	Previous flooding experienced	207
7.2	Bavarian case study – background information	209
7.2.1	Legislative context of flood risk mapping in Germany, Bavaria, and the development of the current flood map and online information service	209
7.2.2	Roles and responsibilities for mapping and users of the flood maps.....	214
7.3	Current flood mapping practices	216
7.3.1	Print	216
7.3.2	Online	217
7.4	Flood hazard and flood vulnerability	219
7.4.1	Data sources	219
7.4.2	Flood vulnerability	220
7.5	Risk analysis	221
7.5.1	Specific definition of risk and methodology for its assessment.....	221
7.5.2	Components of risk assessed	221
7.6	Map design.....	222
7.6.1	Map scales	223
7.6.2	Colour schemes	223
7.6.3	Graphic map background.....	223
7.7	Interview findings.....	225
7.8	Workshops in Bavaria	225
7.8.1	Aims of the workshops	225
7.8.2	Participants.....	225
7.8.3	Workshop design	226
7.8.4	Workshop activities	226
7.8.5	Workshop findings.....	226
7.9	Case study-specific recommendations	233
8	Case study France (Le Val de Tours).....	235
8.1	The case study area.....	235
8.1.1	Physical geographic features.....	235
8.1.2	Human geographic features.....	236
8.2	Previous experience of flooding	236
8.3	Val de Tours – background information	238
8.3.1	Legislative context of flood risk mapping and development of the current flood map and online information service	238
8.3.2	Roles and responsibilities for mapping and users of flood maps.....	239
8.4	Current flood mapping practices	243
8.5	Flood hazard and flood risk (damage potential).....	243
8.5.1	Data sources	243
8.5.2	Flood hazard: highest known flood levels (<i>Plus Hautes Eaux Connues</i> : PHEC)	244
8.5.3	Flood risk prevention plan: Plan de Prévention du risque d’Inondation (PPRi).....	245
8.6	Risk Analysis	245
8.7	Map design.....	245
8.7.1	Map scales	245

8.7.2	Colour schemes	246
8.7.3	Graphic map background	246
9	Findings	247
9.1	Findings from participation in all case studies (<i>including an overview of participants</i>)	247
9.1.1	Introduction	247
9.1.2	Synthesis of case study findings	248
9.1.3	Saxony, Germany	249
9.1.4	Bavaria, Germany	250
9.1.5	Austria	251
9.1.6	Chertsey, England	252
9.1.7	Summary and some key principles/ findings/ conclusions?	253
9.1.8	Participation in action: testing a participatory approach to mapping	253
9.1.9	Lessons for a participatory approach to flood risk mapping	259
9.2	Findings from the MCA-Tool	266
9.3	Findings from visualisation & from EGS (<i>including a comparison between old and new maps</i>)	276
10	Common recommendations: How to come to user-friendly flood maps	281
10.1	Summary of the project	281
10.2	Producers and users of flood maps	283
10.3	Common recommendations on stakeholder participation processes	284
10.4	Common recommendations on contents of flood maps	288
10.5	Common recommendations on visualisation of flood maps	293
10.6	Outlook	296
11	References	297
12	Appendix	309
12.1	Contribution of the project to the overarching topics of the call, implications for stakeholders, and further research needs	309
12.1.1	Connection to the Floods Directive	309
12.1.2	Participation	310
12.1.3	Harmonisation	310
12.1.4	Restrictions	311
12.1.5	Enhancement of resilience	311
12.2	Maps and EGS diagrams / further results	312
12.2.1	Maps	312
12.2.2	Participants	318
12.3	Photo collections Austrian case studies	319
12.3.1	The Wartschenbach test site	319
12.3.2	The Vorderbergerbach test site	322
12.4	Appendix French case study	324
12.5	Fact sheets	329
12.5.1	Project fact sheet	329
12.5.2	Case study factsheet Saxony	330
12.5.3	Case study factsheet Bavaria	331
12.5.4	Case study factsheet Austria 1	332
12.5.5	Case study factsheet Austria 2	333

12.5.6	Case study factsheet England	334
12.5.7	Case study factsheet France	335
12.6	List of figures	336
12.7	List of tables	340
12.8	Acknowledgements	342
12.9	Table of project information.....	343

1 Introduction

1.1 Background and objective

Despite long-lasting attempts to reduce vulnerabilities to natural hazards, the damages resulting from flooding are still not decreasing in Europe (e.g., IPCC 2007). There are several reasons for this: Beside river regulation and urbanisation, social and economic developments lead to an increased damage potential in many river basins across Europe (e.g., Apel et al. 2006; Büchele et al. 2006; Fuchs & Holub 2007).

Since in many respects, floods are beyond the immediate control of humans and this despite an enhanced ability to predict the occurrence of floods, an increased resilience of communities at risk seems vital for both reducing suffering and damages. In this regard, an improved risk awareness of citizens as well as adequate communication forms between citizens at risk relying on information about floods on the one hand, and experts and decision-makers generating information on the other hand, are therefore crucial. This is underlined by recent findings of empirical research conducted within the FLOODsite project (De Marchi & Scolobig 2007; Steinführer & Kuhlicke 2007; Tunstall 2007 et al.).

An important means to reach this aim of improved communication are flood hazard and risks maps, subsequently referred to as “flood maps”. This is also reflected in the recent Floods Directive which defines the mandatory publication of flood maps as well as flood risk management plans as the most important instrument for enhancing awareness and preparedness of people (European Commission 2007). Member states have to undertake a preliminary flood risk assessment within their river basins, and have to compile flood risk maps at an appropriate scale in order to serve as a basis for flood risk management plans. In some of the member countries the methodology of hazard and risk mapping is well-established (e.g., Heinemann 1995, 1998; Hollenstein 1997; Kienholz & Krummenacher 1995; Merz 2006; Merz et al. 2008), even if individual methods and guidelines differ. In accordance with applicable Community legislation, member states should make available the results of the preliminary flood risk assessment as well as the flood maps to the public.

However, apart from the overall legal status in member states of the European Union, several shortcomings in the current practice of flood mapping can be identified (Fuchs et al. 2007; Steinführer et al. 2008, Meyer et al. 2008):

1. Risk communication by flood maps is mostly organised in a one-direction top-down manner. I.e. the public is only considered as the receiver of information and is not directly involved in the risk mapping process.
2. Flood maps are mostly focused on the hazard, if risks are taken into account they are mostly expressed in monetary terms, such as risks to buildings and inventories. Other risk criteria, like social and environmental effects are often neglected so far.
3. Risks maps are often designed and visualised in a way which cannot be easily understood by laypersons and/or not suitable for the respective needs of public authorities in risk and event management.

RISK MAP explored some of these findings in more depth and tried to close the identified gaps by applied methodological and conceptual research being based on a dialogue-oriented creation of risk maps in different European test sites. The major focus was to provide recommendations for a stakeholder-oriented bottom-up approach that can be adopted to individual requirements in the member states. It is therefore

the main objective of RISK MAP to contribute to the enhancement of communities' resilience by improving risk maps. To reach this overall objective RISK MAP departs from the assumption that risk maps are not only a means to inform citizens about future risks; they are also a possible way to stimulate public participation between governmental institutions, private companies and associations, alliances, interests groups, and citizens. More specifically, four central objectives were identified to be addressed in RISK MAP comprehensively:

1. Development of appropriate stakeholder participation processes which allow incorporating local knowledge and preferences into the risk maps as well as specifying the limits of flood maps as a means to foster communication and raising risk awareness. Furthermore, specific needs related to risk management plans will be addressed, i.e. with respect to flood risk and event management.
2. Improving the content of flood maps by enhancing a multicriteria risk mapping tool, which facilitates for the consideration of economic, as well as social and environmental risks, towards a participative dialogue tool, allowing for the participation of stakeholders during the risk assessment and mapping process.
3. Improving the visualisation of risk maps in order to produce user-friendly and understandable risk maps for stakeholders concerned.
4. Gaining in-depth knowledge and providing quantitative information related to the necessary content of risk maps by application of the eye-tracking method and by experimental graphic semiology.

The **major outcomes** of RISK MAP are improved flood maps as well as recommendations on how to compile risk maps, including improved content with respect to the requirements of the Flood Directive, and a target-oriented design that is adjusted to individual stakeholders' needs (e.g. citizens affected and/or professional users). Furthermore, guidelines and recommendation are presented on how organize legitimate participation processes during risk assessment and mapping.

1.2 Structure of the project and of this report

In order to address the scientific objectives outlined above, work in RISK MAP was structured into three thematic steps and applied in five case studies across Europe. The first three thematic steps were concerned with improving maps and started with getting an understanding about the "Status quo in different case studies" (work package (WP 1)). A second was concerned with "Improving Maps" (WP 2) and the third step with elaborating overall "Recommendations" (WP3) To ensure the application and implementation of the research process each of the thematic work packages was grounded in four regional case studies which are summarised in WP4. The work packages and respective tasks were organised as displayed in Figure 1.1. In the following each work package and task will be described in more detail. By doing this also the structure of this report is outlined and guidance is given to the reader where to find the methods, outcomes and recommendations derived by each task, work package, case study or the overall recommendations.

Status quo in different case studies (WP1)

Within the first phase of the project the basis for an improvement of risk mapping was elaborated collecting and taking into account the results of previous projects (e.g. FLOODsite and RISK CATCH) and investigating the status quo of flood risk mapping and participative elements in the case studies. More we followed the following objectives:

- We investigated the "Legal framework" (task 1.1) with regard to flood mapping and participation. The results are summarised in section 2.1. An even more detailed report can be found at (http://risk-map.org/outcomes/DP_13_2010_Unnerstall_Riskmap_legal13950.pdf).
- We focused "Current practices" (task 1.2) by gathering existing flood maps and conducting explorative interviews with regional/local stakeholders and decision-makers in order to further

specify the status quo of current flood mapping practice within the case studies and specific needs with respect to the Floods Directive (see section 2.2 of this report).

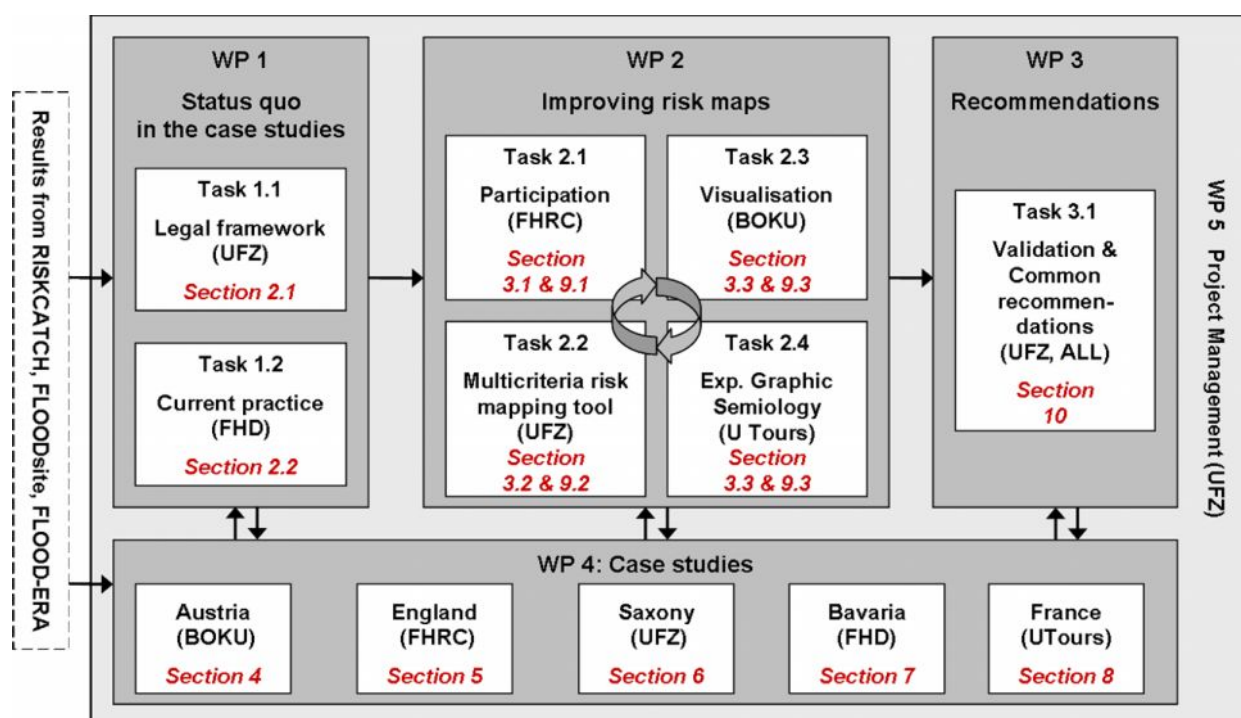


Figure 1.1: Structure of RISK MAP and associated sections in this report

The main part of the project was concerned with “Improving flood maps” (WP2). This was organized in four different but complementary tasks addressing the respective scientific objectives of RISK MAP:

- Develop a better understanding of how “Participation” (task 2.1) is operating in different case studies in order to develop and define appropriate stakeholder participation in flood mapping. These participation guidelines are developed in section 3.1. In section 9.1 experiences and findings from the case studies with regard to the application of this guidance are described and summarized.
- Develop a “Multicriteria risk mapping tool” (task 2.2) which allows for stakeholder participation in the risk mapping process with regard to the contents of risk maps. This tool and its methodological foundations are described in section 3.2. In section 9.2 some findings with regard to its application especially in the Saxon case study are outlined. The software itself and the handbook can be downloaded from <http://risk-map.org/outcomes>.
- Improve the “Visualisation” (task 2.3) of flood maps in order to meet the needs and expectations of different stakeholder groups.
- To apply the method of “Experimental graphic semiology” (task 2.4) to specify the effects of different design criteria on the information procession and thus delivery of information. The method of visualisation and the approach of experimental graphic semiology are described in section 3.3. Overall findings are summarized in section 9.3. The complete results of the experimental graphic semiology tests in Tours can be found at <http://risk-map.org/outcomes>.

In the final period of the project we were concerned with developing “Recommendations” (WP3) for an improved flood mapping. We focused particularly on the question on the questions of how to (1) enhance the communication of risk to affected citizens and on how to (2) address the specific needs of the different

users of flood maps. A summary of the project as well as the overall recommendations of our project with regard to participation processes, contents and visualisation of flood maps are provided in section 10.

In order to guarantee application-oriented transnational research, the work described above was carried out in five regional Case studies (WP 4). There are more information provided in the individual chapters:

1. Austria: Wartschenbach and Vorderbergerbach (alpine torrents), see section 4
2. England: Lower Thames, Chertsey (lowland river), see section 5
3. Saxony (Germany): Vereinigte Mulde, Bennewitz and Wurzen (hill-/lowland river), see section 6
4. Bavaria (Germany): Vils and Rott (alpine foreland rivers), see section 7
5. France: Loire, Tours (lowland river), see section 8

Case study fact sheets describing the characteristics of each case study can be found in the Appendix (Section 12.5)

The selection of case studies followed the premise to capitalize recent results from the FLOODsite project as well as from the RISKATCH project. The four test sites are located in different geographical regions. They are representative of different geographical and geomorphologic conditions (lowland rivers, alpine foreland, Alpine torrents) as well as different catchment sizes (rivulets, torrents, rivers and streams) and thus cover the entire scope of the Flood Directive (FD).

Each case study followed the main thematic strands of RISK MAP. Accordingly, in the first phase (WP1) the status quo in risk mapping in each test site was investigated. In the beginning of the main phase (WP2), local and regional representative stakeholders to be invited to the workshops were identified. With regard to participation at least two stakeholder workshops were carried out in each case study. Taking existing hazard and risk maps as a starting point, limitations in content and visualisation have been discussed with local and regional stakeholders, additional risk criteria were identified and specific needs were defined with respect to risk communication. Based on the workshop findings new maps have been created in each case study and tested by means of eye tracking applying the method of experimental graphic semiology. Therefore, altogether about 40 stakeholders from the different case studies have been served as test persons.

By combining the different results, improved risk maps were presented to the stakeholders in the second workshops. During these workshops, improvements and remaining limitations will be addressed. The results of each case study are described in a case study report and specific recommendations are drawn (see sections 4-8).

While the single case study reports follow a similar rational, they also differ to a certain extent reflecting the professional background of the researchers involved. The Bavarian, Austrian and French case study rather have an emphasis on the tasks of visualisation and contents, while the British case study puts an emphasis on participation. Furthermore the different case studies focus on different user groups. While the British case study focuses on the expectations, needs and experiences of the public; the other case studies focus on emergency managers as well as strategic planners.

2 Status quo of risk mapping

2.1 Summary of legal frameworks for participation

Herwig Unnerstall

The results of Task 1.1 are described in detail in the report “Legal Framework for Public Participation in Flood Risk Mapping - A comparative study on different European member states and on the requirements of the Flood Management Directive” (Unnerstall 2010, available at <http://risk-map.org/outcomes>) and are outlined in the following. Table 2.1 which summarises the formal requirements as defined by the different European directives relevant for flood risk management.

Table 2.1: Public participation requirements in flood risk planning according to EC-directives

Phase \ Requirements	FD – Floods Directive	SEAD – Strategic Environmental Assessment Directive	Coordination with WFD – Water Framework Directive
Preliminary Flood Risk Assessment	Ex-post information of general public (Art. 10 (1))	Not subject to the SEAD	No coordination required acc. to Art. 9 S. 2 Nr. 3 FD
Flood Hazard Maps and Flood Risk Maps	Ex-post information of general public (Art. 10 (1))	Not subject to the SEAD	No coordination required acc. to Art. 9 S. 2 Nr. 3 FD
Flood Risk Management Plans	Encourage active involvement of interested parties (Art. 10 (2)), but no formal procedure	Formal consultation of (general) public and opportunity for comments (appropriate time frame)	Coordination required acc. to Art. 9 S. 2 Nr. 3 FD, but unclear which format. Art. 14 WFD

In regards to the FD in Article 10 (1), the (general) public only requires an ex-post information of the three steps of the directive. The more advanced participation type “active involvement of interested parties” is required only for the Flood Risk Management Plans (FRMPs) (Article 10 (2) FD) and not for the preceding steps. “Active involvement of interested parties” as required by Article 10 FD at the development of FRMPs requires some kind of multilateral consultation on the draft FRMPs that allows stakeholders to discuss relevant issues and to contribute to their solution and forces the planning authority to examine arguments and propositions put forward by the stakeholders. To be effective Flood Hazard Maps (FHM) and Flood Risk Maps (FRM) should also be topic of discussion, as they form the basis for the FRMPs, although the FD does not require a separate consultation procedure. However, the degree of obligation that is attached to active involvement, i.e. to “encourage” (Art 10 (2) FD) it – in contrast to “shall make available” in Article 10 (1) FD – leaves a wide range of implementation options.

The comparison of the current legal situation (and planned implementation of the FD) in the case studies shows some similarities but also differences, especially concerning the progress in implementing the requirements of the FD.

In Austria there are currently a number of different planning instruments available concerning flood risk management which have partly overlapping and partly exclusive scopes of application. They have used different reference events for structuring the information, different criteria for the designation of different degrees of hazards, different intensities and forms of public participation. In general, intensity of participations seems low with the exception of Hazard Zone Plans for Torrent and Avalanche Control (§ 11 Austrian Forest Act). The requirements of the Strategic Environmental Assessment Directive (SEAD) seem to be not yet considered sufficiently, but their relevance for the river development schemes (Gewässerentwicklungskonzepte) is evident.

In England and Wales the FD has been transposed by the Flood Risk Regulations (FRR) in 2009. As regards public participation this transposition remains very close to the FD and offers only a few and rather marginal specification. The central requirement of the FD to “encourage active involvement of interested parties” has been transformed to “to consult the public” without giving further details on the design of this process. Only a few concrete rules can be drawn from the Code of Practice on Consultation in this respect. The Flood and Water Management Act (FWMA) introduced in 2010 has made further changes to the way floods are managed in England and Wales. It establishes also on a regional level Regional Flood and Coastal Committees (RFCCs). Although the rules for assembling them are not yet adopted and it is unclear how these committees will encourage civil society participation.

After the heavy floods in 2002, Saxony was the first federal state in Germany to modernise its flood management legislation even before the Federation revised its legislation. By the Saxon Water Act of 2002 (SaxWA 2002) the development of “flood protection concepts” (Hochwasserschutzkonzepte) was decided which include FHM and FRMP as required by the FD. Similarities to the FRMs have the so-called “hazard indicator maps” (“Gefahrenhinweiskarten”) that contains a “map of damage potential” (Schadenspotentialkarte), but only for extreme events. For the implementation of “active involvement of interested parties” Saxony has adopted a formal consultation procedure covering the general public. Panels of “interested parties” corresponding to the “water forum” established for the implementation of the WFD have not been established and these existing forums have not extended their subject area. For the planning section of FRMs no specific procedure takes place and hence no specific participation process. However, the upcoming new legislation (Draft Law from the 10.2.2010) exceeds in some points the minimum requirements of the FD regarding public participation.

In the federal state of Bavaria, Germany, the FD will be implemented in the next years according to the Bavarian Water Act (BaWA 2010) and the German Federal Water Act (GFWA 2009). For the implementation of “active involvement of interested parties”, Bavaria has yet not adopted any provision that specifies how this process will be carried out, but only assigns the responsibility for it to the State government. Panels of “interested parties” corresponding to the “water forum” established for the implementation of the WFD have not been established and these existing forums have not extended their subject area either. For the planning section of FRMs no specific procedure takes place and hence no specific participation process.

In conclusion, one can assert that that most of member states concentrate in their (planned) implementation of the FD on a formal administrative approach for the “active involvement of interested parties”, in which the administration develops the draft for the management plan that is then publicly displayed so that everybody may comment on the plan within a fixed time period. This only fulfils the minimum requirements of the FD for “active involvement”. There are attempts for a more “political approach”. The establishment of the “water forum”, “round tables” etc. as already occurred in the context of the implementation of the WFD is a step in this direction. The inclusion of flood management issues into the application area of these councils would be the easiest way to go beyond “formal consultation”. This way would also promote the aspired coordination between the WFD and the FD.

2.2 Current practices of flood mapping in the case studies

Johanna Seidel, Wolfgang Dorner

The section will provide an overview of current practices in flood risk mapping. Therefore different aspects are considered, such as flood maps and target groups, the public participation in flood mapping, responsible authorities, terms of hazard and risk and Form of presentation and obligation of public availability. Detailed information can also be found on the website <http://risk-map.org/outcomes>, in the table “Overview of the implementation of Flood Mapping Practices and development of hazard and risk maps”.

2.2.1 Flood maps, defined target groups and public participation in flood mapping

The **Saxon State Ministry for the Environment and Agriculture** addresses a broad user group of flood maps and also offers a large variety of different maps. These include:

- Legally binding flood-prone areas:
Legal basis for (urban) land-use planning and other activities
- Hazard maps for built-up areas / hazard maps for different probabilities for all major rivers (1st Order):
Public awareness raising, emergency management, urban planning
- Hazard indication map for Saxony (Gefahrenhinweiskarte Sachsen), consisting of rather coarse hazard and damage potential maps for 1st Order rivers and extreme events:
Long-term regional planning, emergency planning, planning of protection measures
- Hazard and damage maps on the web: interested citizens and professional

Public participation: Public participation activities took place during the creation of the Flood Protection Concepts (following the 2002 floods), prior to the enacting of the Floods Directive. The Saxon Flood Centre is taking efforts to consider bottom-up initiatives and pilot projects led by the LfULG explicitly address participation of communities and the public.

The **Bavarian Environment Agency** instructs the production of flood hazard and flood risk maps for all areas with a potentially significant flood risk. The agency does not offer a publicly available variety of different maps, such as the Saxon State Ministry for the Environment and Agriculture. The maps have to provide detailed information on flood hazard and flood risk for water bodies with a potentially significant flood risk. The user groups are the following:

- Water Authorities: maps serve as a basis for concepts of flood risk management and flood risk protection measures
- Authorities of regional planning: legal binding for land use planning, also measures for prevention and protection of flood risk
- Persons responsible for disaster prevention and protection: maps as a basis for evacuation and for further concepts of management plans
- Population / Building owners / Residents / Decision makers from industry and business: maps may improve knowledge about flood hazard and flood risk, preventive measure for planning and building

Public participation: no Past activities for public participation.

The *Environment Agency* provides two different types of flood hazard maps on a national basis in **England and Wales**, available for following user groups:

- Outline flood maps (OFM) for rivers and the sea: the flood hazard maps were originally developed as a basis for spatial planning; the maps are also used for emergency planning and response by a whole range of professionals (such as the emergency services, local authorities, water companies, etc.)
- National Flood Risk Assessment (NaFRA) – this information is not provided as a mapped layer but as information accessed from clicking on the outline map.
- Maps of surface water flood risk are provided on a national basis to Lead Local Flood Authorities and Category 1 and 2 responders to combine with their more detailed, local information.
- Maps of areas at risk from reservoir flooding.

The flood maps are produced for the different target groups and, although they were primarily produced for planning purposes, they are now used for many different purposes. Those developing properties do commission their own modelling in order to assess the risk of flooding in a more detailed, property specific way and in some cases this information is incorporated at a local level and used to improve the official maps.

Public participation: The flood maps are commonly used as contextual information when engaging the public about flood risk and where appropriate more detailed mapping and modelling can be used when addressing specific and localised issues. The Environment Agency has a general approach to public participation and communicating and engaging with communities but no activities in relation to flood mapping have been undertaken. An ESRC-funded project “Understanding environmental knowledge controversies” used what they called competency groups to try to incorporate different types of knowledge into flood risk science; the project has not finished yet.

The *Federal Water Engineering Administration of Austria* is responsible for the management of all waters bodies (except waterways and torrents), in cooperation with provincial authorities and the Federal Ministry of Agriculture, Forestry, Environment and Water Management (Department VII 5 - Water Management and Flood Protection) and therefore also for the flood maps concerning these water bodies.

Torrents of which boundaries are defined by ordinance fall into the area of responsibility of *the Austrian Torrent and Avalanche Control Service*, a branch of the *Federal Ministry of Agriculture, Forestry, Environment and Water Management*.

The rivers Danube, March and Thaya are in responsibility of the Federal Ministry of Transport, Innovation and Technology (BMVIT).

Legally, for (1) and (2) flood hazard maps are established with either the 1:100 or the 1:150 event as a design event, the flood hazard maps are used as a basis for any spatial planning, partly for emergency planning and for planning technical protection measures.

Public participation: Everybody with legitimate interest is allowed to comment on the draft within the period of four weeks.

The Regional Departments of the Environment, Land Use Planning and housing in **France** (DREAL or Direction Régionale de l'Environnement, de l'Aménagement et du Logement) are in the responsibility of the flood maps. Risk maps are present in these documents:

- Submersible Surfaces Plan (Plan des Surfaces Submersible or PSS) since statutory order of 30/10/1935 and decree of application of 20/10/1937.

- Exhibition at the Risks Plan (Plan d'Exposition aux Risques or PER) since the law of compensation of natural disasters (N 82-600 of 13/07/1982) followed by the decree of application of May 3rd, 1984...which are replaced since the law n°95-101 of 02/02/1995 by :
- PPRI (Flood Risk Prevention Plan or Plan de Prevention des Risques d'Inondation)

Maps of PPRI (Flood Risk Prevention Plan or Plan de Prevention des Risques d'Inondation): legal basis for land-use planning. These maps are available to local actors (mayor, urban manager, etc.).

Maps of AZI (Atlas of flood areas or Atlas des zones inondables) work as the basis for communication according level of hazard and/or highest known flood levels. These maps are available to everyone.

Public participation: One step of the elaboration of each PPRI is composed of a public consultation and/or a public survey.

2.2.2 Flood hazard / flood risk

2.2.2.1 Hazard

The intensity parameters of the different project areas greatly vary from each other.

The general Saxon flood maps vary from HQ(5/10/20/25), HQ(50), HQ(100) to HQ(200/300). Flood hazard maps are produced for events with return periods of 20 (or 25), 50, 100 and 200 (or 300) years and for so-called "extreme" events (sometimes corresponding to a HQ(200/300) event). The general hazard maps displays three intensity levels (high, medium, low), depending on the water depth. In mountainous areas, these levels depend on the discharge/flow velocity. For non-public use there are five intensity levels. The hazard indication map displays water levels/depth only for the HQ(extreme) and in four levels: 0-0.5 , 0.5-2.0, 2.0-4.0 and >4.0 m.

The **Bavarian** flood hazard maps contain information about the spatial extent of the flood, the water depth and the flow velocity (where appropriate). Following flood scenarios are covered:

- Low probability (HQextreme)
- Medium probability (HQ100)
- High probability (HQ5, HQ10)

The water levels are displayed in 5 levels: 0,00 to 0,50, 0,50 to 1,00, 1,00 to 2,00, 2,00 to 4,00 and > 4,00m. The water depths are based on a 100 year event.

The outline flood maps (OFM) of **England and Wales produced by the Environment Agency** indicate return periods for following categories:

- HQ:100 (rivers)
- HQ:200(coastal)
- HQ1000(extreme) for both rivers and coastal flood risk

The maps of the National Flood Risk Assessment (NaFRA) contain three categories significant, where flood risk of greater than a return period of HQ(75), medium risk which is between HQ(75) and HQ(200) and low risk, where the risk is less than HQ(200). No water level information or intensity criteria are presented on the OFM or NaFRA layer.

The **Austrian** flood maps vary from HQ(1/5/10/30/50 and 100). As the maps are separated for water bodies, torrents and water ways, the maps concerning torrents include HQ(150). Water levels are only given for torrents. 0.7 m is the distinction between red and yellow hazard zones.

The **French** maps contain information about the spatial extent and the water depth but in a separate way. The maps of PPRI (Flood Risk Prevention Plan or Plan de Prevention des Risques d'Inondation) show 100-year events and higher. On the AZI-maps (Atlas of flood areas or Atlas des zones inondables) no water levels but levels of danger shown. It is a combination between speed (low, medium, high velocity) and height of the flood (<0.5m; 0.5m to 1m; 1m to 2m; >2m)

2.2.2.2 Risk

The official damage maps of **Saxony** contain a broad variety of different risk elements. They vary from social, economic and ecological risk and strictly follow guidelines such as the Recommendations for the Establishment of Flood Hazard Maps and Flood Risk Maps, published by the German Working Group on Water Issues of the Federal States and the Federal Government (LAWA). These specifications are also valid for and implemented in **Bavaria**. The following aspects are considered:

- Land use data: ATKIS-Basis-DLM
- Asset values: typical asset values per land use category based on other studies, official statistics, some critical infrastructures, (no indirect losses)
- Relative depth/damage functions also from other studies (Rhine)
- Apart from damages also special vulnerabilities are included:
 - Human lives
 - Essential infrastructure facilities (e.g. water plants, hospitals, power plants),
 - Important infrastructure facilities (e.g. railways, national traffic ways, train stations, ...),
 - Extraordinary cultural heritage or monuments
- Also: hazardous substances!

The **Bavarian** flood risk maps display the possible consequences of the scenarios mentioned above. They highlight the risk for human health, environment, cultural heritage and economy. The information about flooded areas is blended with the information of about land use. The potentially affected land-use classes are highlighted. Following aspects are considered:

- Number of affected population
- Type of economic activity in the affected area
- Installations and facilities listed in den Annex of the EC Flood Directive on prevention of pollution, which could cause widespread pollution in case of a flood
- Protected areas

The HQ_{extreme} events serve as the basis for the assessment of the so-called residual risk. The residual risk is not covered through construction measurements, which are usually sized for HQ100 events. The municipalities and the citizen can use the maps for decision making to deal with the residual risk.

England and Austria:

Only hazard information is provided on the flood maps although some receptor information is shown through the presence of background mapping.

French authorities define risk as follows: A potentially dangerous event, a hazard, only becomes a major risk if it occurs in a place where there is life-threatening, economic or environmental stakes. The risk is defined according to maximum submersion height and flow velocity:

- Low risk : submersion less than 1 meter and no velocity;

- Medium risk : submersion between 1 and 2 meter with no or low water velocity, or submersion less than 1 meter but with medium or high water velocity;
- High risk : submersion over 2 meter with no or low water velocity, or submersion between 1 and 2 meter and with medium or high water velocity;
- Very high risk: submersion over 2 meters with medium or high water velocity or area at particular risk immediately downstream from a reservoir.

The social (housing), economic (offices) and environmental (rural area) dimension are fully integrated since risk maps are legally prescribed in Flood Risk Prevention Plan (PPRI).

2.2.3 Form of presentation and obligation of public availability

The **Saxon State Ministry for The Environment, Agriculture and Geology (LfULG)** provides an interactive, dynamic map tool. In each map, information can be queried and various themes are displayed. Maps are available as pdf-files to download. Data can be ordered or downloaded in vector (layer and shape) format. They also provide a web map service (WMS). Printed maps are available for inspection at relevant agencies (Format DIN A3). All of the offers imply the big variety of different maps. Furthermore, the hazard indication map (Gefahrenhinweiskarte Sachsen) is also available for free on CD-ROM (at selected agencies or upon request).

In **Bavaria** print maps are not publicly available. The obligation to make maps / flood information publicly available takes place through the provision of online maps. Online maps run on a online platform, called IÜG Bayern (Informationsdienst Überschwemmungsgefährdete Gebiete – Informationsservice on flood endangered areas), provided by the Bavarian Environment Agency. The IÜG is an interactive map service. The service gives the opportunity to gain an overview of the status of the investigation and determination of flood areas in Bavaria. In order to address different requirements of the information service, it is possible to choose between a standard and an expert version. The standard version provides specified combinations of maps of different themes, and supplies quick overviews to the user. In contrast to the standard version, the user of the expert version can choose from a large variety of layers and has the possibility to combine them to different maps. When switching between the two user interfaces the map will be retained.

The flood maps are held and updated centrally within the Environment Agency (**England and Wales**) – however local teams have mapping and data specialists who provide data and input into the development of the maps. The Environment Agency provides a publicly available web mapping service. All of the information provided can be accessed as paper copies within Environment Agency office or sent to the person requesting the information. The information is held within a GIS and so in theory it is possible to access it via this with permission and subject to licensing from the EA.

The Federal Ministry of Agriculture, Forestry, Environment and Water Management of **Austria** and the Association of Insurance Companies Austria (VVO) started the project "flood risk zoning Austria-HORA" in 2002 provides a public available interactive dynamic map tool. It displays different probabilities of 30, 100 and 200-year flood events. Existing flood barriers are not considered (worst-case scenario). Print maps are not publicly available

In **France** the legal flood maps are held and updated centrally within the Regional Departments of the Environment, Land Use Planning and Housing (DREAL or Direction Régionale de l'Environnement, de l'Aménagement et du Logement). Printed PPRI (Flood Risk Prevention Plan or Plan de Prevention des Risques d'Inondation) and AZI maps (Atlas of flood areas or Atlas des zones inondables) are available in the prefecture. As there is a formal responsibility on the state (government, prefect, mayor, etc.) to raise awareness of the public about flood risk, several web mapping service are available for the public.

2.2.4 Existing mapping reviews and guidelines

From this review of the current practice of flood mapping in the case studies of RISK MAP some conclusions can be drawn:

- While there is considerable tradition in hazard mapping in the countries only very few examples for existing flood damage or even flood risk maps exist in current practice.
- Furthermore, the case studies show only few commonalities with regard to the contents and especially the visualisation of flood hazard or – if existing - flood risk maps.

Especially with regard to the implementation of the EU Floods Directive and the requirement to develop flood hazard and risk maps several studies have recently focussed on reviewing current flood mapping practices in Europe and – based on this – have developed guidelines for flood mapping.

In this respect first of all the EXCIMAP project needs to be mentioned in which an overview of existing flood mapping practices in Europe was given and a “Handbook on good practices for flood mapping in Europe” was published (EXCIMAP 2007). This includes recommendations on contents of flood maps for different user groups, hazard and risk modelling techniques, required data, etc.

RISK MAP’s predecessor, the RISKCATCH project focussed mainly on visualisation and design aspects of flood maps and developed guidelines on these topics, based on the results of eye-tracking tests (Fuchs et al. 2009).

Furthermore official guidelines have been developed, e.g. by the European Commission the “Risk Assessment and Mapping Guidelines for Disaster Management” (European Commission 2010) giving general recommendations on the steps of risk assessment and mapping not only for floods but also for natural hazards in general.

In Germany the „Bund/Länderarbeitsgemeinschaft Wasser (LAWA)“ published “Recommendations for the establishment of flood hazard and flood risk maps” (LAWA 2010) which provide detailed guidelines on map contents, data sources, modelling approaches and the visualisation of maps, related to the requirements of the EU Floods directive. These build on recommendations and guidelines that had been developed earlier by some of the federal states that are usually responsible for flood and water issues.

Furthermore some overview articles on flood mapping were published (Merz et al. 2007, De Moel et al. 2009) as well as on applications of flood risk mapping on the European (Barredo et al. 2007), national (e.g. De Buijn & Klijn 2009) or regional scale (Büchle 2006, Kienberger et al 2009, Meyer et al. 2009, Ebert et al. 2010).

In contrast to most of these guidelines and publications the focus of the RISK MAP project is not on hazard and risk modelling approaches (here existing data and approaches were used) but more on the viewpoint of the end user. In a combined view on stakeholder participation, their requirements contents and visualisation the special emphasis will lay in the following on the question how to come to more user-friendly flood maps.

3 Methodology for improving risk maps

3.1 Theory & methods of participation

Sally Priest, Joanna Pardoe, Simon McCarthy

3.1.1 Literature review on participation in hazard mapping

3.1.1.1 Introduction

The participation in the decision-making process by those affected by the outcome of a decision has become an increasingly important aspect of environmental policy implementation. This drive to include parties beyond the traditional decision-makers in the process is often attributed to the publication of the 1998 Aarhus Convention¹. The Aarhus Convention provides clear requirements for European Member States to include participation early on in the decision-making process. The Convention emphasises that participation should take place “when all options are open”, implying that participation should play a role in actually informing the outcome. Following the Aarhus Convention, the Water Framework Directive (WFD) (2000) was produced which placed further emphasis on the need for member states to implement participatory processes. The WFD extended the call for participation to include “all interested parties”, not simply the public. These principles have been reiterated more recently in the Floods Directive (2007) where they have been linked to the “production, review and updating of the flood risk management plans”. It is these Directives that have promoted the inclusion of participation in decision-making with regards to water, and more specifically flood risk, management. However, these ‘legal’ drivers towards participatory practices do not act independently. Instead, they are underpinned by an ever expanding literature on participation theory and practice.

Before beginning a discussion on the theoretical and practical implications of participation, it is important to define the type of participation that this paper will refer to. Much of the literature in the field discusses *public* participation specifically. This term is normally used to describe participation by individuals as members of the ‘general public’. In particular, public participation refers solely to individuals whose stake in the issue is not related to their profession. The public participants should comprise individuals personally affected by or involved in the implementation of a decision. This group is typically comprised of individuals who hold a very different perspective to that of professionally interested parties. In contrast to public participation, *stakeholder* participation is recognised as including a broader range of participants. Stakeholders may be individuals or groups, who have an interest in and influence over the decision outcome. The term stakeholder normally includes those with interests in a decision that is determined by their profession and expertise in addition to the public who may have personal stakes in an issue. In some cases the literature referring to stakeholder participation does not include the public but generally speaking stakeholder participation is acknowledged as the participation of *all* ‘interested parties’. For the remainder of this paper, participation will refer to the inclusive definition of stakeholder participation, that is to say, participation by both professional and expert interested parties including members of the public.

¹ Aarhus Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, done at Aarhus, Denmark 1998

3.1.1.2 Participation – normative value

Participation is in theory viewed as an important and valuable feature of decision making. The theory dictates that by involving those with a 'stake' in the decision making process and by taking their perspective into account, decisions will be more legitimate and democratic. This normative rationale promotes participation as valuable in it's own right as part of a democratic process. This relates to Rawlsian notions of equity, equality and empowerment (Stirling 2004).

The rise in interest in participatory approaches is often attributed to Arnstein's article (1969) on different degrees of participation. In the 1969 text, Arnstein develops a 'ladder' of levels of participation which reflect the degree to which participants are enabled through a participatory process to influence decisions (see Figure 3.1below).

In Arnstein's classification, the lowest rungs refer to situations where decisions are made without a participatory element. As such support for these ideas is manufactured after the decision has been taken (Pretty 1993 and Arnstein 1969). Moving up the ladder, Arnstein sceptically views the middle rungs as forms of tokenistic participation, whereby participation is included in the decision making process but does not have genuine influence over the final decision. Finally the highest rungs of partnership to citizen control demonstrate Arnstein's view that full effective participation is synonymous with citizen power to not only influence the decision but to ultimately have control over it (Pretty 1993 and Arnstein 1969). Arnstein advocates that participatory processes should aim to achieve as high a level of influence as possible, suggesting that a process similar to that described by the top rung is preferable to a process of a nature comparable to a lower rung.

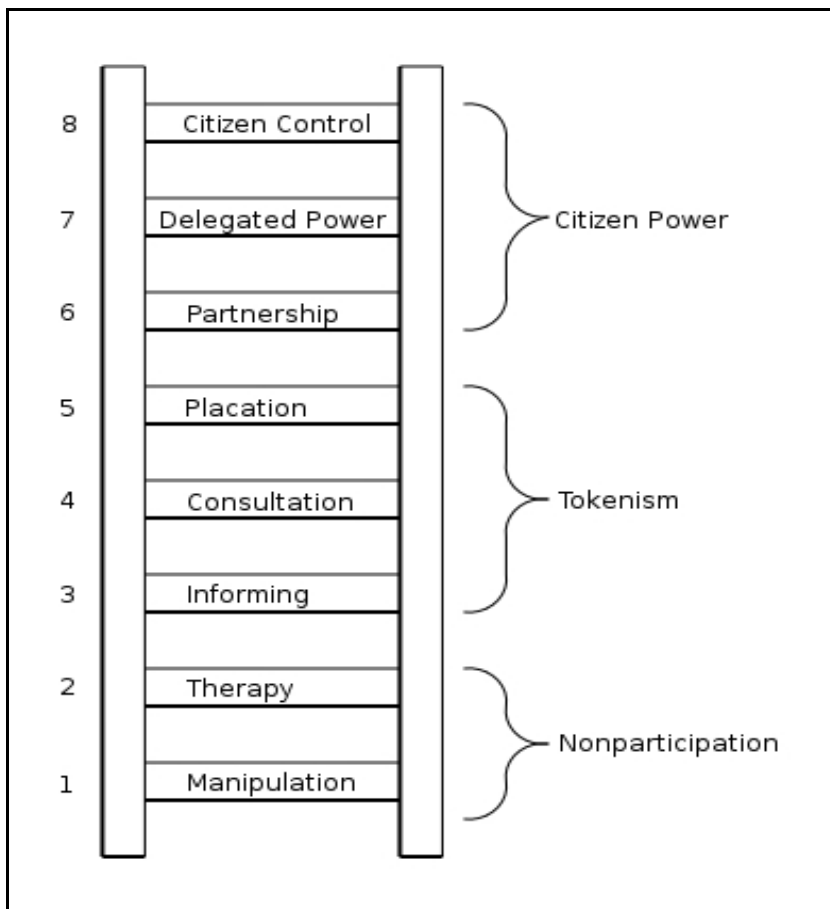


Figure 3.1: Arnstein's ladder of participation

Arnstein's ladder is an important starting point highlighting the need to ensure that the outcome of participation is able to influence the final decision, however, the literature on participation has developed numerous criticisms to such linear classifications of participation. In particular, the literature argues against Arnstein's argument for a linear classification that advocates greater/more intense participation as the most desirable, suggesting instead that the highest levels of participation might not always be the most suitable. For example, Rowe and Frewer (2000) highlight the detrimental impacts of participation with a public that lacks a suitable knowledge and understanding of the issue. In such circumstances it may not be appropriate to allow the public to take full control of decision making in all cases, nor would it be practical.

Arnstein's ladder of participation has also been criticised as it is based specifically on power relationships in decision-making. Arnstein strongly advocates that participation should empower the public and minor groups to take greater control and wield increased power until finally making decisions for themselves. More recent literature discusses alternatives to this 'power-struggle' participation, recognising a number of inherent flaws. The alternative writing on participation considers participatory practices to include a greater range of benefits, beyond simply sharing power. Rasche et al (2006) in particular consider participation to be made up of six different elements. These elements are described as activity, reach, equality, flexibility, power sharing and transparency. Rasche et al use these six dimensions to demonstrate that the intensity of participation in practice does not fit well onto Arnstein's linear ladder, but instead can vary in intensity between the different dimensions. According to Rasche et al (2006) by considering the intensity of participation between the different dimensions it is possible to group participation according to its general attributes, however, the groupings are recognised as imperfect and act simply as guides as to how a participatory process might be characterised. The broad groupings are matched with definitions that highlight their strengths and weaknesses in participation, but the authors are careful to emphasise that there is no hierarchy and rather that participation must primarily be appropriate for the type of outcome required.

Similar to Rasche et al (2006) there is an increasing shift away from the hierarchical conception of public participation levels towards an understanding that participation should be appropriate to the subject or issue. This shift coincides with increasing reports of projects that attempt to apply participatory approaches in practice. Du Toit and Pollard (2008), as one example, have argued that participation cannot be fully achieved or implemented in practice. They suggest that inadequate or incorrect participation is not only impractical but may even result in a more negative and harmful outcome than if no participation had taken place. The results of projects such as these, highlight problems in the practical application of public participation and recommend that instead of aiming for maximum participation and influence, a participatory process should instead be realistic in its goals and tailored to the achievement project goals (Reed 2008 and Yang and Callahan 2007). Indeed, Du Toit and Pollard find that participant expectations are often central to the effectiveness of a participatory process, highlighting that if these expectations are not met by the participatory process, this can result in anger and frustration which can negatively impact upon future participation and fail to achieve the democratic aims of participatory practices.

As the literature moves away from Arnstein's linear model, there is increasing discussion of alternative classifications which consider the components of participation (such as the Rasche et al, 2006 classification) or which consider participation from the perspective of the benefits and effects of participation (e.g. Stirling 2004).

The Rasche et al (2006) classification demonstrates participation as comprising of six dimensions. These are activity, equality, reach, flexibility, power sharing and transparency. The six dimensions resemble the good governance principles discussed above but they also highlight that the intensity of participation can vary along these dimensions depending on the participatory approach that has been deemed most appropriate for the problem at hand. Such alternative classifications as this emphasise an alternative to the hierarchical approach of Arnstein and provide instead a framework for a participatory process that is appropriate. Such frameworks support the view that participation should strive to be appropriate rather than idealistic and they highlight the strengths and weaknesses in participatory approaches according to

their scoring on the different dimensions. This can be an important tool when considering how to achieve effective participation.

Taking the classifications of Arnstein and Rasche (for example) further, Stirling (2004) has developed the ideas of Fiorino to define participation by the outcomes of participation rather than as a hierarchy or classification. These outcomes are defined as three rationales for participation; the normative (described above), instrumental and substantive.

3.1.1.3 Instrumental

The Instrumental rationale

The participation process is designed to increase trust and legitimacy in the mapping process and product. The instrumental rationale seeks for participation to increase networks to promote joined up working.

The instrumental rationale describes how participation in practice can be used to build trust, acceptance and understanding between stakeholders and decision-makers. The instrumental rationale suggests that the process of participation works most effectively where a range of stakeholders, representing different interests are brought together to consider an issue or problem. By discussing and considering the problem and representing competing interests the participants, in theory, gain a greater appreciation for the challenges of satisfying different and often competing interests in order to best resolve of problem. The theory dictates that through such participatory processes stakeholders should be able to understand why a decision is made and why that decision may not fully satisfy their objectives. Through such an understanding it is expected that participating stakeholders may be more willing to accept a decision that does not necessarily satisfy their objectives, arguing that understanding the reasoning and complexity behind the decision will aid this acceptance and generate stronger support for the implementation of the decision.

By involving stakeholders in the decision making process, the instrumental rationale suggests that participation may foster a degree of ownership of the decision which further enhances the effectiveness of implementation. In addition the process of participation allows networks and connections between different stakeholders to be developed and enhanced. This improves the cooperation between stakeholders and further adds support to the implementation phase. Participatory processes thus offer the potential to strengthen interconnections that can improve relations between and attitudes towards stakeholders for future cooperation.

3.1.1.4 Substantive

The Substantive rationale

The participation is designed to increase the breadth and depth of knowledge to be considered and to enable social learning.

Decisions are usually made on imperfect knowledge and information. It can be argued that if all variables are known there is little need to make a decision as the best option is clear. However, in reality, such instances of perfect knowledge and information do not exist. Instead, decisions must be made on the best available knowledge and information.

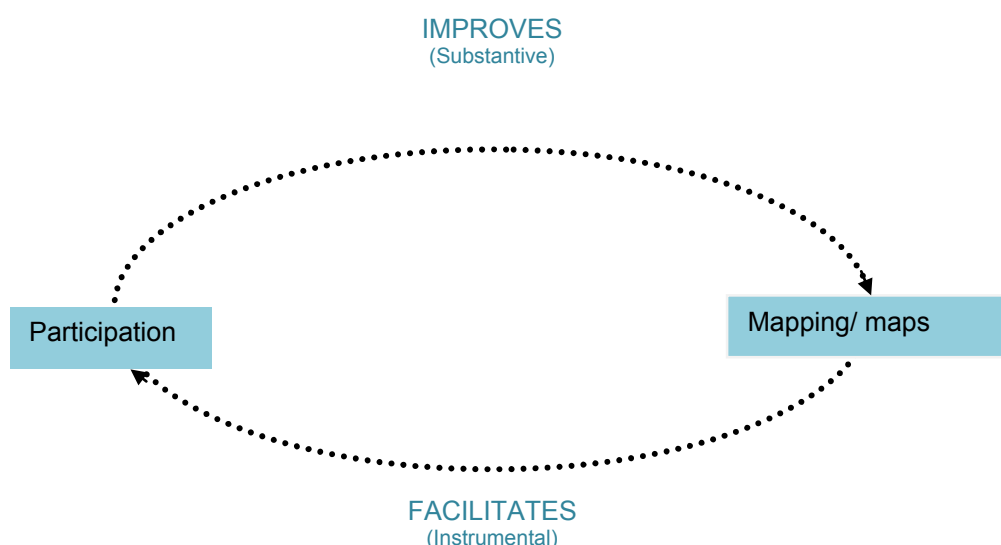
Stirling's substantive rationale (2004) suggests that participation can provide a means for improving the availability of knowledge and information. It recognises that the inclusion of a broad range of stakeholders enables a broad range of perspectives to be included in the decision making process. Each perspective is based on knowledge and information gained through experiences and the wider the range of perspectives, the wider the range of knowledge and information.

The substantive rationale has developed from the view that stakeholders such as the general public, who are not necessarily included in decision making, actually have their own form of ‘expert’ knowledge. In large projects designed at a non-local level, such local knowledge can be overlooked only to result in problems developing during the implementation phase, problems that the inclusion of local knowledge during the consultation phase may have been able to prevent or avoid. As such, the substantive rationale makes the case for participation and stakeholder involvement based on the grounds that it enables broader and deeper knowledge to be taken into account during decision making processes in order to result in better quality decisions that are more likely to be successfully implemented.

The substantive rationale supports the ideas of social learning, arguing that different groups of stakeholders can provide their own type of ‘expertise’ which can be shared to enhance understanding and knowledge.

3.1.1.5 Participation and hazard mapping

As Stirling’s (2004) approach in particular highlights, participation can provide many benefits to improve the effectiveness of decisions. Stirling advocates that participation can provide these benefits in three main arenas: the normative, instrumental and substantive rationales describe these benefits. Moving beyond the theoretical literature to practical application, there is a range of literature that demonstrates the realisation of Stirling’s rationales in practice (for example: Simao et al., 1990; Rowe and Frewer, 2000). The Risk Map project will explore how maps can be used to facilitate a participatory processes, but also how maps can be improved by such a process (see Figure 3.2 below).



Substantive: Participation to improve mapping

Instrumental: Mapping facilitates participation

Figure 3.2: Process of participation in hazard mapping

There is a body of literature that highlights how projects with similar goals to Risk Map have been able to effectively incorporate participation to improve the outcome (for example Klinke, 2009; Hagemeyer-Klose and Wagner, 2009). This literature begins by examining the benefits of a participatory approach in the broader context of hazard mapping, drawing links with the theory described by Stirling (2004).

It is widely recognised that maps are important tools in raising public awareness about natural hazards (Hagemeyer-Klose and Wagner 2009 and Haynes et al 2007). Maps are extensively documented within

the literature as being useful tools for raising hazard awareness due to their suitability towards the conveyance of large amounts of technical information in a small space (Bell and Tobin 2007 and Fuchs et al 2009). As maps are visual products they are potentially better suited to capture attention and convey information to a diverse audience with varied background knowledge (Haynes et al 2007 and van Alphen et al 2009).

The objective of distributing hazard and risk maps to the public is therefore that these maps will raise awareness but also to encourage the public to take action if they discover that they are vulnerable (Hagemeier-Klose and Wagner 2009, EXCIMAP 2007, Grothmann and Reusswig 2006). Where effective, maps can contribute towards efforts that result in a significant reduction in damage when a flood event does occur (see example of Cologne in Grothmann and Reuswig 2006, Bird and Dominey-Howes 2008, Correia et al 1998, Fuchs et al 2009). In order to achieve this objective, maps must be easily understood and interpreted by the recipients. They must also be motivational to encourage recipients to respond to the risk (Leone and Lesales 2009).

Various literatures discuss the issue of the effectiveness of maps (such as Cronin, 2004; Bell and Tobin, 2007). As one body of literature examines the responses of people to hazard maps in general (Cronin, 2004 and Burningham et al, 2008), another section of hazard mapping literature considers the reasons why maps may be ineffective in promoting the public to take action to reduce their vulnerability in response to awareness raising from maps. Hagemeier-Klose and Wagner (2009) and Rowe and Frewer (2000), in particular, found that maps were not particularly effective in achieving this objective. They found that the public would often respond to a map by disagreeing with the contents, believing them to be inaccurate or they would enter a sense of denial to negate the risks (Burningham et al 2008). Hagemeier-Klose and Wagner (2009) highlighted that maps currently are proving unable to override the natural sense of security that inexperienced people feel towards their homes.

The reasons for the ineffectiveness of maps have been debated throughout the literature on hazard and risk mapping. Some argue that the content of the maps has not been designed well enough to communicate to laypersons the level of risk that they face in a manner that is clear to interpret (Burningham et al 2008). Flaws in mapping have commonly been attributed to the content and design of maps, affecting the ease of interpretation for laypersons (Cronin 2004). Recent literature highlights that the underlying problem may be related to the design process which is conducted by experts as opposed to laypersons (Hagemeier-Klose and Wagner, 2009).

The choice of such content is traditionally made by the cartographic designers and experts wishing to convey their technical and scientific knowledge to laypersons (Bell and Tobin 2007). The result of this is a one-way exchange of information with the result that information contained on a map may be too technical or complex and therefore difficult to understand and interpret as a layperson (EXCIMAP 2007 and Bayley and French 2008, Fuchs et al 2009). This literature argues that there is a difference between the perceptions and interpretations of experts and those of laymen (Burningham et al 2008). Bell and Tobin (2007) highlight, through their research, that experts have a different understanding of hazards and hazard maps to the lay public. In particular, they emphasise problems with interpretations of the '100 year flood'², highlighting that the public see the extent of the '100 year flood' as denoting areas potentially affected and areas that are safe, rather than comprehending that a greater flood could exceed these boundaries (Bell and Tobin 2007; Siegrist and Gutscher 2006). However, there are some reports that have found inconclusive evidence to support this theory. The work of Bell and Tobin (2007) and Siegrist and Gutscher (2006) demonstrate that experts and lay persons vary in their interpretation of hazards and hazard maps.

Participation and mapping

As there is an increasing integration of public participatory tools and processes, there is a growing literature concerning the value of addressing the gap between expert and laypersons interpretations of hazard maps (Burningham et al 2008, Hagemeier-Klose and Wagner 2009). This literature suggests that a

² The extent of the '100 year flood' is an American term for describing the extent of a flood that has a 1% or 1 in 100 probability of occurring in any given year. In the US the '100 year flood' extent is the standard modelled flood extent.

solution to the ineffectiveness of hazard and risk maps may be found through the employment of a participatory approach to map development (Klinke 2009). Several studies have been conducted to investigate the potential of such an approach (Hagemeier-Klose and Wagner 2009). In addition, research in this field specifically relating to flooding has been conducted by Fuchs et al (2009). The results of Fuchs et al. (2009) highlight the potential for participation to contribute towards the improved effectiveness of maps. However, there is no literature available to evaluate the effectiveness of these maps as this is a newly emerging area (Haynes et al 2007 and Laurian and Shaw 2008). The results of the incorporation of such participatory approaches, however, has been productive and worked well in helping to inform the design of such maps, suggesting that there can be an increased confidence in the ease of interpretation, but the ability of the maps to encourage lay persons to take action has not yet been tested (Haynes et al 2007, Laurian and Shaw 2008, Cronin et al 2004, Hagemeier-Klose and Wagner 2009 and Fuchs et al 2009).

Participation in practice: Substantive

A participatory approach can improve the content and design of maps by highlighting features that are particularly useful to laypersons (Reed 2008). On another level, a participatory approach can also be used to validate the content of maps. This has been highlighted by the work of Correia et al (1998) and Leone and Lesales (2009) who used participatory mapping to incorporate local knowledge into modelled maps to produce an improved product. Their research has shown that, in some cases, the public have been correct to doubt or query the accuracy of map data, providing examples where the public have contested map content. This provides enhanced knowledge for experts and cartographers. From this perspective, participation has been shown to improve the quality and accuracy of content in addition to developing a map that is better tailored to interpretation by the end-user (Substantive approach) (Haynes et al 2007, Klinke 2009, Correia et al 1998 and Milligan et al 2008).

A method attempted by Simao et al (2009) involved participants assessing a map visible on a computer. They were able to 'attach' comments to the map which were then collated and viewed by the researchers to assess the effectiveness of the map design and the accuracy of the content based on participants' comments. This approach can be labelled a 'participatory Geographic Information System (PGIS)'. GIS in itself is a powerful tool in mapping as it allows a vast amount of information to be 'layered' on to a single map. Beyond the production of map products, GIS is also suited to the analysis of spatial data by experts. There is a new literature emerging that examines the use of GIS by the lay public (for example White et al 2010 and Rowe and Frewer, 2000). The literature on this area currently focuses on providing a new method for the lay public to interact with visual information and convey their knowledge and ideas to the experts in a novel format. Such a method is an example of an exercise to gain greater knowledge and gain feedback on the aesthetic aspects of map functionality. Participatory GIS assists with the development of a two-way transfer of knowledge (Rowe and Frewer 2000). This creates a more interactive experience which can engage the public more effectively in the issues.

Beyond examining Participatory GIS, there has been limited research published on methods for involving the public to gain a better understanding of their subconscious processes in map reading. The leading research in this area is produced by Fuchs et al (2009) who investigated the use of Graphic Semiology to assess the functionality of maps and how the public reads them on a more subconscious level (Fuchs et al 2009, Spachinger et al 2008 and Chipman et al 1996).

Other options for participatory methods include producing multiple maps which participants are asked to comment on. There is a body of literature that has begun to assess the variations in content in maps and how the colours and symbols are interpreted by the public. EXCIMAP is a project involved in the assessment of maps, detailing current practices in various European states. Beyond this, others such as Siegrist and Gutscher (2006) have conducted research on symbology and colours in mapping in specific countries which provides detailed comments on why certain symbols were preferred over others. This literature can provide a useful starting point for developing different map contents and designs for use in the participation workshops.

Participation in practice: Instrumental

By including the public in the mapping process, legitimacy and transparency goals can also be met, tackling disillusionment (Bayley and French 2008, Milligan et al 2008 and Hagemeyer-Klose and Wagner 2009). As Burningham et al (2008) discussed, criticisms have been made of the Environment Agency in the UK in that there is a lack of understanding that the public will tend to evaluate information on risk from various sources. This can develop a sense of distrust if the sources give different results.

Including the public in the development of these maps enables a two-way process of social learning to be facilitated. This allows the public to understand the intentions behind the maps and the importance of the information conveyed. In addition, the 'experts' producing the maps will be able to learn how the public interpret and evaluate the information and what action (or inaction) that results in. Such a process of social learning can foster greater understanding and therefore greater trust between the stakeholders involved (Burningham et al 2008, Bayley and French 2008 and Cronin et al 2004).

3.1.1.6 Conclusion

As demonstrated above, the literature supports the adoption of a participatory approach to mapping. The literature highlights that participation has potential to overcome the gap between expert production and layperson use. There are several examples of such approaches being applied and also examples of the maps that have been produced; however, there is a lack of evaluation of such products, leaving a gap in the literature regarding the effectiveness of participatory maps in practice. The literature, however, emphasises the need to adopt a participatory approach in contrast to the traditional map production by experts as it highlights how maps vary in content and design following a participatory process. As several examples of participatory mapping are available there is a good volume of material on methods that could be used and the expected results of these. Overall, the literature highlights that the methodology utilised must be tailored towards the desired type of outcome in order to be effective.

3.1.2 Participation framework

Working Definition of Stakeholders:

"Stakeholder includes all persons, groups and organisations with an interest or "stake" in an issue, either because they will be affected or because they may have some influence on its outcome. This includes individual citizens and companies, economic and public interest groups, government bodies and experts"
(HarmoniCOP "Learning Together to Manage Together ...")

3.1.2.1 Introduction

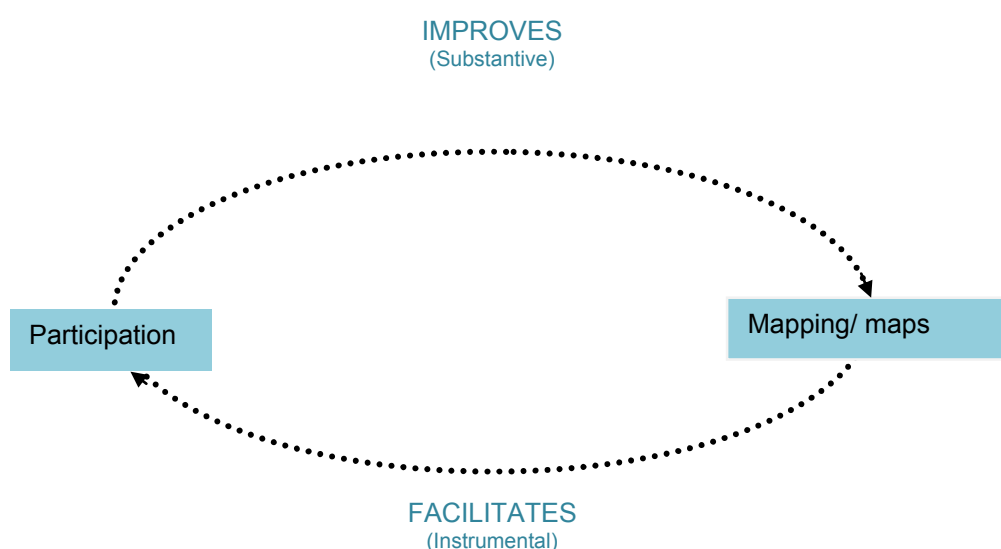
Stakeholder participation has come to be widely regarded as a crucial component of decision making. The theoretical benefits of such participation are widely advocated throughout a broad based literature, however, implementation of participation in practice has resulted in concerns that the theoretical benefits of participation are not easily realised. The result of numerous attempts to practice the theory has demonstrated a need for a carefully considered approach to participation that is tailored towards the specific project, task or decision.

Learning from the findings reported in the literature, RISK MAP aims to implement effective stakeholder participation through a tailored approach (Bayley and French 2008). The RISK MAP project is comprised of four case studies from three European States, each with a different context and institutional system. As such, the following framework can be used to guide the design of the participatory process to be tailored towards the individual case studies.

3.1.2.2 Conceptual framework

The literature on hazard mapping and participation, taken together demonstrates that participation may overcome the obstacles to effective hazard mapping and risk communication. Based on the rationales described by Fiorino (2004), the conceptual framework for the Risk Map project can be viewed as demonstrated in the diagram 3.3.

As the diagram shows, the objectives of the Risk Map project are twofold. Firstly the project aims to explore how mapping may be used to facilitate participation. Secondly, the project will examine how participation in turn improves flood maps. These two objectives can be viewed as focussing on the substantive and instrumental rationales described by Stirling.



Substantive: Participation to improve mapping

Instrumental: Mapping facilitates participation

Figure 3.3: Process of participation in hazard mapping

Considering the first objective (participation facilitated by mapping) according to Stirling's rationales, the instrumental rationale fits this objective. The instrumental rationale implies that by involving the public in a flood mapping process, they may be better able to understand how maps are developed, allowing them to make an informed judgement of their accuracy and reliability. Equally, the involvement of the public in mapping should increase impressions of trust and legitimacy as the maps will have been developed with public opinions taken into account. The Instrumental rationale recognises the benefits of participation as fostering the building of networks and trust. This is also facilitated by co-operation in the participation process which allows stakeholders to connect with each other to develop networks and trust. The aim of the process will be to explore how effective a participatory mapping process is at facilitating the instrumental aspect of participation.

From the perspective of the second objective, whereby participation improves mapping, this relates to Stirling's substantive rationale whereby the participation of a broader group of stakeholders than is normally engaged in mapping is expected to be able to improve maps by contributing more detailed information to improve, verify and correct mapped results.

The co-operation and social learning components of the process relate to the substantive and instrumental rationales (Stirling 2004) (Substantive and Instrumental). The Substantive rationale recognises the benefits of participation as enriching and enhancing decision making by providing a greater breadth and

depth of knowledge and information for consideration. This is facilitated by a process of social learning, whereby different stakeholders are able to share their knowledge, ideas and opinions to influence the participation process, but also where social learning is facilitated by the process itself.

3.1.2.3 Designing a participatory approach

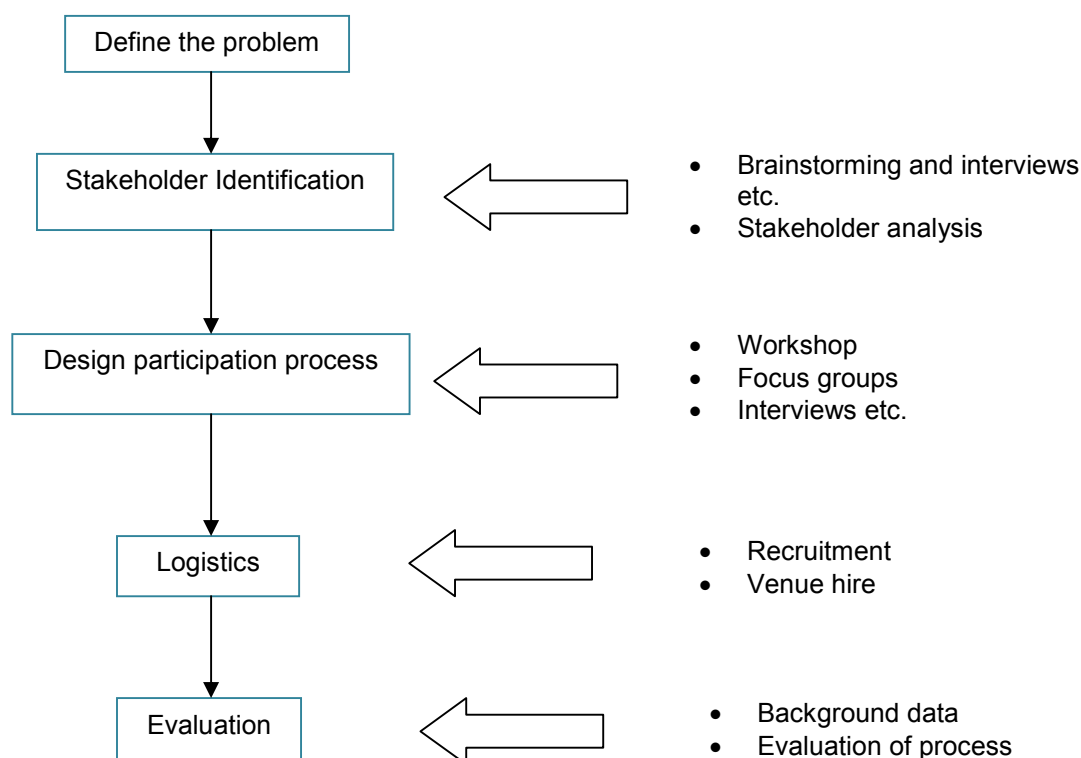


Figure 3.4: Process for designing a participatory approach

The above diagram depicts the design process for the workshops in general stages. These general steps provide a direction for the design process whilst remaining highly flexible in order to accommodate and tailor the process towards the objectives and requirements of each case study.

Define the problem

A clear definition of the problem to be considered is the initial stage in the design of a participatory approach. The problem will guide the entire design process and will influence the choices made at each stage. By focussing on the problem or issue, the participatory approach can be tailored towards the particular project objectives. According to the literature such an approach should result in a more effective and successful participatory approach compared to methods which centre on achieving maximum participation as a goal (such as advocated by Arnstein's ladder in Figure 3.1).

Stakeholder identification

Once the problem has been defined this can be used as a focus for the identification of the relevant stakeholders. The process of stakeholder identification should be conducted with the primary aim being to achieve a broad reach of participants, that is to say that the participants should reflect a wide variety of perspectives on an issue, in order to ensure that all perspectives are considered throughout the process.

In order to achieve as wide a range of stakeholders participating as possible, it is important to identify stakeholders in an open and inclusive process. There are many different methods that may be used to

achieve this and these methods may be combined or used in sequence to further improve stakeholder identification. Some examples of useful stakeholder identification methods are discussed below. Ultimately, the approach settled upon should be tailored to suit the particular circumstances of each case study (Laurian and Shaw 2008).

Brainstorming

In order to create as inclusive a list of stakeholders as inclusive as possible for invitation to participate in the workshops, a first step is to create a brainstorm of potential stakeholders. Potential stakeholders will include any groups, organisations or individuals affected by or important in the implementation of the outcome. The goal of this step is to create a full list of all possible stakeholders, with no restrictions at this stage. The list can be creative and include stakeholders such as future generations. This process is often conducted as a top down process, with project leaders developing the list. As such it is very possible that some stakeholders may be forgotten or not known about in the first place. In order to minimise this potential problem, it is advisable that the brainstorming process be conducted by more than one individual (Lupo Stanghellini and Collentine 2008).

Interviews and focus groups

To further develop the list of stakeholders, scoping interviews and focus groups may be conducted with some of the initially identified stakeholders to investigate whether they feel other groups would be particularly important to include. This process may highlight new groups and individuals that were missed during the brainstorming process.

Whilst stakeholder identification will likely occur as an initial step in the process of designing and implementing participatory decision making, stakeholder identification can also be conducted throughout the later stages. This approach might be achieved by inviting participants to identify any missing stakeholders throughout the process whenever contact is made with participants. However, this approach would require a process to be designed that allows for the integration of new participants at several different stages and such a process might not be suited to the project under consideration (Posthumus et al 2008).

Analysing the stakeholders

Following the main process of initial stakeholder identification, it is likely that refinement of the full list will be necessary due to budget or similar feasibility constraints. In order to assist the refinement of the stakeholders list, a method of stakeholder *analysis* may be employed.

Stakeholder Analysis enables the identification of the interests and knowledge that different stakeholders possess. This allows the stakeholder list to be tailored to be representative and more equitable, as project facilitators may be able to identify multiple stakeholders that represent the same issue. In these circumstances the list may be refined so that only one of the many stakeholders representing the same perspective or knowledge is invited to participate. It is important that this stage of the process concentrates on such narrowing of the list but in a manner that retains an equitable representation of stakeholder interests.

There are a variety of methods that may be used to assist in the process of stakeholder analysis and refinement of the stakeholder list. These are well documented in the literature, however, this should not preclude new methods being developed and trialled.

Some examples of current methods for stakeholder analysis include rainbow diagrams, which depict how a stakeholder might be affected or might be able to affect the process/project. Alternatively, categorisation may be conducted through methods such as card sorting. Categorisation can help to divide a list of stakeholders into categories such as the level of interest, influence or cooperation. Another method is knowledge mapping which helps with the identification of who knows who and who knows what (Raadgever et al, 2008; Billgren and Holmén 2008; Klinké 2009).

One particularly useful example of Stakeholder Analysis categories is that of the Environment Agency (EA). The EA categories are as follows³:

- **Sector** (public, private, voluntary, community)
- **Function** (user, service provider, regulator, landowners, decision-maker)
- **Geography** (living within postal district Y, living in flood risk area)
- **Socio-economic** (income, gender, age, length of time living in area)
- **Effect** (directly affected, indirectly affected, able to affect the work/issue)
- **Understanding/experience** of topic X (none, low, medium, high, more than you)
- **Known or likely position** (for or against project Z)

At the end of this process the stakeholder list will be illustrated with more details on the nature, knowledge, connections, influence and interest of different stakeholders with regard to the project. Representatives of the different perspectives may then be identified and where multiple groups or individuals represent the same perspective, knowledge, influence or value, it may be possible to reduce the stakeholder list so that an equal number of representatives will participate representing each different perspective.

The reduction of duplicates is particularly important in order to ensure equality in the process. By including a balanced number of representatives from each different perspective, participation will be inclusive and equitable. This is particularly important when it comes to the workshops themselves, as an even number of representatives from different perspectives will reduce the potential that one group may dominate another based on the fact that they simply outnumber other representatives. Such a process optimises participation and therefore achieves greater efficiency in the process in addition to be inclusive and equitable.

Of course, this process begins to introduce potential problems in meeting the idealistic participatory process goals. It must be recognised that individuals with the same stake may highlight different issues and place emphasis on different aspects of a problem as individuals are all unique and may therefore represent variations in opinions. Although this filtering deviates from idealistic participation, it does recognise the realities of participation and permits reasonable allowances for this. Filtering, it is hoped, at least provides a mechanism for ensuring the credibility of the participatory process by maintaining the variety and breadth of participants within a realisation of resource constraints.

As part of the stakeholder identification and stakeholder analysis process it is important to ask those contacted if they can think of any other individual, group or organisation that they feel should be included. This will help to widen the reach of participants. In addition, during this process it may be possible to briefly survey the opinions of potential stakeholders on the nature of the problem or issue. The results of this can feedback into the process to help better define the problem or issue to reflect the perspectives of the participants. The process of re-defining or modifying the problem based on participation may also assist in the following stages of optimising participation as it may highlight new groups that may or may no longer be relevant to the process. At this point a brief reflection on the stakeholder analysis and optimisation processes should help to further improve the efficiency, effectiveness and inclusion of the project.

Select participation method

Once stakeholders have been identified and analysed, the method for facilitating participation may be designed. There are many different participatory methods well documented in the literature but again new methods can also be developed. Some of the most commonly used and well documented methods are described below to provide ideas for method design.

³ Taken from Environment Agency "Working with others; Building trust with communities: A guide for staff", p.13

Workshops

Workshops as a method for participation involve the simultaneous attendance of a group of stakeholders who participate in activities that help explore the issue and provide a platform for discussion. Workshops are characterised by several tasks which participants work collaboratively on. The participants may work together as one large group or may be split into smaller groups. Splitting into smaller groups is preferable in order to provide greater opportunity for each participant to share their ideas.

Focus Groups

Focus Groups are similar to workshops but are characterised by larger grouping, rather than split groups. In addition, focus groups tend to be discussion based rather than in workshops where tasks and activities are central and used to enable discussion. Focus groups allow all participants to discuss together but rely upon facilitation to ensure the discussion is appropriately moderated.

Interviews

Interviews take place on smaller basis than workshops and focus groups. They tend to be conducted on a one-to-one basis but may be done with two or three people at once. Interviews place the researcher in a more central role than in workshops and focus groups. For interviews the researcher is less a facilitator and moderator but instead plays a more active role directly engaging in the two-way discussion.

Questionnaires

Questionnaires can be conducted by the researcher or without support. Commonly, questionnaires are designed to be completed without assistance from the researcher and are designed to capture opinions and knowledge more anonymously. Questionnaires tend to ask key questions which require shorter and simpler answers rather than facilitating a more complex discussion or dialogue.

Logistics

When the participatory method has been selected and designed, the next step is to put the method into practice. This will involve recruiting the stakeholders previously identified and organising the participatory process. Some important considerations/logistics for the final stages before participation takes place are:

- How to invite participants
- When to host the participation event (which days and what time)
- Where to host the event

How to invite participants

There are various methods that may be used to invite participants to attend the workshops or focus groups. The methods chosen should consider the culture and circumstances of the case study area in particular. For this it may be helpful to consider whether face-to-face contact (i.e. by knocking on doors) would be preferable and feasible or whether recruitment may be achieved through letters, telephone calls or emails instead. Alternatively, a variety of methods may be used together or in stages, for example a letter may be sent to advise of the project and this might be followed up by a telephone call to issue the invitation.

When to host the participation event

For questionnaires that don't require researcher support, this is less important but for workshops and focus groups in particular, the timing needs careful consideration. Depending on the types of participants, events may be best attended if held during the day (say for professional participants) or in the evening (say for public participants who are likely to be at work during the day). In addition the week chosen and the day of the week should be considered. Are there any weeks that people are particularly likely to be away from the area on holiday (for example mid-term holidays in the UK)? Are there particular days when participants are unlikely to be prepared to give up their time (for example Weekends)? Again, these details will depend on the circumstances and culture of the case study area.

Where to host the event

The location of the events such as focus groups or workshops should encourage participants to attend. As such it may be beneficial to site the event in a central location or near to the majority of the participants. This will depend on whether the participants are from one single area or whether they are based in different places, making it impossible to locate a site near to everyone.

Evaluation

Evaluation of the participatory approach is an essential component of the process. Evaluation can be used to ensure that the participatory approach met its objectives, that participants benefitted as planned and to explore where lessons may be learned for future participatory activities.

The evaluation should aim to gain further insight into the effectiveness of the process from the perspective of the participants. Evaluation can thus be utilised to capture participants' opinions and experience of the participatory process. Questionnaires and interviews are commonly used methods for evaluation of participatory processes. Questionnaires are used to quickly capture a range of information in a standardised format which lends itself to statistical analysis. In addition, questionnaires are slightly removed from direct reporting to the hosts which may aid honest and open reporting. Interviews are useful to capture more detailed information. They are less anonymous than questionnaires but can capture a greater depth of information.

3.1.2.4 Conclusion

To conclude, this framework has set out a flexible method for designing a participatory process. The options presented should be considered with the specifics of the case study in mind to ensure that the process is suitably tailored towards the case study to maximise effectiveness.

3.1.3 The RISK MAP process

The workshops should be designed with the two main rationales (substantive and instrumental) in mind.

For the Substantive rationale to be realised, a suitable workshop design would be one that facilitates social learning. Social learning will enable knowledge and opinions to be shared between participants and also with facilitators. This will increase the breadth and depth of knowledge to be considered in the decision making process (Stirling 2004 and Petersen et al 2009).

In order to facilitate the instrumental rationale, a workshop can be designed to include processes that allow participants to collaborate and work in groups. This will present opportunities to co-operate and in doing so to build networks and trust (Stirling 2004 and Milligan et al 2008).

3.1.3.1 Aims and objectives

The aims of the workshop can be divided into two broad parts:

- Aims of the participation process
- Aims of the mapping process

The aim of the participatory process is to use maps to foster participation, using maps and mapping as tools to enable stakeholders to engage with issues concerning flood risk management and the role of flood risk maps. The tasks conducted in the workshops will aim to allow stakeholders to participate in the decision making process, achieving the normative rationale. In addition, by cooperating on group tasks the participants will have opportunities to build networks between themselves and with the coordinators,

achieving the realisation of the instrumental rational. The mapping tasks and processes in the workshops may also facilitate the sharing of knowledge, opinions and understanding contributing towards social learning and the substantive rationale.

The second aim of the workshops relates to the mapping process, in which the workshops aim to contribute towards improved understanding of the requirements of stakeholders for flood risk maps. The tasks of the workshops will be designed to capture the knowledge, opinions and perspectives of participants (facilitating the substantive rationale), in order to help design and modify maps to improve their usefulness to stakeholders.

Whilst the aims discussed here remain very broad, it is important to recognise that throughout the process, these aims will be narrowed down according to the input of the stakeholders and participants desires/requirements. This will allow the process to be directed by the stakeholders/participants, making it a more effective process with minimal bias from the coordinators.

3.1.3.2 Workshop framework

The framework set out in Figure 3.5, below, demonstrates the general stages in the workshop process. These stages will vary in content and application based on the particular circumstances of each case study. As such, the stages remain open and flexible. In the following sections, the different stages of the framework will be discussed in greater depth. Each stage will set out a range of ideas with suitable flexibility and guidance on the considerations that each case study should make when designing their process in detail.

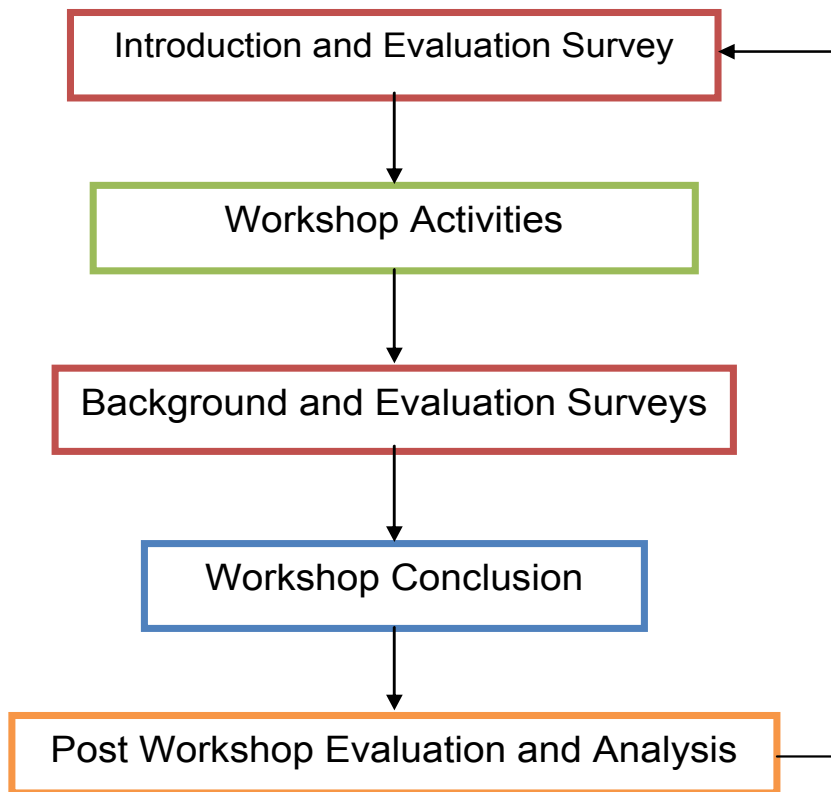


Figure 3.5: Workshop framework

3.1.3.3 Workshop introduction

The Workshops can begin with a brief introduction to the project and the workshop process. The introduction is an important stage as it may help to ease participants, creating an atmosphere conducive to discussion and activity.

Aspects to consider including in the introduction are bulleted below:

- Introducing the co-ordinators by name- the participants are more likely to feel comfortable and find the coordinators approachable if they know who they are
- Introducing the participants to each other- particularly beneficial for professional users, to help them identify potential networking opportunities, but also to create a comfortable atmosphere
- Introducing the project- giving details of the general project aims and objectives, in particular demonstrating the purpose and value of participation so that participants understand their importance in the process and why they have been selected

The information that is given on the project, in the introduction, should be concise so as to maintain interest and not overwhelm participants. It should be made clear why the participants have been included and what the process will consist of. However, it is important to ensure that the information given to the participants at this stage does not sway their opinions and comments. Guidance on the type of topics to be discussed is important to ensure that the process is productive, but this should not stretch to influencing or guiding the results of the process to fit a preconceived result. For example, no information on an expected outcome should be provided, as this should still be open at this stage.

There are a range of methods that may be used to present the introduction. These may vary from basic, informal introductions without visual aids, to electronic presentations and short videos. The methods chosen for the introduction should be tailored to suit the participants and the project. Table 3.1, below, provides a simple breakdown of the potential presentation types to assist the identification of a suitable method for the introduction.

Table 3.1: Presentation methods for the workshop introductions

Method	Pros	Cons
Informal, basic introduction. Sitting in a circle on the same level. No visual aids	Helps provide a relaxed setting. Reduces any divide between participants and coordinators. All seen on a similar level.	Without visual aids, participants may lose interest, especially if introduction is long. Some audiences may expect a more professional appearance.
Basic presentation with visual aids such as power point slides	Visual aids may maintain interest, particularly suitable for introductions that must give technical or background information to ensure all participants have sufficient knowledge to participate.	Less suitable for very short presentations or simply introductions to coordinators and participants.
Formal, professional presentation	May help raise opinion of process, participants may take process more seriously.	Creates a more formal environment, less conducive to achieving the instrumental rationale.

In order to ensure that participants feel comfortable to give their honest opinions and share knowledge, it is important to reassure them that the information they provide will be treated with full confidentiality. Participants need to be assured that their names will not be linked to their comments or results and that their data will be protected under the relevant data protection laws. This aspect should be covered in the introduction and may be supported by a written sheet that reiterates this.

3.1.3.4 Evaluation survey

Evaluation is an important aspect of any participatory process, as it facilitates an assessment of the level of success achieved by a process. In order to complete an effective evaluation, it is important to consider evaluation throughout the process and design the workshops accordingly.

As one of the main aims of the RISK MAP project is to use mapping to *foster participation* this process needs to be evaluated with the inclusion of the participants' perspective. In order to gain the participants' perspective, well-designed evaluation surveys can be used to collect information on the participants' experience. The RISK MAP project may achieve this by conducting two sets of evaluation surveys- one at the beginning of the process, to gauge expectations and hopes for the process, and a second survey at the end of the process, to assess how hopes and expectations may have changed during the process and to collect the participant's views on the overall success of the project. Both evaluation surveys may be brief, so as to maximise the time available for the workshop activities.

3.1.3.5 Workshop set-up

The workshops activities will facilitate active participation and provide participants with opportunities to share knowledge and opinions in addition to networking and building trust. In order to best facilitate interactions the workshop activities may be conducted in small groups. The size and number of groups will depend on the number of participants in total. By splitting the participants into groups, this will create a

more informal environment for cooperation and social learning. In addition small group sizes will be more likely to allow every participant an opportunity to be active and to have their say.

When dividing into groups, equality is a key consideration. Where the range of participants results in a bias towards one group or another or where there are several particularly dominant actors, these should be divided between the groups so that there are an equal number of representatives from different issues in each group. The stakeholder analysis process conducted during the design of the participation process, may be used to support the allocation of participants to groups in order to ensure a good spread of 'stakes' in each of the small groups. In addition, by having only a single representative from each issue in a small group, this may encourage a more tolerant approach whereby the individuals are more likely to compromise to achieve consensus as they will not be able to simply outnumber other interests.

3.1.3.6 Workshop activities

The inclusion of a variety of workshop activities will facilitate the realisation of a range of aims and objectives. The activities chosen should be tailored towards the circumstances and specific objectives of each case study. The following activities are given as examples with options for tailoring. It may, therefore, be desirable to include all activities or a selection of these, depending on the specifics of each case study. In addition, any alternative activities may be suggested or included; this list is not exhaustive.

A possible order for these tasks may be to begin with the most open tasks, i.e. the tasks that permit the greatest degree of creativity from the participants, with the least direction from the co-ordinators. These tasks will score highly on the aim to facilitate participation (through mapping). However, in order to achieve the second aim (to improve the contents and style of maps to increase their usefulness/utility) it may be necessary to guide participants further. However, by conducting these tasks last it will ensure that the guidance does not influence the results of the more open tasks.

Blank maps

One activity for the workshops is the "blank mapping task". This task is intended to allow participants maximum creativity by providing maps that are entirely blank or contain very limited information such as an outline map with a few towns or landmarks marked on for orientation. The more blank the map is, the greater the allowance for creativity. However, the level of information contained on the maps can be increased for audiences likely to be phased by a completely or relatively blank map. The following are options to consider for tailoring the activities to suit the case study.

Creative mapping

In order to find new creative ways to depict flood risk information, the participants may be guided by being told that they should demonstrate flooding on their map and may be given a short list of examples of features they may want to include. They may then be asked to depict this information on the map in any way they wish. The results may highlight novel ways of depicting flood risk information, but if the participants are guided in which aspects to include, this will limit the potential for the task to demonstrate the features that participants would want to see included.

Content preferences

The blank mapping task may be modified to encourage participants to consider, and demonstrate, the type of flood risk information that they may wish to see on future flood risk maps. This could be achieved by providing participants with the blank or basic maps and inviting them to depict on the maps the information that they would require or desire and find useful when thinking about preparing or responding to a flood event. The methods they use to demonstrate this information may highlight a level of creativity but will be particularly important in demonstrating the preferred content of a risk map.

Substantive mapping

The blank/basic mapping activity may be used to facilitate the sharing and gathering of local flood risk knowledge. If participants are familiar with flooding in particular areas they may be provided with basic

maps that contain location information such as place names and topography. The participants may then be invited to demonstrate their knowledge of flooding problems in the area on the map. The way in which they show this information may provide ideas for the style of the risk maps, but this task will be particularly important in order to gain additional, local knowledge and to facilitate the instrumental rationale by demonstrating to the participants a recognition of the value of their personal knowledge and experience.

Example/existing maps

The second main activity is to introduce a variety of flood risk maps to the participants. Coordinators may wish to include the current map(s) format in this task to further test current effectiveness. The prototype maps can test a range of features and layouts, ranging from simple to complex in their designs. The maps can be provided to the participants in small groups in order to encourage them to discuss the maps and features between them. The discussions could be guided by providing open questions or general topics to structure discussion or the discussion may be left completely open as suits. The participants may be encouraged to demonstrate on the maps the features that appeal to them as well as features that they dislike. By drawing, highlighting or attaching sticky notes to the maps, there will be a record of the comments. This may help the coordinators with their analysis and it may help the participants to recall the features that they may wish to discuss in a wider group discussion.

Such an exercise facilitates social learning, sharing knowledge on how different map features may be useful to different stakeholders and end-users. In addition, the exercise may also foster cooperation and enable participants to build networks with each other as they collaborate on the tasks. This exercise, therefore, fulfils both the substantive and the instrumental rationales.

For participation with members of the general public, coordinators of the workshop can sit in on the discussions to gain an understanding of the reasons behind preferences and opinions. Alternatively, if participants are professional users they may be able to discuss their ideas in small groups to then report back to the wider group. It may be possible to then hold a brief discussion between the group as a whole to wrap up the results of the first exercise and move on to the second. Of note here, however, is that the smaller group discussions followed by a collaborative general discussion may not be appropriate for small numbers of participants. In the case that participation numbers are low it may be preferable to have one general group discussion without splitting into smaller groups for preliminary discussions.

3.1.3.7 Concluding the workshops

At the end of the workshops a final evaluation should be completed. This may follow the same format as the previous workshop, i.e. a survey. If using a survey, it may be brief in simply asking for a response on the effectiveness of the workshops based on a small range of aspects. Alternatively the survey may be more comprehensive gauging feelings and opinions on many aspects of the workshops. The benefit with a short survey is that it can focus on the most important aspects of the project. Alternatively a longer survey may be useful to provide greater context and further information for consideration. Providing a final comments box or page is also important as it will allow participants to draw attention to particular aspects or to expand on their comments and answers, enhancing the evaluation process.

The evaluation survey may focus on participant's experiences of the process and may ask them similar questions to the first evaluation survey to evaluate how their opinions may have been changed by the process. The participants should feedback on aspects of the process that worked well and aspects that may be improved. This feedback will be particularly useful in preparing the second set of workshops that follow from the experimental graphic semiology experiments.

The background survey may also be conducted at the end of the workshop. This will provide a 'CV' of the type of participants that took part in the workshops to assist with the analysis of the process.

At the end of the workshops the participants should be thanked for their time and efforts. They should also be provided with any additional or supporting information, in particular:

- Contact details for the project coordinators (should they have any queries or concerns following their involvement).
- Details of when and where they may be able to access the final reports, summaries and project outcomes.
- Written information about the project and anything else that may be legally required, such as information on data protection.
- Leaflets or information on general advice should they be concerned about flood risk.

3.1.3.8 Post workshop analysis

Following the completion of the first workshops, a full analysis of the workshops can take place to identify strengths and weaknesses in the process. The evaluation surveys and the notes made by co-ordinators during the workshops assists this process and help identify where changes might be made for the second round of workshops to improve the participatory element.

In terms of the mapping aims, the analysis at the end of the workshop will help to identify the content and style features of the maps that can be used to design the prototypes for the experimental graphic semiology. The maps will be developed based on the outcomes of the various mapping tasks in conjunction with the comments made by participants during the process. The maps should be designed to best reflect the priorities and preferences of the workshop participants and in this task it is particularly important that the coordinators limit any bias they may introduce. The coordinators may then be able to justify the decisions they make on the content and style of the maps by referring to the results and comments of the participants and their work in the workshops.

From this point, the second round of workshops can be designed. The second workshops can follow the participatory framework laid out above, with modifications and adaptations to the particulars based on the outcomes of the first workshops. It can be expected that there will be a greater divergence in the tasks undertaken in the second workshops between the case studies, as each workshop itinerary will primarily be tailored to account for the results of the first workshops. The main tasks conducted in the second round of workshops are likely to be very different to the first as the process will have moved on from brainstorming and capturing ideas about the content, to perhaps testing the new maps. However, this is flexible and will be directed by the results of the first workshops.

3.2 Description of the participative multicriteria risk mapping tool (FloodCalc)

Sebastian Scheuer

The core objective of Task 2.2 has been the extension of an existing raster-based, participative, multicriteria risk mapping tool (FloodCalc). With this software tool, flood risk can be computed and mapped based on evaluation criteria and their respective criteria maps (Meyer et al., 2009; Kubal et al., 2009, see <http://risk-map.org/outcomes> for a comprehensive user manual). Furthermore, the tool allows for a further integration of flood risk into a multicriteria flood risk measure by means of multicriteria analysis (MCA) methods. The use of MCA methods helps to deal with the huge variety of data involved in flood risk assessment, e.g. to make both tangible (market) and intangible (non-market) assets commensurate, which is a prerequisite e.g. for the application of weighted summation (WS) approaches (Malczewski, 1999; Zimmermann & Gutsche, 1991). WS approaches generate a weighted average multicriteria value and are favored by most flood risk assessment methodologies (Malczewski, 2006). Also the multicriteria risk assessment in the FloodCalc tool relies on a WS approach. The risk assessment methodology implemented in FloodCalc follows the schema described by Chen et al., (2001), Malczewski (1999) and Smith & Petley (2009) and involves 1) the identification of evaluation criteria; 2) the preparation of criteria maps; 3) the assessment of flood consequences; and 4) MCA flood risk evaluation and mapping. The superordinate objective for these tasks is the consideration of each component of flood risk, i.e. its economic, social and environmental dimension. This objective is in line with the directive 2007/60/EC on the assessment and mapping of flood risk (The European Parliament and the Council of the European Union, 2007).

Figure 3.6 summarises the corresponding workflow which is carried out using the FloodCalc software. Firstly, hazardous events, risk dimensions and evaluation criteria need to be specified. To define a hazardous event in FloodCalc, its respective return period as well as available intensity measures (inundation depth, flood extent etc.) need to be given, and the hazard intensity data imported accordingly. Such data is obtained from flood estimation and mapping (Ramírez, 2000; Santos et al., 2011; Smith & Ward, 1998). FloodCalc is able to handle various flood intensity measures (i.e. a flood hazard created in the tool could be assigned a set of different intensity measures). Thereafter, risk dimensions need to be created, which serve as an encapsulation of evaluation criteria. The risk dimensions *may* be weighted by the user according to stakeholder preferences. Finally, evaluation criteria need to be specified. Evaluation criteria represent elements at risk, i.e. components of the natural, built or social environment which are at risk of being flooded. A given element at risk may be represented by one or more evaluation criteria, depending on its attributes (Drobne & Lisec, 2009; Malczewski, 1999). For example, residential buildings pose an element at risk, which might be described by criteria representing distinct asset categories, e.g. a criterion to account for fixed asset values and a criterion to account for the value of household effects. Compiling evaluation criteria is a crucial step in the risk assessment process and should conform to the following qualitative requirements: completeness, comprehensiveness, measurability, decomposability, non-redundancy and functional independency (cf. Bouyssou, 1990; Malczewski, 1999).

Values for evaluation criteria need to be provided in the form of a criterion map (Malczewski, 1999). Such maps constitute raster datasets which hold the respective asset values. For the previous example, the values for fixed assets or household effects (and therefore tangible asset categories) could be given in €/m². Furthermore, criteria maps may hold the total number of people residing in a given area. For non-market criteria which cannot be directly monetized (hence posing intangible criteria), a criterion map holds simple Boolean values indicating the spatial absence (0) or presence (1) of the criterion in question. Criterion maps will typically need to be prepared using Geographical Information Systems (GIS) prior import into FloodCalc, although also the tool provides several means to analyse, manipulate and process raster data. Moreover, a stage-damage function needs to be assigned to each evaluation criterion. Stage-damage functions determine the susceptibility of an evaluation criterion/element at risk in respect to

flooding as a function of hazard intensity. Examples for different stage damage functions can be found in Davis & Skaggs (1992), IKSIR (2001) or Kok et al. (2004). A library containing different stage-damage functions is provided with the FloodCalc tool. These functions are based on the inundation depth, which is according to Genovese (2006) the most important intensity parameter. Since FloodCalc can handle various intensity measures, damage functions relying on additional intensity parameters could be defined in principle.

Prior damage and multicriteria risk assessment weights have to be applied to the previously defined evaluation criteria (Figure 3.6). Sets of weights can be derived from participatory methods such as interviews and workshops, or equal or arbitrary weights could be applied alternatively. The applied weights ω must be in the range $0 \leq \omega \leq 1$. The higher the weight assigned to a criterion, the higher is the criterion's relative importance. The sum of weights must be equal to 1. Finally, each criterion needs to be assigned to one of the risk dimensions (Figure 3.6). Thereafter, the damage and risk assessment can be commenced.

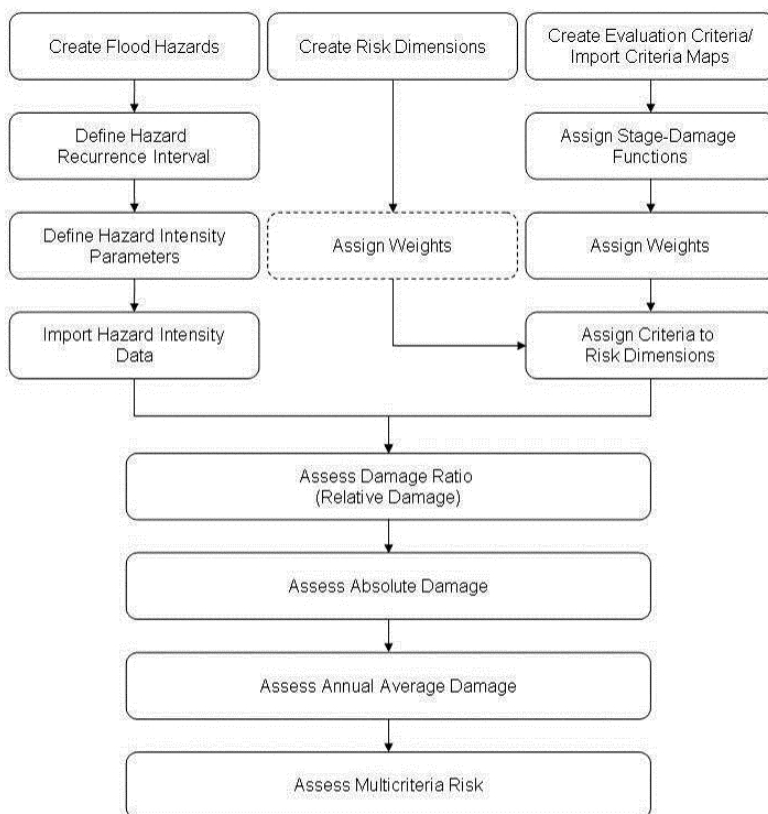


Figure 3.6: Multicriteria risk assessment methodology implemented in the FloodCalc tool following Chen et al., (2001), Malczewski (1999) and Smith & Petley (2009).

Risk assessment in FloodCalc is separated in four distinct steps: damage ratio assessment; absolute damage assessment; the assessment of the annual average damage (or the annual average affected population, or annual average affected area for intangible criteria respectively); multicriteria risk assessment (Figure 3.6). Annual average damage refers to the flood risk for each respective evaluation criterion. In the following, the term will be used synonymously for the individual flood risk of market- as well as non-market goods.

The damage ratio d (or relative damage, respectively) for each evaluation criterion is computed by FloodCalc as a function of hazard intensity and susceptibility, i.e. based on the assigned stage-damage function:

$$d = f(I_1, \dots, I_n) \quad (E1)$$

For tangible criteria, d will be in the range 0 (no damage) $\leq d \leq 1$ (total loss). For intangible criteria, typically no stage-damage function exists which relates hazard intensity to a certain degree of damage. Hence, a simplification must be made for such criteria. In FloodCalc, it is assumed that intangible criteria can either be affected by flooding ($d=1$) or not affected ($d=0$), depending on the flood extent. This simplification naturally involves a high degree of uncertainty. Nonetheless, it allows for the consideration of intangible evaluation criteria in a qualitative way, which would otherwise not be possible.

Based on the damage ratio d , the absolute damage D is then computed:

$$D = dq \quad (E2)$$

where q is equal to the asset value for tangible asset categories, the total number of people or the presence or absence of an intangible criterion. Hence, for tangible criteria, D equals to the total monetary damage caused by a particular flood event. For intangible criteria, D is equal to the flood-affected area. Finally, D holds the number of affected people if a population criterion is being assessed.

The annual average damage $\bar{D}$ for a given evaluation criterion is thereafter computed using Equation (E3), where $D(P_i)$ corresponds to the criterion's absolute damage for the i th flood event with probability P_i , of n total flood events considered (Lugeri et al., 2010):

$$\bar{D} = 0.5 \sum_{i=1}^n (D(P_{i-1}) + D(P_i)) \cdot |P - P_i| \quad (E3)$$

The annual average damage can be regarded as the flood risk for each evaluation criterion. On its basis, subsequently the multicriteria risk R_{MCA} is assessed in two steps. Firstly, all $\bar{D}$ must be standardized. Standardization is required to obtain commensurate values for each evaluation criterion (Malczewski, 1999). FloodCalc offers various standardization approaches. In most cases, a linear scale transformation is used, which results in standardized annual average damages $\bar{D}'$ in a range from $z_{\min}$ to $z_{\max}$:

$$\bar{D}' = \frac{\bar{D} - \bar{D}_{\min}}{\bar{D}_{\max} - \bar{D}_{\min}} (z_{\max} - z_{\min}) + z_{\min} \quad (E4)$$

where $\bar{D}_{\min}$ and $\bar{D}_{\max}$ correspond to the absolute minimum and maximum annual average damage value of the evaluation criterion in question, and $z_{\min}$ and $z_{\max}$ are typically chosen so that $z_{\min}=0$ and $z_{\max}=1$ (Kienberger et al., 2009). Following standardization, aggregation is performed on the basis of the a priori assigned weights. Firstly, all evaluation criteria of each risk dimension q are aggregated firstly into the aggregated economic, social or environmental risk R_q respectively, with a being equal to the number of evaluation criteria $a \in q$:

$$R_q = \sum_{i=1}^a \omega_i \bar{D}'_i \quad (E5)$$

In a second step, the multicriteria flood risk components R_q are aggregated into R_{MCA} similar to Equation (E5). Since weights are specified a-priori, each realisation of multicriteria flood risk is dependent on the preferences of stakeholders and decision-makers. Each computation result can be mapped. FloodCalc

provides a simple mapping component for this purpose; alternatively, data may be exported and further processed in GIS. The tool has successfully been employed in the Saxon case study, where all computations have been made using FloodCalc, and all data has been prepared for mapping with the tool.

Another core objective of Task 2.2 has been the extension of FloodCalc with a knowledge base (KB) to allow for the use of different kinds of knowledge in the assessment process. Such knowledge integration aims at developing a common, shared understanding of a given topic (domain) to draw on all available knowledge, in this case within risk assessment. Knowledge integration provides the basis for the development of KB and knowledge-based applications and systems (KBS, cf. Kiryakov, 2006; White et al., 2001). The use of KB and KBS aims at addressing complex environmental problems and impacts, which is also the reason that (local) knowledge integration gained a high interest in research lately (Failing et al., 2007; Raymond et al., 2010). Local knowledge is the fact-based expertise which is held by a specific group of people in regard to specific local phenomena such as flooding (Giordano et al., 2010; Robertson & McGee, 2003; Scholz et al., 2004). In order to be of any use in research and for KB/KBS development, local knowledge needs to be structured and formalized, since it is often based on observations and is therefore informal and tacit. This is also true for the preferences of stakeholders and decision-makers.

Ontologies pose consensual, formal, explicit abstract models of a domain, capturing its relevant terms (concepts, i.e. its vocabulary) and their semantics (i.e. their relations) as well as axioms to account for their intended meaning (Atkinson et al., 2006; Gruber, 1993; Guarino, 1998). Ontologies and ontology building methodologies thus provide effective means for knowledge integration and formalization. They furthermore resemble a profound basis for the development of KB, since ontologies are sharable and extendable, hence fostering collaboration and participation especially within interdisciplinary domains such as flood risk assessment and flood risk management (Ruiz & Hilera, 2006).

To build the ontology proposed in Task 2.2, an ontology building methodology combining the METHONTOLOGY approach (Fernández-López et al., 1997; Fernández-López et al., 1999) and the UPON methodology (De Nicola et al., 2009) has been applied. The applied approach encompasses 1) the ontology specification; 2) conceptualisation (referring to the elicitation of relevant concepts and the modelling of a concept hierarchy, their relations and of axioms); 3) formalisation, i.e. the encoding of the previously conceptualized domain model using a formal knowledge representation language; and 4) testing. The proposed ontology should serve as a KB basis for the FloodCalc flood risk assessment tool. It should thus be able to capture relevant expert knowledge on flood risk assessment (e.g. the relationship between elements at risk and hazardous events or hazard characteristics such as hazard intensity measures) as well as local knowledge and stakeholder preferences. Since the proposed ontology should also contribute to risk mapping, it shall also contain information about relevant map types and their respective content in regard to policies, directives and stakeholder preferences.

Hence, the relevant terms t in regard to these objectives need to be elicited. This results in a lexicon of terms L , which is enriched with glossary entries (cf. De Nicola et al., 2009). The ontology is then conceptualised by firstly identifying core concepts following the middle-out strategy (Uschold & King, 1995). This strategy proposes that such terms t from the lexicon L are selected which are deemed the most relevant, thus denoting core concepts C (e.g. *flood*, *element at risk*, *hazard*, *intensity measure*, *depth*, *extent*, *risk*, *map* etc.). The resulting set of core concepts $\{C\}$ is then refined in later steps to create a concept taxonomy (Gómez-Pérez et al., 2004). I.e., all concepts are hierarchically organized. Furthermore, the relationships between the concepts of $\{C\}$ are being modelled (which formalizes knowledge such as e.g. elements are threatened by floods). This is typically done by the use of binary relations $R \subseteq C_1 \times C_2$, which link the so-called relation's domain C_1 (being element at risk in the previous example) with the range C_2 (flood, cf. Gómez-Pérez et al., 2004). At the end of the conceptualisation phase, a semantic network $SN = (\{C\}, \{R\})$ has been obtained which is then formalized by means of a knowledge representation language.

A knowledge representation language can be referred to as a formal, machine-interpretable and thus computable knowledge representation (Corcho et al., 2006). To formalize (i.e. encode) the semantic

network of the proposed ontology, the Web Ontology Language (OWL) has been chosen. OWL builds upon the Resource Description Framework (RDF/RDFS), features an expressive richness and receives much community support (Corcho et al., 2006; Gómez-Pérez et al., 2004). In OWL, concepts *C* correspond to classes, and taxonomic constructors allow for the codification of the modelled concept hierarchy (Smith et al., 2004; see Box 1 for examples). Instances (i.e. members) of classes are called individuals (for example, the 1 in 500-year flood event for the Saxon case study is an individual of the class *Flood*). Relations *R* are either modelled as object properties (which link two concepts, or individuals respectively), or as datatype properties (which link a concept with a literal, i.e. a numeric or textual data type value, cf. Motik et al., 2006). Finally, OWL features means to impose cardinality, existential and universal restrictions on classes and properties (Motik et al., 2006).

Box 1: OWL examples for classes and relations

The following example demonstrates how the term/core concept *flood* is encoded using OWL in the form of an OWL class. It becomes obvious that the *rdf:ID* attribute denotes name of the class. For each class, a human-readable label (*rdfs:label*) can be defined for a specific language (*xml:lang* attribute), and the glossary entry for the respective term flood is given as *rdfs:comment*. The *rdfs:subClassOf* element is an taxonomy constructor, which in this case denotes that the concept *Flood* is a subclass of another concept (*rdf:resource*) *HazardousEvent*.

```
<owl:Class rdf:ID="Flood">
<rdfs:label xml:lang="en">Flood</rdfs:label>
<rdfs:comment xml:lang="en">A period of high DISCHARGE of a river, resulting from
conditions such as: heavy PRECIPITATION; intense melting of snow and ice; the breaching
of natural barriers (such as ice dams); the collapse of artificial BARRAGES. River
floods have been defined as 'events' of such magnitude that the channels cannot
accommodate the peak discharge. In other words, a flood is a flow in excess of the
channel capacity, and results in inundation of low-lying flat land adjacent to the
channel.</rdfs:comment>
<rdfs:subClassOf rdf:resource="#HazardousEvent"/>
</owl:Class>
```

In the next example, an object property is defined which accounts for the fact that a flood (and therefore each hazardous event) is described in its effects by hazard intensity parameters. Therefore, the exemplary object property *describes* associates the *IntensityMeasures* domain (*rdfs:domain*) with the range (*rdfs:range*) *HazardousEvent*.

```
<owl:ObjectProperty rdf:ID="describes">
<rdfs:label xml:lang="en">is an intensity measure of</rdfs:label>
<rdfs:comment xml:lang="en">...</rdfs:comment>
<owl:inverseOf rdf:resource="#isDescribedBy"/>
<rdfs:domain rdf:resource="#IntensityMeasures"/>
<rdfs:range rdf:resource="#HazardousEvent"/>
</owl:ObjectProperty>
```

Finally, an example demonstrates the use of OWL datatype properties. The exemplary datatype property *hasProbability* is used to account for the fact that each hazardous event has a specific recurrence interval *T* (e.g. 1 in 100 years) and thus a probability $P=1/T$. The hazard probability *P* is of a double datatype (*rdfs:range*) and linked to the *HazardousEvent* domain.

```
<owl:DatatypeProperty rdf:ID="hasProbability">
<rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#double"/>
<rdfs:domain rdf:resource="#HazardousEvent"/>
<rdfs:label xml:lang="en">...</rdfs:label>
<rdfs:comment xml:lang="en">...</rdfs:comment>
</owl:DatatypeProperty>
```

The FloodCalc tool has been extended with an XML interpreter to be able to parse and interpret the knowledge encoded with OWL. Several functions within the tool make use of the tool KB to assist the user in the flood risk assessment process. The underlying semantic network of the Task 2.2 flood risk assessment ontology and its use in the FloodCalc tool will be explained in more detail in Section 9.2 of this report.

3.3 Methods of visualisation & and the approach of Experimental Graphic Semiology (EGS)

Sven Fuchs, Kamal Serrhini, Gaëtan Palka

The European Flood Risk Directive emphasises non-technical mitigation measures on a catchment scale, in particular risk mapping with the aim of separating values at risk from hazardous areas via spatial planning actions (Fuchs, 2009; Fuchs et al., 2009a). On the European level, such maps are required, specifically with respect to flood risk, until 2013 (Commission of the European Communities, 2007). However, apart from procedures on how to compile such maps, little information is available regarding the most suitable map symbolisation and the possible impact of these maps on decision-making processes (McKendry, 2000). There is a general agreement that for certain hazards, such as floods, the best geographic scope of an analysis may differ from suggestions on a national level (Commission of the European Communities, 2010).

Flood risk information is assumed to be transferred from experts to a general audience via maps – technical and scientific information on risk is communicated from a known, intentional source (the experts) along designated channels to specified recipients (the public, the decision makers) (Bell and Tobin, 2007). So far, the procedure of risk mapping is based on this kind of linear model from the specialist producing the map (transmitter) to the targeted reader (receiver), known as experimental graphic semiology (Imhof, 1972; Bertin, 1977; Cauvin et al., 2007). Yet map-making as a commonplace activity occurs within certain limits. GIS users and other untrained mapmakers often do not have specialised skills in cartographic design (Wood and Keller, 1996; Monmonier, 2006, 2007), which can be summarised with respect to flood risk maps as follows: Flood hazard experts are creating flood hazard maps for other experts, such as land-use planners, without taking into account the challenge of targeted communication to either this group of experts, or even other stakeholders involved such as the general public or political decision makers.

As a result, maps may have the power to inform or misinform, lead or mislead, clarify or confuse through the use or misuse of design principles (Cassetari, 2007; Lilley, 2007) regardless of the accuracy of their data, as stated by McKendry and Machlis (2009). Four essential components of this traditional approach of map design have been identified by Covello et al. (1987): the message source, message design, delivery channel, and target audience. In practice, experts draft and devise risk maps and associated documentation, and end-users (public authorities, people concerned, and laypersons) receive these maps as finished products regardless of whether or not they understand the message that is meant to be included. Experimental graphic semiology is based on certain rules and recommendations neglecting any specific requirements depending on the culture or knowledge of the receiver. Reversing this linear model by establishing the new approach of experimental graphic semiology, a cyclical model was proposed aiming at an integration of visual and cognitive perception by the receiver (Serrhini et al., 2008). This model requires the quantification of properties and characteristics of visual perception, and thus an analysis of map reading behaviour.

Methods emerging from the social sciences, such as direct or indirect observations including (in-depth) interviews, surveys, or group discussions, provide some hints with respect to appropriate mapping techniques (e.g., Slovic et al., 1982; Green et al., 1987; Green et al., 1991; Lave and Lave, 1991; Khaled Allouche and Moulin, 2001; Laurier and Brown, 2008). Furthermore, apart from early studies on the relationship between map design and map use (e.g. Robinson, 1952), cognitive approaches were taken to understand the relationship between map design and communication (Blades and Spencer, 1986), leading to guidelines for map production that enable the map user to think, understand, interpret, discover, and learn with maps (Eastman and Castner, 1983; Gilmartin, 1981). However, with respect to flood risk maps, it is not only a question of whether or not maps are effective in transmitting information but also if and how the information communicated is meaningful with respect to creating risk awareness.

Moreover we must remember that the perception of flood risk is different between experts and laypersons. While some studies argue that considerable differences exist (e.g., Fischhoff et al., 1982; Lazo et al., 2000), often depending on whether or not affected people live in hazard-prone areas (Siegrist and Gutscher, 2006), other studies conclude that there is little empirical evidence for such a proposition (Rowe and Wright, 2002). Information on risk is an essential step to enhance risk awareness and to create disaster-resilient communities. Nevertheless, until now only little information has been available related to the necessary design and impact of the relevant maps and how they may be most effectively created as tools for risk communication and decision-making.

In order to contribute to such open questions and thus partly to close the outlined gap, risk maps were created for alpine catchments, catchments in the mountain forelands and river catchments following both common as well as innovative approaches of GIS-based map production. These maps were presented to various user groups (stakeholders from public authorities, experts in cartography, affected citizens and laypersons) using the method of eye tracking supplemented by experimental graphic semiology. By analysing the results, recommendations for the design and compilation of risk maps were developed. Accordingly, by applying these results, target-oriented, non-technical flood mitigation should be increased and the support of decision-makers will be enhanced by at least initiating a discussion on efficient risk communication by hazard and risk maps.

3.3.1 Compilation of risk maps

The risk maps compiled for this study were geared to the multiple-scale structure specified in the European Flood Risk Directive (Commission of the European Communities, 2007). Consequently, from a natural sciences point of view and with respect to flood hazards, risk (R_{ij}) was defined as a quantifying function of the probability of occurrence of a process (p_{Si}) and the related extent of damage (Fell et al., 2008; Varnes, 1984), whereby the latter was specified by the value of elements at risk (A_{Oj}) and the vulnerability ($v_{Oj, Si}$), see Equation 3-1. Vulnerability was defined by a function of a given process intensity on physical structures and was therefore expressed as the expected degree of loss for an element at risk as a consequence of this impact (Fuchs, 2009). Consequently, the vulnerability value ranged from 0 (no damage) to 1 (complete destruction).

$$R_{i,j} = f(p_{Si}, A_{Oj}, v_{Oj, Si}) \quad (3-1)$$

The compilation of risk maps always remains a matter of scale, since large-scale assessments of individual sub-catchments require a method which is different from medium- or small-scale assessments of larger catchments in the lower river districts (Fuchs et al., 2009b).

In general, the hazard was assessed for the smaller-scale test sites (Chertsey, UK; Bennewitz/Wurzen, D; Pocking/Schwaibach, D; and Agglomération de Tours, F) by either taking information from existing hazard maps as a basis or by modelling appropriate probabilities of occurrence and the associated flood levels (peak discharge) using the hydrodynamic model HYDRO_AS-2D (Pocking/Schwaibach, D). The first method was chosen to avoid upcoming discussion related to precision and accuracy of already approved hazard information and (drafts of) hazard maps, and consequently to avoid related discussion with the responsible administrative stakeholders responsible for the compilation of such hazard information.

For the larger-scale test sites (Wartschenbach and Vorderbergerbach, A) hazard information was compiled based on an object-based assessment of the hazard, which was carried out using the software Flo-2D, and additional validation based on the existing hazard maps due to the reasons outlined above.

Risk maps were prepared based on the analysis of relevant hazard scenarios, the elements at risk exposed and the associated vulnerability. Depending on the scale, risk was either obtained by calculating spatially explicit values for individual objects or by applying average values per area during the sets of

calculation. Since average values per area were based on empirical assumptions, the result provided a small-scale overview on the risk situation for a larger region, e.g. a valley bottom. Additionally, risk analyses were carried out on a large scale and the calculations resulted in quantitative risk for individual objects, and were therefore suitable for larger scales, e.g. individual torrent fans.

The initially dimensionless risk Figures were converted into a number of visualisable forms in order to test different illustrative facilities and to obtain a set of maps for every catchment featuring several suggestions of design and layout. In doing so, either the cumulative risk or the individual risk was analysed both from a comprehensive point of view related to the studied scenario and in terms of annual risk. Large-scale maps were based on object-specific risk and provided information on either exposed building categories, exposed total damage or expected annual damage. Small-scale maps were based on (1) an object-based approach for individual buildings and land plots, or (2) aggregated information based on land use plans and mappings. These maps provided information on monetary loss or on the number of persons at risk. A further set of maps was related to the vulnerability of elements at risk. A complete set of maps is shown in Appendix 12.

3.3.2 Visual strategies and method of eye-tracking

Visual strategies can be distinguished by three categories of eye movements: (1) continuous motion, (2) jerks, and (3) saccades, pursuits and fixations. From an ophthalmic point of view, the latter category is the most important when quantifying reading behaviour. Saccades are fast ocular movements with variable speed. They are triggered by fuzzy visions of an object (i.e. the appearance of a peripheral retinal stimulus) or by auditory stimuli, and are directed towards the right, the left, or vertically. Pursuits are slower ocular movements, and are triggered by the examination of a moving target (or stimulus) and therefore constitute central vision. Fixation is the condition when the gaze remains fixed during an interval ranging between 100 and 1000 milliseconds on a surface $\leq 144 \text{ mm}^2$; however, during the fixation of a motionless stimulus, the eye is not entirely motionless itself – micro-saccades and micro-tremors can be registered (Larmande and Larmande, 1990).

The method of eye tracking using conventional methods such as direct observation, photography, oculography, and additional accompanying surveys is based on studies of cognitive processing in reading and information processing (Rayner, 1998). In the last decades, eye-movement tracking was increasingly applied for the study of map perception and design (Steinke, 1987). Considerable influence on this technique traces back to Jenks (1973), who started with the documentation of thematic map exploration. Dobson (1979) continued this work and determined that readers concentrate their fixations in certain areas of a map that might contain the most informative figurative elements. Carrying out experiments to determine whether or not presence or absence of certain map elements affect the way the map is read and understood, this work was extended by Steinke (1979). Although he concluded that less informative parts of a map received less attention, map reading activity turned out to be considerably complex and individualistic.

About the same time, Board and Taylor (1977) concluded with respect to map reading that fixation pauses and small saccades might be evidence either for poor map design, for a less accessible map content, or for a poor map reader, or a combination of all three. More recent studies include experiments on alternative map designs and map reading activity (Antes et al., 1985) and the effects of experience on the performance of map reading tasks (Chang et al., 1985). The particular focus of these studies was on the overall arrangement, layout, and balance of map elements. The general conclusion was that map design did not considerably influence map reading efficiency, but experienced map users seemed to explore map content significantly better. The analysis of eye movement records showed that the duration of fixations was shortest for sensitised users and longest for laypersons.

Castner and Eastman (1984, 1985) carried out studies on perceived complexity of maps and how complexity might influence the map reading process. They concluded that perceived complexity of maps

affects the way maps are read and understood. This was also the main finding of Brodersen et al. (2001). Moreover, maps being presented to different end-users will result in different patterns of recognition (Cauvin et al., 2007). Based on the acknowledged perception differences, an innovative technique was developed in the RISKATCH project that enables (1) a new understanding of reading behaviour and comprehension and (2) a deduction of the most attractive map components that are essential for target-oriented risk communication (Fuchs et al., 2009a; Fuchs et al., 2009b). Based on these findings, the method of visualisation was developed for the RISK MAP project.

3.3.3 Method of visualisation

The project partners were equipped with a general guideline of how to compile risk maps according to the findings published in the Final Report of RISKATCH (Fuchs et al., 2008). These general guidelines were based on the overall conclusion that the structure of maps influences the visual strategies of the readers. Presumably related to culture and education, textual elements are considerably attractive to the gaze. Furthermore, the central elements of the map have to contrast the background and should be designed in bright and dark colours, respectively. Additionally, the position of various elements in a map, i.e. the title, the legend, and the central figurative element, is of particular importance for the visual comprehension; therefore, map perception is iconographic. The more accessible visual information is the more effective it will be in terms of visual transmission of information. Moreover, particular reading behaviour of specialists, sensitised people and laypersons (Fuchs et al., 2009b) led to the conclusion that perception is anthropic. Hence, risk maps should be compiled according to these different needs, in particular bearing in mind that approximately 65 % of the observation time of subjects is devoted to less than 25 % of the map surface. By acknowledging such preferences concerning graphic representation and arrangement, an optimum risk map should be based on the general model outlined in Figure 3.7 to allow for efficient and target-oriented communication of flood risk. A risk map compiled according to these conclusions would result in a visual strategy that is composed of three clear sets of ocular movements. Starting from the centre, the eye moves to the title of the map, following a vertical axis downwards the legend section and returning back to the central element of the map. If there is sufficient time, the additional peripheral elements of the figurative part are explored.

The following minimum requirements should be met when risk maps have to be compiled:

1. Hazard analysis
 - a) Assessment of historical events, including available cadastres, chronicles, and communication with people concerned
 - b) Process modelling by appropriate software tools for defined (targeted) design events
 - c) Evaluation of existing hazard maps
 - d) Validation of the results
2. Analysis of values at risk
 - a) Spatially explicit analysis of number and values of exposed buildings, this step can either be carried out object-based (large-scale) or by applying average values (small-scale)
 - b) Subsequent analysis of people at risk, e.g. by using statistical data related to the number of persons per building
 - c) Individual analysis of elements with high-risk potential (hospitals, schools,...)
 - d) Analysis of vulnerability for identified values at risk with respect to the process scenarios selected
 - e) Intersection of process scenarios with values at risk and related vulnerabilities in order to calculate the cumulative risk for the defined scenario. Dividing the values by the annuality of the design event results in the expected annual risk

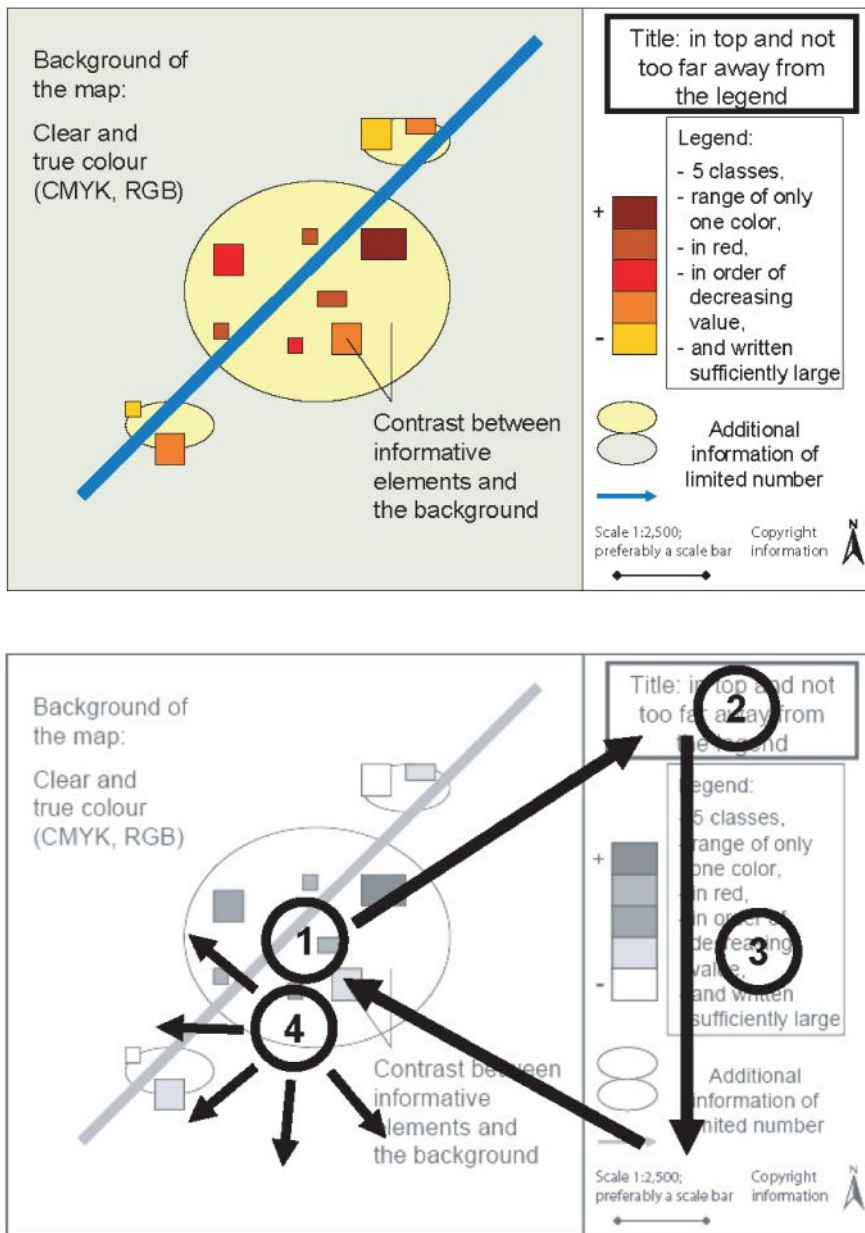


Figure 3.7: Suggestions for the compilation of risk maps in order to allow for an efficient and target-oriented risk communication (Fuchs et al., 2009b).

Specific elements of semiology that have to be taken into account when designing risk maps include the contrast, the level of discretisation and the colour range and hue. These specific elements of semiology for a cartographic representation of risk include:

1. A map background in bright colour in order to increase the contrast to informative elements and to avoid an overload of information;
2. A sufficiently large legend, preferably on the right side of the central element of the map, with a conservative amount of information (five classes of discretisation) comprised from one range in colour and arranged in decreasing values, since the concentration of information in

the legend needs to be visible (contrast and colour use) and accessible (limited number of information);

3. A sufficiently large scale such that the elements of the map are easily recognisable.

Consequently, the visual elements studied included the scale, the position of the legend and the title, the complexity of the legend, the presence or absence of pictograms, and the level of discretisation and the colour range and hue.

If risk maps were designed according to these findings, information would be delivered in a visually efficient manner. Consequently, if these requirements were met, risk communication will be enhanced because the level of individual perception and understanding is increased. This deepened insight might result in an increase in both, individual preparedness and public participation, which with respect to flooding and torrent hazards starts with the notion of risk. Therefore, access to information is implicitly necessary. If this information can be delivered target-oriented, i.e. by using the method of experimental graphic semiology, the impact of non-technical measures will be increased, and possible future losses might be reduced to a minimum.

In order to develop the range of visual elements to be tested, each project partner compiled a set of risk maps according to the outlined general methods of visualisation. These were then further specified according the results from the individual workshops within the test sites (see sections 4-8), and were subsequently assessed and modified with respect to the needs of the approach of experimental graphic semiology.

3.3.4 Experimental graphic semiology

A map is the most suitable tool for efficiently communicating spatial information. Maps are constructed by following a form of “grammar”: using graphic semiotics (Bertin, 1977) usually according to a linear model (from designer to user without taking the latter's preferences and needs into account). As indicated above we proposed a circular pattern (user – map designer – user) that integrates the visual and cognitive perceptions of the readers (Serrhini et al., 2008, see Figure 3.8). This circular pattern used a method based on:

- the quantification of eye movements (visual oculométrie),
- a survey using a questionnaire (see the Appendix), and
- conversation and workshops within the five test sites, respectively, which were completed by an approach based on the interactive elaboration of an idealised flood risk map (puzzle).

From RiskCatch to RiskMap

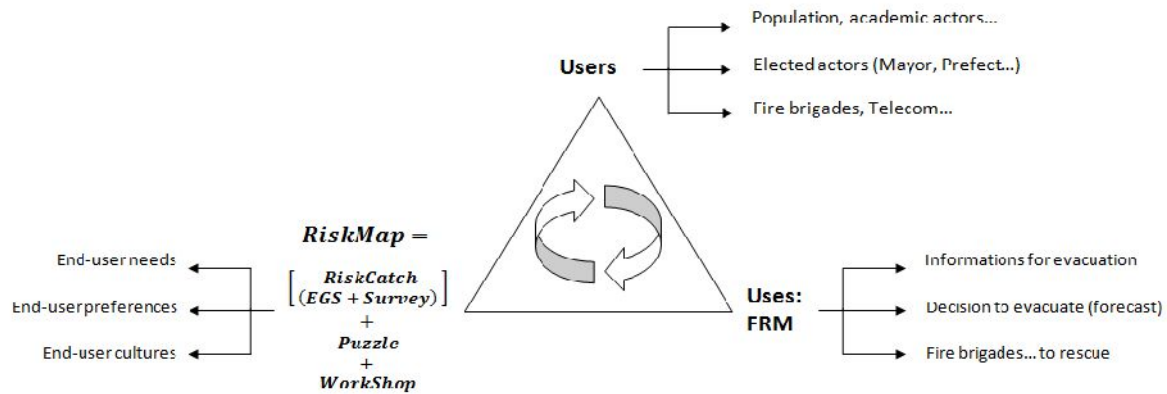


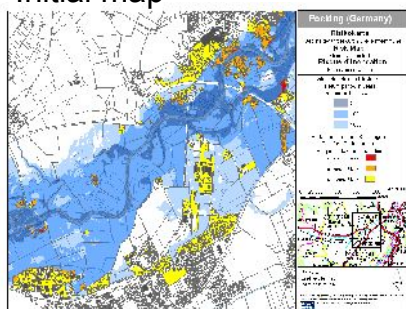
Figure 3.8: Experimental graphic semiology (from RISK CATCH to RISK MAP, see Serrhini et al., 2008 and Fuchs et al. 2009b)

Two principal eye movements characterise the visual strategies and were the basis of the developed experimental protocol:

- fixations during which information is recorded, and
- saccades defined as rapid eye movements between individual fixations.

The maps used were a result of (1) discussion and input from workshops organised by the project partners with volunteers (lay people and academics), and (2) from a close collaboration between partners from different test sites and the French team in order to adjust semiotic aspects and criteria resulting from the successor of RISK MAP (RISK CATCH). As a result, an evolution of risk maps can be achieved until the production of the final maps used during the eye tracking test (Figure 3.9).

Initial map

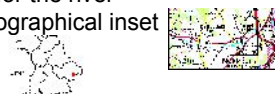


Findings:

- * the river is insufficiently highlighted due to the poorly contrasting shades of blue
- * the topographic inset does not pinpoint the site
- * the major risks are not highlighted

Proposals:

- * reduce the number of simulated floods and use a stronger contrasting blue for the river
- * replace the topographical inset with a schematic map

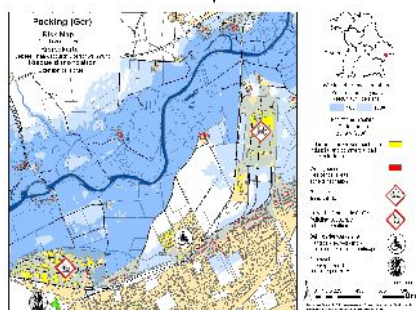


- * use appropriate pictograms in order to highlight the major risks.



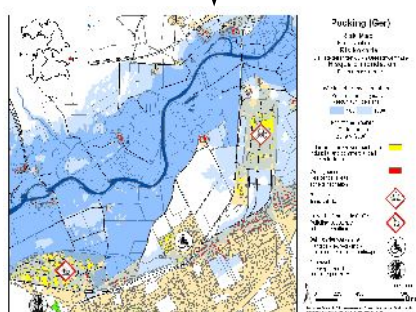
Finding:

- * the title top left is on the opposite side to the legend



Proposal:

- * group together the textual and graphic elements



Finding:

- * the key is not uniformly organized compared to maps for the other sites

Proposal:

- * make the key uniform (symbols on the left and what they signify on the right)

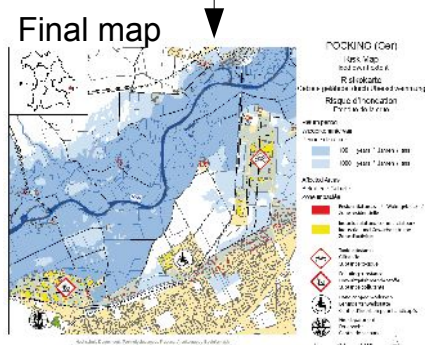


Figure 3.9: Evolution of risk maps during the preparation for the test in Tours (example from Pocking test site, Germany).

After this step of adjustments, four maps were selected per country that were found to be most suitable for a comprehensive and stepwise test of eye movements (Appendix 12.2). Using these maps, logigrams were created to define criteria for the experimental protocol (Figure 3.10).

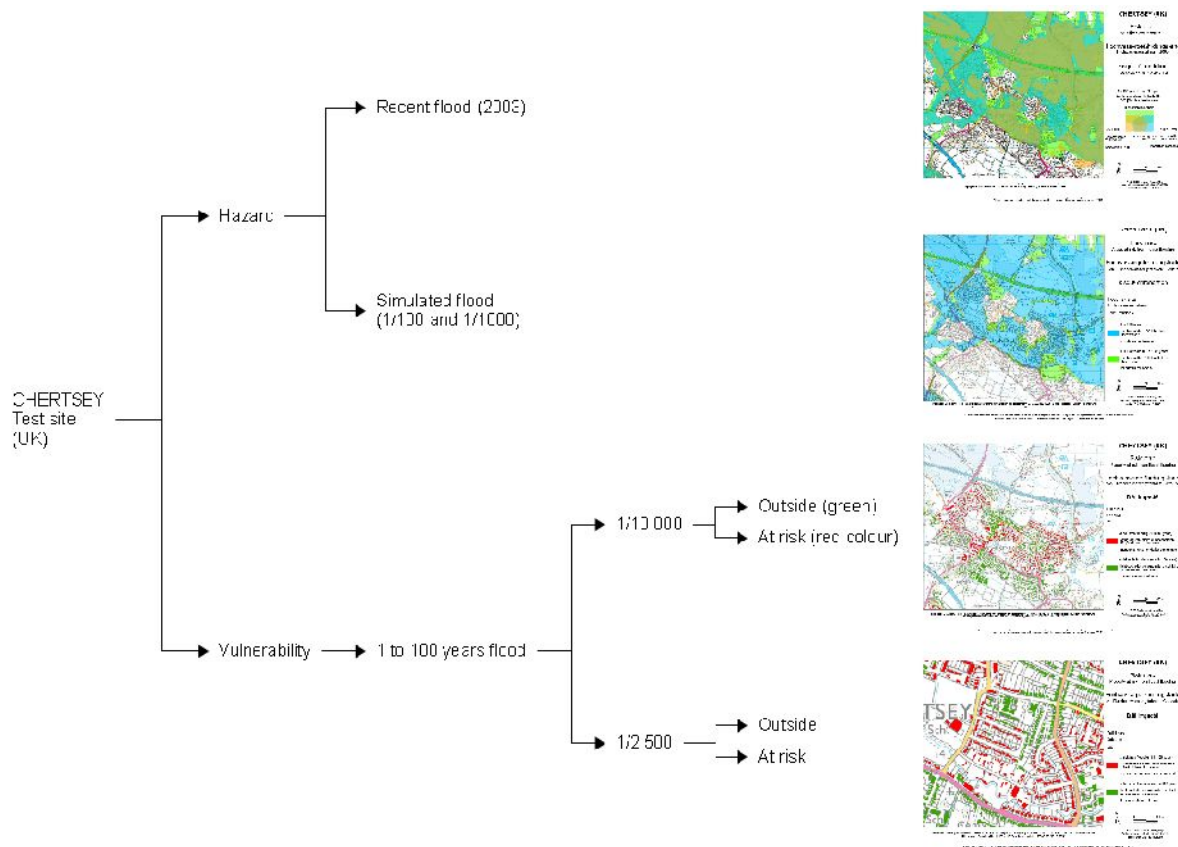


Figure 3.10: Logigram used for each individual set of risk maps (example from Chertsey test site, UK).

3.3.5 Experimental protocol

The individuals tested (sample) comprised 41 volunteers from the five test sites in the partner countries of the consortium, and were grouped into four categories (Appendix 12.2):

- policy makers
- flood risk management actors (e.g., emergency services, local administration),
- population directly affected by flood risk (e.g., housing) or indirectly affected (e.g., cut-off in infrastructure services), and
- researchers, multipliers in education (e.g., teachers) and students.

The experimental protocol was composed from four coordinated parts, preliminary vision tests, the record of eye movements, a survey, and the interactive elaboration of an idealised flood risk map (puzzle).

3.3.5.1 Preliminary vision tests

These examinations test the capacity of the volunteers to fully perceive all the information from the largest to the smallest area, such as text. Three tests are used to check the eyesight, visual acuity tests, Parinaud tests and Hishihara test.

Among the 38 volunteers (three volunteers did not send back the survey), 32 volunteers (84.21 %) have average vision (farsighted and near-sighted) allowing them to read the projected maps comfortably and 97.37 % of all the volunteers could see the colours of the projected maps sufficiently well. (Appendix 12.2)

3.3.5.2 Record of eye movements

The equipment used is the video-oculograph (Métrovision company⁴) from the Service d'Exploration Fonctionnelle, Département d'Ophtalmologie, CHU Bretonneau in Tours. The recording was done in two phases: the calibration which precisely defines the point looked at on the screen by the volunteers and the recording of the subjects' actual eye movements. Each map was projected for 15 seconds in order to see which constitutive elements of the map attract the volunteers' eye during the first few moments of the projection. The record gives the number of fixations, the duration of fixations, the number of saccades and which points of the map are looked.

The statistical analysis of average number of fixations, average duration of fixations and average number of saccades can define how easy or hard it is for every individual to read a map (Renshaw et al., 2004, see Figure 3.11).

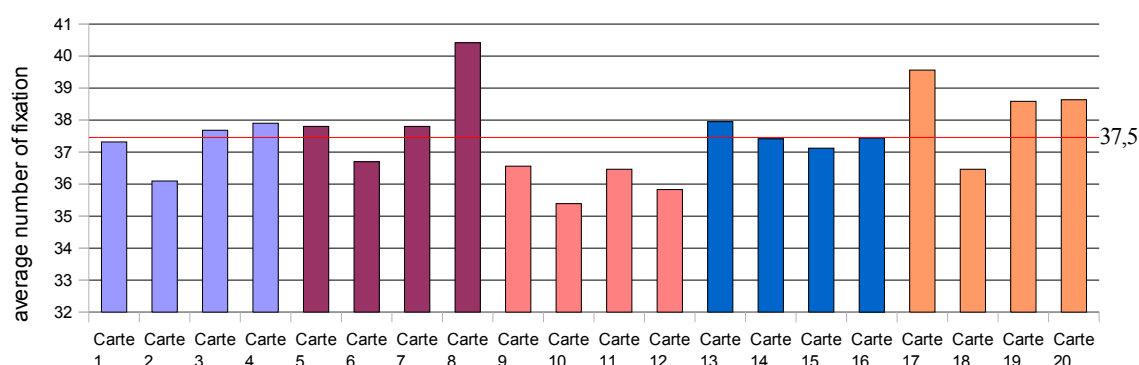


Figure 3.11: Average number of fixations for each map.

Another studied element is which elements of a map attract the look and are the most informative (Dobson, 1979, see Figure 3.12).

⁴<http://www.metrovision.fr/>

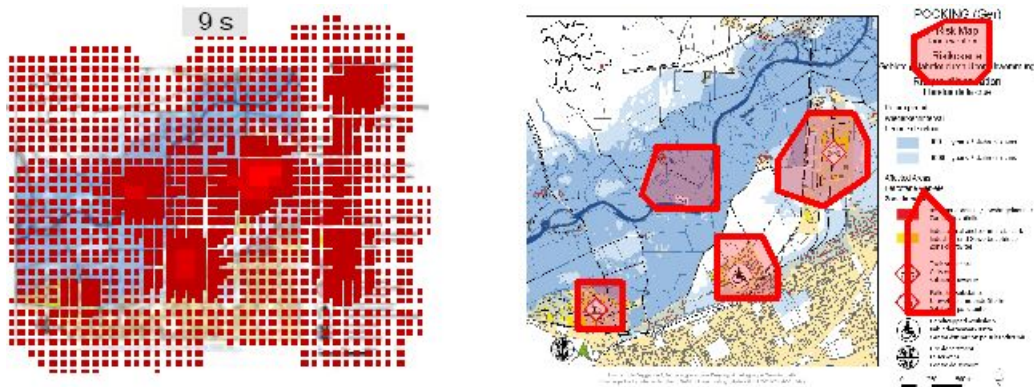


Figure 3.12: Example of the most attractive elements in a map (example of Pocking, Germany).

Subsequently, the visual strategies of each individual group of test persons and for each map were modelled to represent how a map guides the gaze (Figure 3.13).

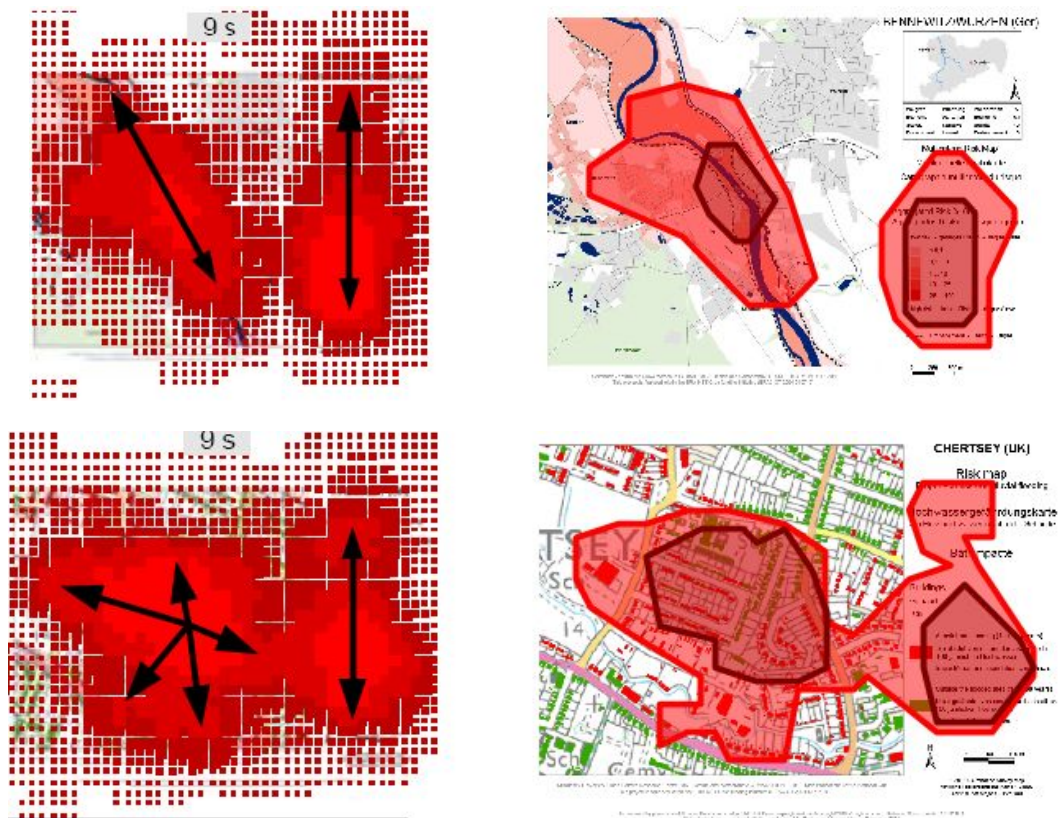


Figure 3.13: Examples of visual strategies developed during the map reading, top: example of Bennewitz, Germany, bottom: example of Chertsey, UK.

3.3.5.3 EGS survey

Using a survey, the maps were evaluated by the individuals subsequently after the record of eye movements (Appendix 12.2). The survey was composed of four parts. Two parts were related to the volunteer himself (vision test results and relation to the risk maps), another part was concerned with the

evaluation of ten maps (two per test site). Each individual was asked to evaluate five criteria for each map presented: complexity, density of information, aesthetic aspect, innovation, and usefulness with respect to risk management tasks. The main aim of the survey was to see how a criterion evolves with the others and see whether or not a modification of the level of one criterion can increase or decrease the level of another criterion. The relation (positive and negative correlation and intensity of correlation) between the different criteria is shown in Figure 3.14.

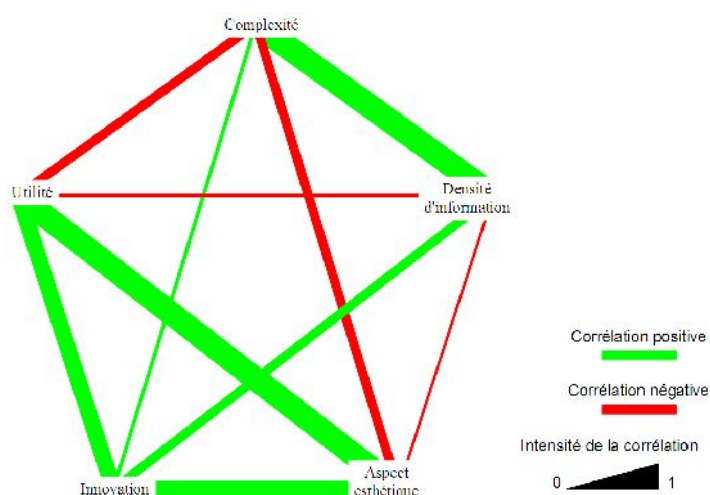


Figure 3.14: Correlations between the five criteria tested.

Finally the last part of the survey addressed the preferences of individual groups of potential end-users with respect to scale, legend, hazard and impact, number of topics presented and map type.

In Figure 3.15 and Figure 3.16, the preferences of the local population affected by flood risks are opposed to the preferences of flood risk management actors. To give an example, the local population prefers a simple legend (composed from two themes and moderate discretisation) compared to the group of flood risk management actors where a tendency towards complex legends is proven. Local population strongly prefers only one topic being depicted while the group of flood risk management actors is comfortable with several topics shown in a flood risk map.

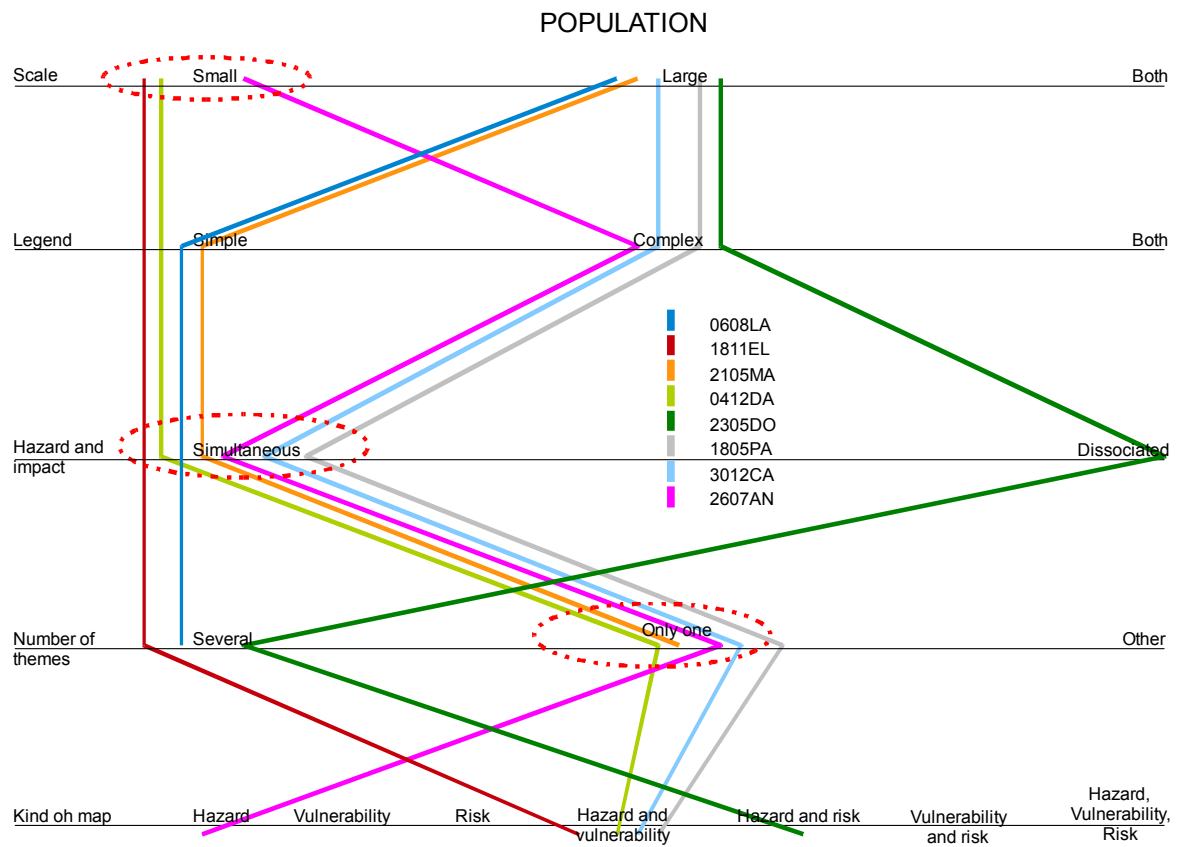


Figure 3.15: Preference graph for local population. Code Numbers and coloured lines represent the answers of individual test persons to the questions of the survey

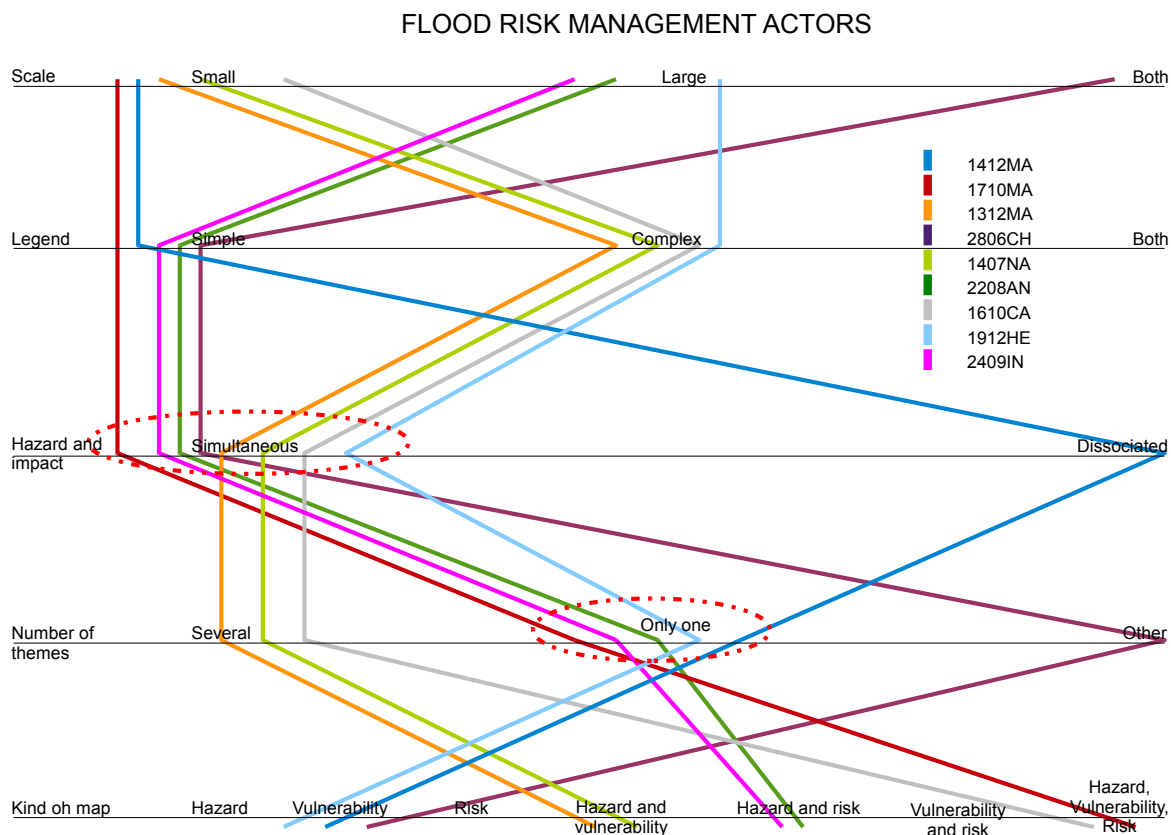


Figure 3.16: Preference graph for flood risk management actors. Code Numbers and coloured lines represent the answers of individual test persons to the questions of the survey

3.3.5.4 Interactive elaboration of an idealised flood risk map (puzzle)

The interactive elaboration of an idealised flood risk map (puzzle map) attempts to assess the preferences of map-readers by giving them the opportunity to draw their preferred maps by answering some effortless questions. Designed using an open, interactive question-and-answer system (GIS), this approach was targeted to define the semiotic characteristics of the map as a whole, but also with respect to each layer of information together with the reasons for making the choices in this specific context. The prototype product for RISK MAP was constructed by using data from the Tours district test site, France.

The main focus of this procedure was to test

- the colour used to represent the extent of a hazard event (colour of gradients);
- the extent of discretisation for the most important risks (number of classes);
- the aid of the discretisation in case of simultaneous representation of the hazard and its impact on major risks (discretisation on the event, on major risks or on these two pieces of information simultaneously), and
- the number of levels of representation associated (density of information/complexity).

4 Case study Austria

Sven Fuchs

The rationale of choice for the Austrian case study was to select test sites that serve as typical mountain catchments with respect to the methods to be applied in order to compile risk maps. Hence, a considerable amount of values at risk has to be affected, and a time series of past events causing damage has to be available. With respect to these prerequisites, the test sites of (1) Wartschenbach (4.2) and (2) Vorderbergerbach (4.3) were chosen. In these test sites, necessary data and recommendations for improved risk maps is already partly available (Fuchs et al., 2008b; Serrhini et al., 2008). Furthermore, in-depth knowledge is available since these study sites had been subject to extensive research activities in the aftermath of multiple events occurring in the test sites and harming settlements located on the individual fans (Fuchs et al., 2007a; Totschnig et al., online first). Additionally, reliable relations with stakeholders are well established, which are central for the success of RISK MAP, e.g., the Austrian Torrent and Avalanche Control Service as directly responsible management authority in the test sites and concerned with the implementation of the EC Flood Directive; and the Lower Austrian Centre for Civil Protection as an official emergency management body within the Federal State of Austria, having already experience in flood risk mapping and emergency planning.

4.1 Case study Wartschenbach

The Wartschenbach catchment is situated in the Eastern Alps in the community of Nußdorf-Debant next to the city of Lienz, Austria, between 670 m and 2,113 m above sea level (a.s.l.). Owing to the considerable amount of unconsolidated material and glacial deposits, and to the steep gradient of 30-40 % the catchment is susceptible to erosion processes, in particular debris flows and associated phenomena. Several damaging torrent events were reported in particular since the 1990s.

4.1.1 Physical geography of the catchment

The springs of Wartschenbach are located in the south-eastern Schober group (crystalline unit located between the Tauern Window in the north and the Perm-Mesozoic Lienzer Dolomites in the south) of the Eastern Alps in the region of Zettersfeld. This region is characterised by para-gneiss and mica-schist enclosing some sub-ordinated amphibolite layers. The relatively smooth upper part of the catchment is very wet and dominated by glacial deposits of the Würmian glaciation which in case of heavy precipitation tend to be unstable and a major source of debris in the torrent. The Zettersfeld is topographically a hilly area with intermediate plain areas, intersected by small depressions. Apart from the Wartschenbach as main torrent of the area, two other small torrents are tributary, the Stieralmbach from the western part of the catchment, discharging in the Wartschenbach at around 1,550 m a.s.l., and the Raderbach from the eastern part of the catchment, discharge at around 1,440 m a.s.l. The upper part of the catchment is characterised by mountain pastures, and the lower part of the catchment (approx. 30 %) is covered with mountain spruce forest (*Picea abies*). Between 1,300 m and 900 m a.s.l., the Wartschenbach forms a deep creek characterised by Mylonite and small fault lines originating from the orogenesis. In the lowest part of the catchment, the Wartschenbach builds a torrent fan, and discharges into a groundwater lake situated in the riparian area of the river Drau. The overall size of the south-exposed Wartschenbach catchment is 2.6 km².

The overall amount of annual precipitation in the region is 1,282 mm (rain gauge at Zettersfeld, 1,866 m a.s.l., annual mean air temperature: 3 °C), while a considerable amount of this precipitation is related to intense rainfall events of short duration (Angerer et al., 2000). The monthly precipitation sums are given in Table 4.1.

Table 4.1: Precipitation data Zettersfeld. Source: Hydrographischer Dienst Tirol

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Σ
Σ [mm]	1	43	79	91	156	191	103	148	99	55	272	44	1,282

4.1.2 Human geography of the catchment

The (orographic) right and upper part of the torrent fan is situated within the municipality of Gaimberg, the lower part within the city of Lienz, and the orographic left part of the torrent fan is located in the municipality of Nussdorf-Debant. Settlement activities can only be traced back to the 1930s municipality of Gaimberg. In 1960, twelve buildings are reported to be situated on the fan (Gaimberg and Nussdorf-Debant), while in 1995, 18 buildings were located in Gaimberg, and a total of approximately 40 buildings are located in endangered areas in 2010.

4.1.3 Previous flooding experienced

With respect to torrent hazards, the concept of design events does not fit in the overall concept of design floods developed for lowland rivers. Nevertheless, some information on a process magnitude and frequency is available (Hübl et al., 2002).

- The HQ_{10} is approximated by a debris volume of 2,000 m³-7,500 m³ of bedload being mobilised (as in the 1996 and 1998 event);
- the HQ_{50} is approximated by a debris volume of 35,000 m³-50,000 m³ of bedload being mobilised (as in the events of 1995, 1997 [2x], and 1999; in 2000, the magnitude was approximated with 20,000 m³)

The flood history is strongly connected to the land use of the upper part of the catchment (forest clearance) and the development of the tourism industry in the Zettersfeld region (the upper part of the catchment was turned into a regional skiing area, e.g. www.lienzer-bergbahnen.at/zettersfeld/winter/), see Table 4.2.

Table 4.2: Flood record of the Wartschenbach catchment. Source: (Event documentation of the Austrian Torrent and Avalanche Control Service, and Angerer et al., 2000; Hübl et al., 2002).

1879/1882	Debris flow, agricultural areas and roads were damaged.
1966	Fluvial sediment transport; three damaged buildings and damage to agricultural areas and roads.
12 06 1972	117.2 mm precipitation/47 h (meteorological station of Lienz) resulted in fluvial sediment transport and area-wide flooding.
18 10 1980	110.2 mm precipitation/24 h (meteorological station of Lienz), clogging of bridge.
19 07 1981	82.5 mm precipitation/24 h (meteorological station of Lienz), Debris flow/fluvial sediment transport, losses to agricultural areas and roads.
06 08 1995	Heavy thunderstorm (incl. hail) at 8:30 p.m. in the north-eastern part of the catchment, 35,000 m ³ debris were mobilised, 25,000 m ³ of which were deposited in the retention basin and 10,000 m ³ were deposited outside the channel bed. Damage to 20 buildings, to agricultural areas, roads and to multiple cars.
27 06 1996	A thunderstorm mobilised approx. 2,000 m ³ debris, 1,200 m ³ were re-deposited in the lower part of the catchment and 800 m ³ reached the fan. Local flooding at "Jaggler" and "Tschapeller" farms.
25 07 1997	Mobilisation of approx. 6,000 m ³ , which were deposited in the retention basin; damage to the road to "Jaggler" farm.
16 08 1997	Heavy thunderstorm (incl. hail) in the western part of the catchment, 50,000 m ³ debris were mobilised, 5,000 m ³ were re-deposited in the middle reaches, 25,000 m ³ were deposited in the retention basin, and approx. 20,000 m ³ reached the torrent fan. Fourteen buildings and one commercial building were damaged.
06 09 1997	Heavy thunderstorm (incl. hail) in the catchment, 35,000 m ³ debris were mobilised, 25,000 m ³ of which were deposited in the retention basin and 10,000 m ³ were deposited outside the channel bed. Damage to five buildings, and the commercial building of "Bachlechner".
25 07 1998	Intense rainfall lead to fluvial sediment transport, approx. 7,500 m ³ were mobilised and deposited in the retention basins. Damage to the road to "Jaggler" farm.
07 10 1998	The retention basin was filled with 5000 m ³ debris. No damages.
27 07 1999	In November 1998, a landslide (triggered by the events of 1995 and 1997) reached the channel bed. A thunderstorm (night between 27 and 28 July) resulted in a debris flow event with considerable amounts of woody debris; approx. 35,000 m ³ were mobilised, and deposited in the retention basins. Damage to the road to "Jaggler" farm.
21 09 2000	Heavy precipitation resulted in the mobilisation of 20,000 m ³ debris in the lower part of the catchment. The lower channel bed was widened by five metres, and the material was deposited in the retention basins.

Photo collection →see Appendix 12.4

4.2 Case study Vorderbergerbach

The Vorderbergerbach catchment is the right tributary to the Gail river in the Carnian Alps, which represent the border to Italy in the Southern part of Carinthia, Austria. The catchment area covers 26 km² between 690 m and 1,560 m a.s.l. Lithologic, the basin is comprised from limestone and Ordovician shale, and covered by de-posits from the Wurmian glaciation. Several damaging torrent events are recorded in the event registry causing damage in the village of St. Stefan-Vorderberg located on the fan.

4.2.1 Physical geography of the catchment

The catchment of Vorderbergerbach is characterised by a considerable potential for sediment mobilisation due to the coverage of large plain areas with ground moraine material, i.e. in the area of the Dellacher Alm and Dellacher Bach. This material tends to surface landslides in case of high intensity precipitation events. These plain areas are surrounded by rock walls composed from Ederkalk (limestone) and Bänderflaserkalke (limestone), both of them resulting in small grain sizes when weathered. Valleywards, the torrent channel enters an area of dark schist which is prone to erosion. At 1,200 m a.s.l., the torrent channel crosses a gorge section (Kesselwaldgraben) with Ederkalk limestone, grey schist and sandstone geology.

The fluvial sediment transport is caused by both, the large amount of loose material of small grain sizes (down to clay) from the Wurmian glaciation as well as the erodible banks of the bedrock channel, i.e., the schist material (Hübl et al., 2004).

The springs of Vorderbergerbach are located on the hillslopes of Poluding (1,999 m a.s.l.) and in the area of the Kesselwald forest in a southwest-northeast direction. A further right tributary is the Görtshacher Bach from the area of Görtshacher Alm, joining the torrent at 1,318 m a.s.l. At an altitude of 1,200 m, the Seebach is joining the main torrent from the left (northern) side just before a west-east oriented gorge stretch (Kesselwaldgraben) which is characterising the middle reach of the Vorderbergerbach. Just after this gorge, the Dolinzabach originating from the southern edge of the Starhand mountain (Dolinza Alm) is joining the main channel from the right (south, 940 m a.s.l.). Before entering the fan, the Vorderbergerbach is incising in a second gorge stretch (Maria Graben). The channel bed is crossing the fan and tributary to the Gail river, which is the main river of the entire valley. The Gail is tributary to the Drau river, which itself is tributary to the Danube river. The overall size of the catchment is 20 km².

Statistic precipitation data is only available from rain gauges adjacent to the test site at (1) Feistritz an der Gail (580 m a.s.l.): mean precipitation 1,311 mm, annual mean air temperature 7.3 °C, and (2) Nassfeldhütte (1,513 m a.s.l.): mean precipitation 2,803 mm, annual mean air temperature 3.8 °C (Source: Hydrographischer Dienst).

4.2.2 Human geography of the catchment

Since detailed data related to the torrent fan would reach beyond data privacy, the general overview on the settlement area is provided instead.

The entire community covers an area of 67 km² at a mean elevation of 726 m a.s.l., and the number of inhabitants is approximately 1777 [census data of 2001]. The test site of Vorderberg is only one of the 20 settlements within the community: Bach, Bichlhof, Bodenhof, Dragantschach, Edling, Hadersdorf, Karnitzen, Köstendorf, Latschach, Matschiedl, Nieselach, Pölland, Pörschach, Schinzengraben, Schmölzing, St. Paul, St. Stefan, Sus-sawitsch, Tratten, and Vorderberg.

4.2.3 Previous flooding experienced

With respect to torrent hazards, the concept of design events does not fit in the overall concept of design floods developed for lowland rivers. The flood history is strongly connected to the land use of the upper part of the catchment, nevertheless, the events and associated losses were only vaguely documented so far (Table 4.3). By Hübl et al. (2004), the event of 23 August 2003 was estimated as a 1-in-100 year event with a bedload volume of 50,000 m³-80,000 m³ (and 120 m³/s peak discharge).

Table 4.3: Flood record of the Vorderbergerbach catchment. Source: (Event documentation of the Austrian Torrent and Avalanche Control Service, and Hübl et al., 2004)

1810	Large amounts of debris deposited on the village square.
1837	Large amounts of debris deposited around the church.
1902	Inundation from the Gail river in Unterdorf region; large amounts of debris from Vorderbergerbach catchment damaged buildings.
1920	Multiple inundations and landslides in the upper part of the Vorderbergerbach catchment.
1965/1966	Major inundations in the entire region of Carinthia, evacuation of inhabitants of St. Stefan was necessary. June 1966: debris was accumulated alongside the buildings located on the river channel.
22 06 1996	Inundation of multiple cellars due to a flash flood from Vorderbergerbach.
23 08 2003	50.000 m ³ -80.000 m ³ of bedload (peak discharge of approx. 120 m ³ /s) were mobilised, and partly deposited in the village.

Photo collection →see Appendix 12.3.

4.3 Background information

In the following section, background information on hazard mapping in Austria is provided.

4.3.1 History of hazard mapping

During the last decades, an increase in land-use activity could be observed in European mountain regions. Taking the Republic of Austria as an example, settlements have been expanded, leading to extensive land consumption and associated population growth. Since the 1970s, the average useable living space increased from 22 m² per person in 1972 to 38 m² in 2001 (Statistik Austria, 2004). As a major part of Austria is located in mountain areas above 1,000 m a.s.l. (this is approximately 36 % of Austria's territory, and approximately 19 % of Austria's territory is located higher than 1,500 m a.s.l.), areas suitable for permanent settlement are limited. In the entire country, 37.2 % of the land area is suitable for permanent settlement and associated economic activities, while in some Federal States, the values remain noticeably below one third of the area. Due to this scarcity, land use activities have repeatedly been extended into areas which are endangered by natural hazards such as mass movements, torrent processes, and avalanches. As a consequence, property values prone to these processes increased accordingly.

Natural hazards, in particular those occurring in mountain areas such as torrent processes and avalanches, have been a focus for scientists since the 18th century – long before modern academia (re-)discovered this niche and established a continuously growing and diversifying field of research. If these early works are analysed the level of detail and the underlying interpretative framework is astonishing given the academic knowledge of that time. One could even conclude that the results and suggestions provided by these sources still influence the scientific debate in the early 21st century.

The priest and physicist Zallinger zum Thun (1778), even if focusing at the local level of the Federal State of Tyrol, Austria, provided a quite comprehensive overview on causes and effects of flooding processes. This included hydraulic and geomorphologic processes which influence the discharge behaviour in mountain streams, as well as engineering measures that may be appropriate for decreasing vulnerability and to prevent future losses in the watersheds. The civil servant Freiherr von Aretin (1808), who at that time was a surveyor for hydraulic engineering and road construction in western Austria, described not only the root causes of landslides and torrent processes from a geomorphic point of view, but also addressed incurred damage in more detail. Annual direct and indirect losses were estimated to equal 1 million

Gulden⁵ in the Federal State of Tyrol only, including necessary tax abatements. Furthermore, and this turns Aretin's monograph into a modern textbook example, he illustrated the anthropogenic misuse of the mountain environment as an amplifier for vulnerability, above all with respect to agriculture, mining and forestry. Further causes of considerable damages originated from the imprudent construction of buildings in endangered areas by regularly using inappropriate building material. Aretin demanded legal regulations to better direct land development in areas not prone to hazard processes, and that these regulations should be accompanied by executive authorities such as federal police forces and forest administration. The monograph concludes with a chapter on event management, and could therefore be seen as an early technical handbook for natural hazard risk management. Duile (1826), as assistant of the Tyrolean and Vorarlberg provincial administration responsible for hydraulic engineering in Austria, focused on the implementation of torrent control works to reduce the susceptibility to hazards. This included the suggestion to retain material disposable for erosion in the upper parts of the catchments, which was also the main conclusion of Streffleur (1852). The costs for necessary mitigation measures should thereby not be provided by the provincial administration but should be distributed among the beneficiaries in a socially agreeable manner – an early attempt of cost sharing through awareness-building. Müller (1857), a Bavarian railroad engineer, focused at the same time on silvicultural measures to reduce erosion. Further details aiming at a minimisation of damages are given on technical mitigation measures to stabilise the channel beds of torrents and to retain material prone to erosion processes. Thereby, Müller's work was mainly based on studies undertaken during field trips in the Eastern Alps, a tendency that can be observed in the subsequent years: The geologist Koch (1875) and the geographer Lehmann (1879) started to report on torrent events by taking an increasingly modern scientific approach, i.e. by referring to previously published works and by underpinning their arguments with measured data. The forest engineer and Swiss professor Landolt (1886) continued this development by presenting a comprehensive monograph on the assessment of torrent and avalanche hazards. This included information on the release of these processes and the effects in the runout areas. Concerning the reduction of vulnerability he suggested – apart from engineering structures in the process areas and afforestation to reduce erosion and avalanche release – the construction of buildings outside areas affected by hazards were possible, which could be seen as a first step towards the modern hazard mapping, and local structural protection to prevent damage in areas already built-up and for exposed road networks. Two years later Coaz (1888) published a monograph on avalanches in the Swiss Alps, comprehensively analysing the causes and effects of avalanches, avalanche activity, incurring losses and possible structural mitigation concepts. Toula (1892) emphasised in his Vienna lecture the results of previous studies, and highlighted the protective effects of mountain forests for erosion prevention, as also reported earlier by the American environmentalist Marsh (1865). Wang (1901;1903), Associate Professor for Torrent and Avalanche Control in Vienna, Austria, provided a detailed compendium on torrent mitigation with a strong emphasis on engineering approaches of stabilisation, retention and silvicultural aspects of erosion prevention. Elements at risk exposed and the question of vulnerability played only a marginal role in his work. This was also the case in Penck's publication related to mountain hazards (Penck, 1912) and the most recent text book published by Strele (1950), a former head of the Tyrolean and Vorarlberg branch of the Austrian Torrent and Avalanche Control Service. In contrast, Stiný (1910), a geologist with a background in engineering and who was a professor at the Vienna Technical University, pointed out in his monograph related to debris flows that considerable interactions exist between hazardous processes and the anthroposphere. He reported on direct and indirect losses to settlements and infrastructure as a result of debris flows, and he additionally addressed the negative effects of natural hazards on alpine tourist destinations. With respect to the use of alluvial cones for settlement and agriculture purpose, Stiný assumed that the costs that incur in the aftermath of torrent events for reconditioning and the necessary repairs of destroyed buildings will by far exceed the benefits created thereby. Hence, strategies to prevent or to reduce the effects of natural hazards in areas of settlement and economic activities trace back around 250 years in the Alps.

Official authorities were first founded in 1884 (Länger, 2003a, 2003b) based on a first legal regulation (Österreichisch-Ungarische Monarchie, 1884). In the second half of the 19th and in the early 20th century, protection against natural hazards was mainly organised by implementing permanent measures in the

⁵not transferable into € at present.

upper parts of the catchments to retain solids from erosion and in the release areas of avalanches. These measures were supplemented by silvicultural efforts to afforest high altitudes. Since the 1950s, such conventional mitigation concepts, which aimed at decreasing both, the magnitude and the frequency of events, were increasingly complemented by more sophisticated technical mitigation measures. Until the 1970s, mitigation concepts were mainly aimed at the deflection of hazard processes into areas not used for settlements. Watershed management measures, forest-biological and soil bio-engineering measures, as well as technical measures (construction material: timber and stone masonry) were implemented. Thus, conventional mitigation concepts consider technical structures within the catchment, along the channel system or channel track and in the deposition area (Holub and Fuchs, 2009). According to the approach of disposition management (reducing the probability of occurrence of natural hazards) and event management (interfering the transport process of the hazard itself), a wide range of technical measures is applicable for an active prevention (ONR, 2009, seeTable 4.4). Structural mitigation inevitably has its limitations, and conventional technical measures against mountain hazards, such as deflection and retention walls as well as torrential barriers, were supplemented by land use control through planning instruments, i.e. hazard zoning, since the 1970s (Stötter and Fuchs, 2006). Further approaches include warning and monitoring, evacuation procedures, civil protection and disaster management norms and codes (Hübl et al., 2009). The overall aim of such passive prevention measures is to reduce losses without directly influencing the process behaviour by separating process trajectories from values at risk (seeTable 4.4). Studies related to the effectiveness of mitigation measures conclude that a combination of active and passive mitigation concepts is not only more reliable due to unpredicted process behaviour, but also more cost-efficient and therefore recommended from the economic point of view (Fuchs and McAlpin, 2005; Fuchs et al., 2007b; Holub and Fuchs, 2008). This issue has been described earlier from a theoretical point of view by Russel (1970).

Table 4.4: Matrix of mitigation measures to mitigate mountain hazards (adapted from ONR, 2009).

		Permanent protection	Temporary protection
Active measures	Preventive effect	Influencing the event disposition	Forest-biological measures
			Technical protection measures
		Influencing process	Technical protection measures
	Reaction to event		Emergency response
Passive measures	Preventive effect	Hazard map Hazard-adjusted land use Local structural protection Management plans (evacuation)	Information Warning Alert Evacuation Closure
	Reaction to event		Disaster management

4.3.2 Legislative context

In the Austrian legislation, multiple regulations with respect to natural hazards exist (Figure 4.1, see also section 2.1). However, no uniform and consistent text of law with respect to the protection from the effects arising from natural hazards is given. In contrast, implications governed by public law are large in number and multifaceted, and include articles in the Austrian Forest Act (Republik Österreich, 1975), the Austrian Hydrography Act and the Disaster Fund Act (Republik Österreich, 1996) at federal level as well as laws regulating spatial planning and land use planning on the Länder level, just to name the most prominent. Further articles with implications for natural hazard risk management are covered by individual articles of the federal traffic law and the law related to disaster management. On the Länder level, articles of the laws related to fire brigades and of the policies for disaster aid include individual regulations with respect to natural hazards. Subsequently, multiple agreements between the federal state and the Länder exist, above all regulating financial issues with respect to early warning systems, mutual rights related to alerts, and several articles on financial compensation. Hence, due to the strong federal character of the Republic of Austria, legislation and execution of issues arising from dealing with the effects of mountain hazards are assigned to different federal, Länder, and local authorities depending on their respective jurisdiction and competence (Figure 4.1). Accordingly, these authorities get also individually active with respect to the administration of the private sector, e.g., concerning aspects of prevention and loss adjustment. Despite these multiple responsibilities at different governmental levels, the most important and fundamental laws – the Austrian Forest Act (Republik Österreich, 1975) and the associated decree related to hazard mapping (Republik Österreich, 1976) – will be addressed subsequently (cf. Holub and Fuchs, 2009).

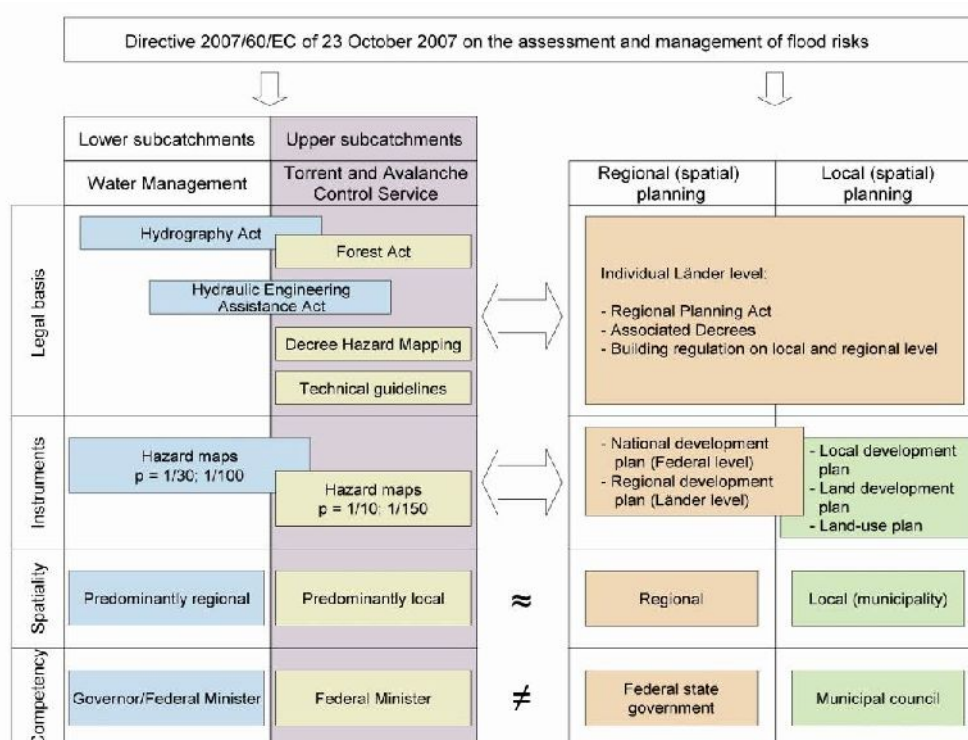


Figure 4.1: Structure of the planning system related to flood hazards in Austria (Holub (2009), modified from ÖROK (2005)).

In Austria, the methodology for delimiting hazard zones is regulated by a national legal act (Republik Österreich, 1975) and an associated decree (Republik Österreich, 1976). The implementation of these regulations is assigned to the Federal Ministry of Agriculture, Forestry, Environment and Water

Management (BMLFUW) and administrated by the governmental departments of the Austrian Service for Torrent and Avalanche Control (WLV) in the upper parts of the catchments and the Federal Water Engineering Administration in the lower parts of the catchments. The Austrian Forest Act (§ 8b) of 1975 prescribes the delimitation of hazard zones in catchment areas susceptible to natural hazards such as torrential floods or avalanches (Forest Act § 99) and areas reserved for mitigation measures. In § 11, the compilation of hazard maps and the involvement of communes and population are regularised. The contents and designs of these maps are specified by a decree associated to the Forest Act (Republik Österreich, 1976). According to § 5(2) of this Decree on Hazard Zoning, all available data and information on natural hazards as well as interactions between individual hazard processes have to be considered during the compilation of hazard maps. Furthermore, interferences with the human environment, such as infrastructure facilities and settlements have to be taken into account. Hazard maps are usually based on the area of an individual community, and should be compiled in a reproducible manner to allow for validation during the approval process by the Federal Ministry of Agriculture, Forestry, Environment and Water Management. Hazard maps are based on a design event with a return period of 1 in 150 years, and an event occurring more frequent with a return period of 1 in 10 years (Republik Österreich, 1976). In § 6 of the Decree on Hazard Zoning, the criteria for delimitation of hazard zones is prescribed. According to these prescriptions, red hazard zones indicate those areas where the permanent utilisation for settlement and traffic purposes is not possible or only possible with extraordinary efforts for mitigation measures. Yellow hazard zones indicate those areas where a permanent utilisation for settlement and traffic purposes is impaired by hazard processes. Furthermore, specific other areas have to be displayed in the hazard map: blue colours mark areas to be provided for future mitigation measures, above all silvicultural measures, brown colours indicate areas affected by landslides and rockfall, and purple colours indicate areas that can be used as protection due to their natural properties, such as protection forests or natural retention basins.

From a legal point of view, the hazard map does not bind land use planners directly in their decisions since the delimitation of hazard zones is not statutory regulation in accordance with the Austrian Superior Administrative Court (VwGH 27.03.1995, 91/10/0090, Hattenberger, 2006; Kanonier, 2006). As a consequence, hazard maps are not normative acts resulting in certain external effects or actions but they are classified as an opinion of experts providing a forecast for prospective developments of natural hazards effects. Accordingly, if the protection against natural hazards is intended to be fundamental for the decision-making of an administrative body, any conflicts arising between these decisions and the content of hazard maps have to be at least technically justified. Approaching this issue differently, administrative responsibility will be neglected considerably if the content of hazard maps is not taken into account accordingly in any governmental action. Hence, hazard maps are not legally binding for spatial planning purpose unless there is particular reference in the individual spatial planning law of the individual Länder, e.g. the Tyrolean Act on Spatial Planning explicitly addresses the protection of areas suitable for building activities against the adverse effects of natural hazards (Amt der Tiroler Landesregierung, 2006 § 1 Abs. 2 lit d). Nevertheless, the content of hazard maps is internally binding for any administrative body in terms of an order, in particular for the governmental departments of the Austrian Service for Torrent and Avalanche Control (WLV) and the Federal Water Engineering Administration (Hattenberger, 2006). Furthermore, due to European and international law, i.e. the Alpine Convention (CIPRA, 1998) and the European Flood Risk Directive (Commission of the European Communities, 2007), areas endangered by natural hazards have to be depicted accordingly in order to exclude them from further development activities.

Regional planning and regional development are a matter of the Austrian Länder and related legal regulation is within the individual Länder responsibility. Hence, for the regional as well as local planning level multiple regulations with respect to land utilisation, land use planning and building development exist. Considering areas endangered by natural hazard processes the traditional way to direct development activities in areas not exposed is an overall major principle but also a major task for local administrative bodies responsible, since areas for development are relatively scarce. However, as outlined by Kanonier (2006) the principle of Länder legislation providing higher-order environmental policy guidelines and establishing mandatory regulations to support municipalities for executions on a local level is no longer traceable in the present spatial planning reality. Although regional planning and the subordinated land

development plan as main administrative tool are statutory, an implementation on the local level is not necessarily deducible. Because of the particular interests of stakeholders involved, higher-order regulations might be solved with respect to individual local needs differently. Furthermore, recently introduced participative approaches are gaining increasingly importance in order to provoke cooperation with parties affected. These affected parties regularly experienced restrictions for development of existing building land due to defined hazard zones (as a consequence of updated hazard information), including prohibition of development within a defined period in time and within a certain location. Consequently, stakeholders on the local level might disesteem Länder requirements, which will be mirrored directly on the local political decision level. An additional problem is the different horizon of spatial planning activities (5-10 years on the local level, 30-50 years on the regional level) and the hazard mapping process (10-20 years). In this regard, the implementation of the European Flood Risk Directive will contribute to a harmonisation since according to Art. 4, preliminary flood risk maps have to be compiled until December 2011, and according to Art. 6 the Member Countries are obliged to prepare area-wide flood risk maps until December 2013. Furthermore, these maps have to be regularly updated during a six-year interval. Regional planning and regional development are a matter of the Austrian Länder and related legal regulation is within the individual Länder responsibility. Hence, for the regional as well as local planning level multiple regulations with respect to land utilisation, land use planning and building development exist. Considering areas endangered by natural hazard processes the traditional way to direct development activities in areas not exposed is an overall major principle but also a major task for local administrative bodies responsible, since areas for development are relatively scarce. However, as outlined by Kanonier (2006) the principle of Länder legislation providing higher-order environmental policy guidelines and establishing mandatory regulations to support municipalities for executions on a local level is no longer traceable in the present spatial planning reality. Although regional planning and the subordinated land development plan as main administrative tool are statutory, an implementation on the local level is not necessarily deducible. Because of the particular interests of stakeholders involved, higher-order regulations might be solved with respect to individual local needs differently. Furthermore, recently introduced participative approaches are gaining increasingly importance in order to provoke cooperation with parties affected. These affected parties regularly experienced restrictions for development of existing building land due to defined hazard zones (as a consequence of updated hazard information), including prohibition of development within a defined period in time and within a certain location. Consequently, stakeholders on the local level might disesteem Länder requirements, which will be mirrored directly on the local political decision level. An additional problem is the different horizon of spatial planning activities (5-10 years on the local level, 30-50 years on the regional level) and the hazard mapping process (10-20 years). In this regard, the implementation of the European Flood Risk Directive will contribute to a harmonisation since according to Art. 4, preliminary flood risk maps have to be compiled until December 2011, and according to Art. 6 the Member Countries are obliged to prepare area-wide flood risk maps until December 2013. Furthermore, these maps have to be regularly updated during a six-year interval (Commission of the European Communities, 2007).

Until now, a considerable diversity of interpretation is detectable with respect to the inclusion of natural hazard prevention in the spatial planning process in different Länder in Austria. Since regulations related to regional planning and development include – besides the prevention against the adverse effects of natural hazards – several other aims, multiple interests in utilisation and possibilities of development are confronted with the need to protect settlements and infrastructure against possible losses resulting from hazard processes. Hence, a conflict of objectives is inevitable.

4.3.3 Roles and responsibilities

To implement long-term planning policies and related spatial planning aims into practice, multiple measures and instruments on different administrative levels are possible. Two major principles to avoid an increasing risk potential exist, the avoidance to extend development land into areas affected by natural hazards, which is currently undertaken by implementing hazard maps into spatial planning practice, and the prescription of certain building regulations and structural measures, such as local structural protection.

Thereby, spatial planning activities are not able to lower existing values exposed in already built-up areas. In contrast, by limiting re-zoning at local governmental level, constructional development activities of plots located in endangered areas are adjusted in order to not increase values at risk exposed considerably. These mandatory restrictions in development on the local level are part of a hierarchical multi-stepped system within the regional planning and land use planning legislation as well as in the building laws at the Länder level and below in the municipalities (Kanonier, 2006). The regional development plan is therefore an appropriate tool to prescribe in a top-down approach certain regulations to individual municipalities on the local level. Hence, a minimum requirement is the depiction of hazard zones in these plans, whereas the level of detail varies considerably between individual Länder in Austria. While in the Federal State of Vorarlberg areas of certain relevance for the planning process have only to be visualised, it is mandatory in the Federal State of Salzburg to identify areas necessary for flood runoff and flood retention as well as areas indicated in hazard maps (Amt der Salzburger Landesregierung (2004), Slbg ROG § 16 Abs. 2 lit. c; Amt der Vorarlberger Landesregierung (1996), VlbG RplG 1996 § 12 Abs. 5). However, the communal administrative opportunity for judgement might be considerable, above all with respect to possible exceptions applicable to guarantee the economic development of a certain region. The extent of consequences arising from natural hazard processes is directly influenced by the legal execution in the respective community or region (Holub and Fuchs, 2009).

According to the Austrian Forest Act (Republik Österreich, 1975) the roles and responsibilities for hazard mapping are explicitly stated as follows:

- § 11. (1) Creating and implementing hazard maps – including necessary adjustments – lies under the competency of the Federal Minister for Agriculture, Forestry, Environment and Water Management, supported by subordinated government agencies according to § 102 Abs. 1. These subordinated government agencies (District offices of the Austrian Torrent and Avalanche Control Service) regularly start their work with respect to hazard mapping and the implementation of any mitigation measures only on request of a local authority, i.e., communities or municipalities affected by natural hazards.
- (2) In hazard maps, areas endangered by torrents and avalanches have to be depicted, the respective level of hazard, and areas that need specific cultivation or need to be kept free for protection measures.
- (3) The draft of the hazard maps has to be submitted to the mayor; the mayor is responsible for providing access for inspection by the citizens during four weeks.
- (4) Everybody with a legitimate interest is allowed to comment on the draft within this period.
- (5) The draft of the hazard map has to be approved by a commission (Subs. 6) according to accuracy and – if necessary – corrected; accurately timed comments according to (4) have to be taken into account.
- (6) The commission is composed from one representative of the Federal Ministry, one representative of the community affected and of the respective Federal State, as well as one representative of the Austrian Torrent and Avalanche Control Service. The commission makes a decision by the majority of votes.
- (7) The Federal Minister for Agriculture, Forestry, Environment and Water Management finally has to approve the draft of the hazard map submitted by the commission, this draft subsequently will become an official document.
- (8) Governmental offices acc. to § 102 Abs. 1 lit. b have to make public the hazard maps, duplicates have to be submitted to the regional authorities concerned.
- (9) In case of changes in the fundamentals (e.g., process behaviour) or the respective assessment the hazard maps have to be updated according to Subs. (3)-(8).

As outlined above, the hazard map has to be considered by the respective planning authorities in the nine Federal States within Austria, however, the implementation and direct influence on planning issues is different between the individual Länder.

4.4 Current flood mapping practices

The current practices in hazard mapping in Austria⁶ are stated in the Decree on Hazard Mapping (Republik Österreich, 1976) as follows:

- § 4. (1) The authorities/divisions within the Austrian Torrent and Avalanche Control Service have to assess data necessary for (a) an analysis of the root causes for processes, including geological, hydro-geological, hydrological, meteorological, climatic and biologic parameters and possible cultural and other anthropogenic impacts, and (b) the collection of information related to frequency and magnitude of events, including available data on losses.
- (2) The authorities/divisions within the Austrian Torrent and Avalanche Control Service have to evaluate these data; and to include them in the written part of the hazard maps.
- § 6. In a hazard map the following areas have to be depicted based on a “design event” (probability of occurrence ~ 1 in 150 yrs.):
 - a) Red hazard zones indicate those areas endangered by avalanches and torrents where the permanent utilisation for settlement and traffic purposes is not possible or only possible with extraordinary efforts for mitigation measures;
 - b) Yellow hazard zones indicate those areas where a permanent utilisation for settlement and traffic purposes is impaired by hazard processes;
 - c) Furthermore, specific other areas have to be displayed in the hazard maps: blue colours mark areas to be provided for future mitigation measures, brown colours indicate areas affected by landslides and rock fall and purple colours indicate areas that can be used as protection due to their natural properties, such as protection forests or natural retention basins.
- § 8. (1) The cartographic part of the hazard map as well as the textual explanations have to be based on the respective state-of-the-art and on the experience of the experts [of the Torrent and Avalanche Control Service]. (2) If general principles change, or underlying conceptions, or the evaluation criteria change, hazard maps have to be revised accordingly by the Austrian Torrent and Avalanche Control Service.

⁶ NB: This procedure is only applicable to the upper parts of catchments under the responsibility of the Austrian Torrent and Avalanche Control Service. For lowland rivers, other legal regulations apply.

4.5 Flood hazard and risk

In the following section, an overview on the data sources and methodological steps undertaken with respect to the Austrian case study (Wartschenbach and Vorderbergerbach, see Figure 4.2) is given.

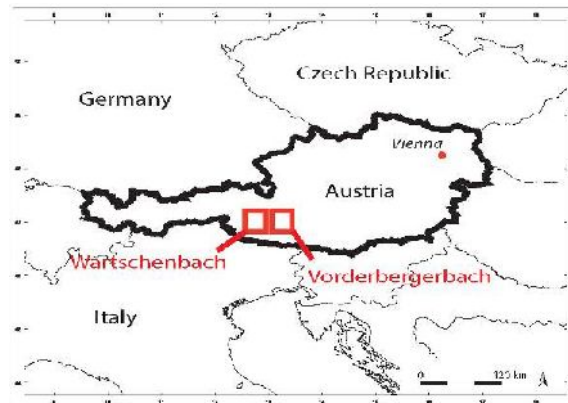


Figure 4.2: Test sites for the Austrian case study.

4.5.1 Flood hazard

For the Austrian test sites, a set of large-scale process analyses was carried out based on an object-based assessment of the hazard, which was carried out using the software Flo-2D⁷. The modelling of the Wartschenbach test site was carried out by a re-calculation of the well-documented torrent event of 16 August 1997, and the modelling of the Vorderbergerbach test site was calibrated by the well-documented event of 29 August 2003 (Figure 4.3). Resulting flow depths and accumulation heights were used as proxies for process magnitudes in order to allow for the assessment of vulnerability and risk. Therefore, a GIS-based real estate appraisal based on a method described in Keiler et al. (2006) was undertaken, and a vulnerability function for torrent processes was developed for the debris flow-like event of Wartschenbach 1997 (Fuchs et al., 2007a), compare the following section). In order to avoid any political discussion of the currently valid hazard maps, the modelling results were validated by the respective event documentation and by these maps and the modelling input data was adjusted to fit the outlines of the hazard zones⁸. As result, the process magnitude was expressed in terms of intensity, and was grouped in two classes: ≤ 0.7 m and > 0.7 m.

⁷www.flo-2d.com, last access March 03, 2011

⁸A technical procedure that was also necessary in other case studies within the RISK MAP project.

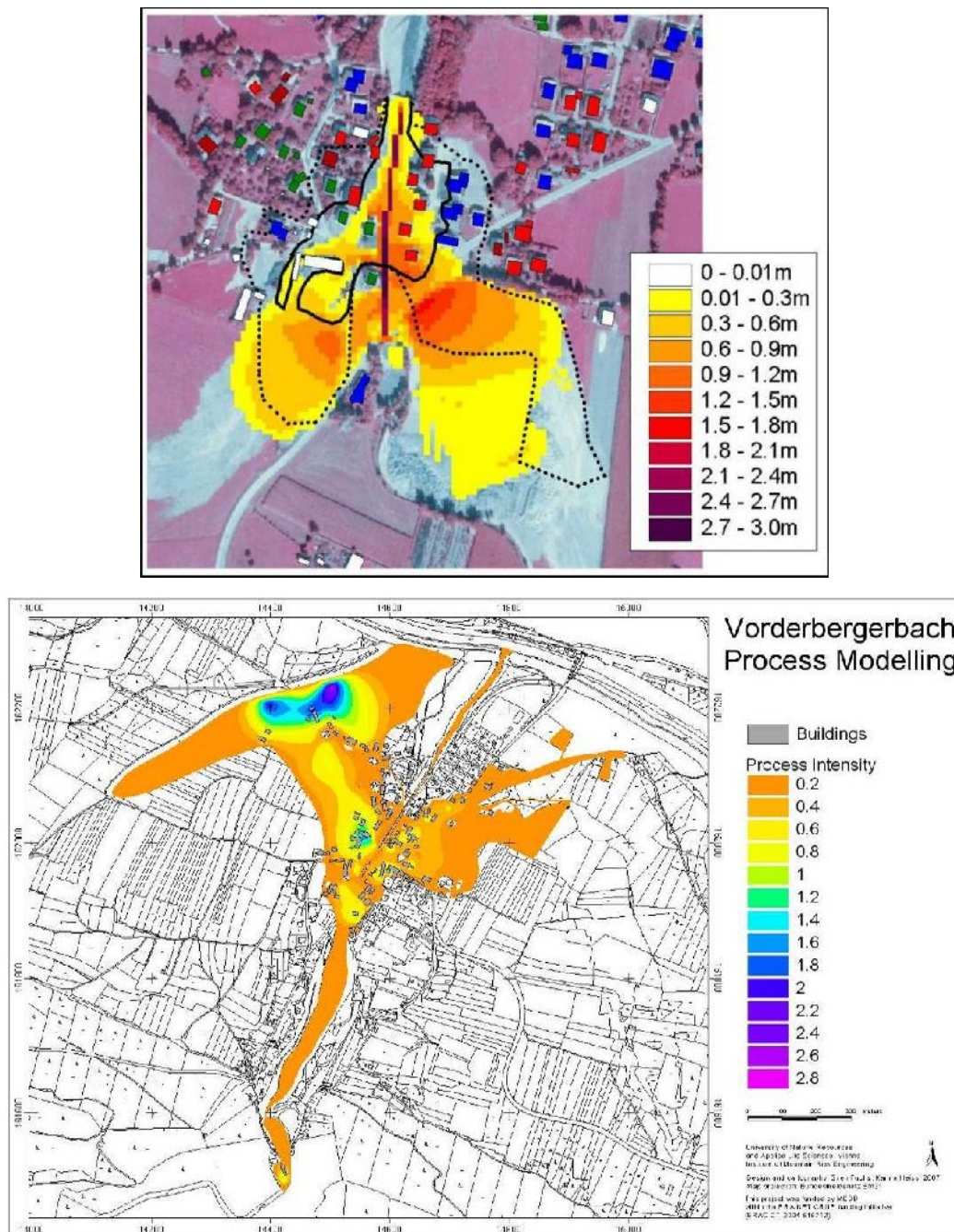


Figure 4.3: Final results of the hazard modelling for the Austrian case studies (top: Wartschenbach, bottom: Vorderbergerbach).

4.5.2 Flood risk

With respect to the determination of flood risk the focus was on (1) economic risk, (2) societal risk defined in terms of people at risk, and (3) the determination of vulnerability equations necessary for the calculation of risk.

Until now, only little work has been carried out to determine vulnerability values for objects exposed to torrent processes, in particular when using an object-based approach. Vulnerability values proposed in the literature show a wide range, above all with respect to medium and high process intensities (Fuchs, 2009; Fuchs et al., 2007a). Furthermore an application of these values might lead to an overestimation of vulnerability, as an assessment for alpine torrent events had shown (Fuchs et al., 2007a; Totschnig et al., online first). Within RISK MAP and based on recent studies⁹, data from the Austrian test sites were used to empirically analyse and assess the vulnerability of buildings to torrent processes, and to establish a respective vulnerability function. Since the analysis was based on process intensities and is thus independent from recurrence intervals, not only the risk resulting from design events can be calculated but also every other event with a different frequency.

The vulnerability of elements at risk was measured using an economic approach. The main criterion therefore was the damage susceptibility (vulnerability), which describes the amount of damage related to the specific damage potential of the considered element at risk, often referred to as loss severity. Following this definition, the vulnerability was derived from the quotient between the loss that occurred during the documented events, and the individual reinstatement value for each element at risk in the test sites. The losses due to the underlying torrent events were collected using information from the federal authorities. Since in Austria an obligatory building insurance against losses from natural hazards is not available so far, property losses are partly covered by a governmental fund¹⁰. Consequently, these losses were collected on an object level immediately after an event by professional judges. For this study, these data were used, adjusted to inflation and attributed to the information on every single element at risk using GIS. In a second set of calculations, this ratio obtained for every single building in the test site was attributed to the process intensities of the respective events. As a result, a vulnerability function was developed, linking process intensities to object vulnerability values (Fuchs et al., 2007a; Fuchs, 2008; Totschnig et al., online first). Consequently, this vulnerability function was used as a proxy for structural resistance of buildings with respect to dynamic debris flow impacts and impact resulting from fluvial sediment transport, and thus was used for a spatially explicit assessment of torrent risk.

Currently, only few conceptual suggestions and operational methods are available for the comprehensive assessment of values at risk endangered by mountain hazards (for a related discussion, please refer to Fuchs et al., 2008a; Fuchs and Keiler, 2008; Heinimann, 1998). Accordingly, the evaluation of damage potential is often based on subjective estimations rather than on widely-accepted standardised approaches. Hence, results of such assessments are rarely comparable, and do not necessarily mirror the actual situation satisfyingly. With respect to integral risk management, the assessment of values at risk has to be based on a spatially explicit valuation using GIS techniques. Thus, the following procedures

⁹ emerging from RISK CATCH as well as from a research project funded by the Austrian Science Fund, Contract L535-N10, "Vulnerability to torrent events")

¹⁰ In Austria, natural hazards are not subject to compulsory insurance. Apart from the inclusion of losses resulting from hail, pressure due to snow load, rock fall and sliding processes in an optional storm damage insurance, no standardised product is currently available on the national insurance market. Moreover, the terms of business of this storm damage insurance explicitly exclude coverage of damage due to avalanches, floods and inundation, debris flows, earthquakes and similar extraordinary natural events (Holub and Fuchs, 2009).

Furthermore, according to the constitution of the Republic of Austria, catastrophes resulting from natural hazards do not fall under the national jurisdiction. Thus, the responsibility for an aid to repair damage resulting from natural hazards generally rests with the federal states. As a consequence, any claim for damages is subject to a considerable insecurity, and any natural and artificial person has to take individual precautions. Thus, the society seems to be highly vulnerable to natural hazards in Austria.

However, the federal government enacted a law for financial support of the federal states in case of extraordinary losses due to natural hazards in the aftermath of the avalanche winter in 1951. The so-called 'law related to the disaster fund' (Katastrophenfondsgesetz) is the legal basis for the provision of national resources for

- preventive actions to construct and maintain torrent and avalanche control measures, and
- financial aids for the federal states to enable them to compensate individuals and private enterprises for losses due to natural hazards

in Austria. The budget of the catastrophe fund originates from a defined percentage (since 1996: 1.1 %) of the federal share on the income taxes, capital gains taxes, and corporation taxes. The prescribed maximum reserves amount to € 29 million.

outlined in Borter (1999) and further developed by Keiler et al. (2006) are recommended for an area-wide application in European mountain regions with respect to persons, infrastructure lines and buildings at risk.

Based on the modelling results of defined design events and recent events, respectively, the associated damage potential was assessed on a multi-temporal and spatially explicit manner, and edited for the use within a GIS environment.

The basis for this procedure was a digitised layer of the values at risk, e.g. a building shapefile originating from orthophotos and information extracted from the land register plan. The surface area of buildings provided the source for any further economic valuation. This valuation was carried out by means of average reconstruction values for different building categories, multiplied by further characteristics of these buildings such as building height and technical equipment.

The elements at risk – which were defined as those buildings within the test sites located on the fan – were analysed object-based on large scale with respect to their spatial location and extension. The type and size of the buildings was recorded from digital datasets of the communality administration and validated by remote sensing techniques as well as field studies. These data provided the basis for a monetary evaluation of the reconstruction values. These values were calculated using the volume of the buildings and average prices per cubic metre according to the type of building, as suggested by Kranewitter (2002) and Keiler et al. (2006, see Table 4.5). Following these suggestions, different price levels were applied, depending on the function of the buildings as well as on the number and kind of storeys. This information was extracted from the construction descriptions and updated by field studies. The average reconstruction value for every building resulted, using the current price level.

Table 4.5: Floor height, number of storeys, and average values per m³ used during the set of calculation. Modified from Keiler et al. (2006: 122)

Type	Floor height [m]	No of storeys	Value/m ³ [€]
Detached house	2.8	3.5	350
Apartment building	2.8	4.0	385
Hotel	3.0	5.0	528
Guest house	3.0	3.5	435
Restaurant	3.0	3.0	399
Public building	3.5	3.5	406
Office building	3.5	1.0	342
Commercial building	4.0	1.0	330
Garage	4.0	1.0	212
Agricultural building	2.8	1.0	200
Car park	2.8	1.0	235
Barn	3.5	1.0	171
Storage building	6.0	1.0	105
Power substations	4.0	1.0	371

The number of persons at risk was derived from the number of households per building and multiplied by the average number of persons per household, e.g. by using information from the respective national statistical offices. If a considerable amount of values at risk were comprised by tourist infrastructure, the number of tourists being present in endangered buildings could be derived from the number of beds in the hotel and restaurant industry, multiplied by the respective rate of occupation (Fuchs and Keiler, 2008).

The dataset was generated (1) object-based related to the geographical location and (2) area-based with respect to the total area harmed by the design event. Thus, two different methodological concepts representing two different possibilities of data availability could be evaluated against each other. Methodological as well as spatial limits and uncertainties were quantified and critically evaluated. Issues in

economical evaluation were addressed and determined within the test sites. The results of these multi-scale assessments were evaluated according to accuracy and preciseness.

4.6 Risk analysis

Having analysed the relevant hazard scenarios, the elements at risk exposed and the associated vulnerability, risk analysis is a method to estimate and assess the impact of a hazard to a given environmental setting. Hence, the method of risk analysis is the prerequisite of risk mapping, and is carried out applying the risk function (Equation 3.1 in section 3.3.1)) using GIS. Thereby, the compilation of risk maps was based on intensive cooperation between all partners in order to fulfil the requirements for the experimental graphic semiology study (see Section 3.3.4), which resulted in a set of risk maps for every catchment that included several suggestions of design and layout. The originally dimensionless risk was converted into several visualisable forms in order to test different illustrative facilities.

4.6.1 Specific definitions of risk and method for assessment

The risk maps compiled for this study were geared to the multiple-scale structure specified in the European Flood Risk Directive (Commission of the European Communities 2007). Consequently, from a natural sciences point of view and with respect to flood hazards, risk (R_{ij}) was defined as a quantifying function of the probability of occurrence of a process (p_{Si}) and the related extent of damage (Varnes 1984; Fell et al. 2008), whereby the latter was specified by the value of elements at risk (A_{Oj}) and the vulnerability ($v_{Oj, Si}$), see Equation 3.1. Vulnerability was defined by a function of a given process intensity on physical structures and was therefore expressed as the expected degree of loss for an element at risk as a consequence of this impact (Fuchs 2009). Consequently, the vulnerability value ranged from 0 (no damage) to 1 (complete destruction).

4.6.2 Components of risk assessed

The initially dimensionless risk Figures were converted into a number of visualisable forms in order to test different illustrative facilities and to obtain a set of maps for both, the Wartschenbach and Vorderbergerbach catchment featuring several suggestions of design and layout. In doing so, either the cumulative risk or the individual risk was analysed both from a comprehensive point of view related to the studied scenario and in terms of annual risk. Cumulative risk was defined as risk related to one spatial object, and individual risk was defined as being related to the number of persons affected.

4.6.3 Aggregation method

The cumulative risk was assessed by using the variable of “annual damage”, which was grouped into four classes (1-250, 251-500, 501-750, > 750 €) and shown at an object level. Individual risk was not monetised but shown as the number of persons affected, this information was as well aggregated into four classes (0, 1-5, 6-10, > 10) and shown on an object level. Both sets of information were further underlain by either the process intensity (< and > 0.7 m according to national Austrian rules for hazard mapping) or by a newly introduced information on vulnerability. This information was deduced from previous studies (Fuchs et al., 2007a; Totschnig et al., online first) and grouped into four classes (0-0.25, 0.26-0.50, 0.51-0.75, 0.76-1.0) and as an alternative into a semi-quantitative variable (S, M, L, XL).

4.7 Alternative mapping

Due to the findings of the RISKATCH project (Fuchs et al., 2009a; Fuchs et al., 2009b) the following guiding principles were applied with respect to the map design in the Austrian case study: both the spatial and dynamic analysis highlighted certain aspects that were identified as being important for an efficient delivery of risk information, i.e., that in coloured zones and written information approximately 90 % of the fixations were concentrated; that the concentration of information in the legend needs to be visible (related to the contrast and colour used) and accessible (only a limited number of information should be included to attract the eye), and therefore, that the spatial localisation of information considerably influences the perception by the reader.

Hence, the entire set of maps was built up in a landscape format with the legend on the right side. Only two classes of information were included (either expected annual loss or number of persons affected, plus information on the process intensity or vulnerability, respectively. Additional information related to special risks (e.g., an artificially introduced retirement home, industrial buildings, or the localisation of hazardous material) was provided. A scale bar (in order to avoid misinterpretation of the scale when adjusting the size of the maps) as well as the orientation as well as copyright and source information were included (see Figure 4.4 and Figure 4.5). The torrent was named as well as the major evacuation road; the latter being additionally indicated by either a pictogram or a green arrow. According to the international character of the RISK MAP project, all major information was indicated in three languages (German, English, French) in order to meet the requirements of the eye tracking test (maps should be accessible to all individuals being tested).

4.7.1 Map scales

The initial map scale was set to 1:2,500 (Wartschenbach) and 1:5,000 (Vorderbergerbach).

4.7.2 Colour schemes

Colour schemes were chosen related to the findings of the RISKATCH project (Fuchs et al., 2009a; Fuchs et al., 2009b). The major (risk) information was shown in five classes, a red colour scheme was used for those buildings with a classified annual damage or with a grouped number of persons at risk, while a second colour (grey) was used to show no-data information. The information related to the process intensity was either shown by red and yellow colours according to the Austrian regulations of hazard mapping, or in a blue colour scheme (with respect to vulnerability in decreasing order). Additional information was given by individual colour schemes (retirement home: black, industrial building: hatched). Standardised pictograms or colours were used for the supplementary information on escape routes (green) and hazardous material (orange).

4.7.3 Graphic map background

The graphic map background was the land register plan (black and white, vector format) according to the previous findings of the RISKATCH project (Fuchs et al., 2009a; Fuchs et al., 2009b).



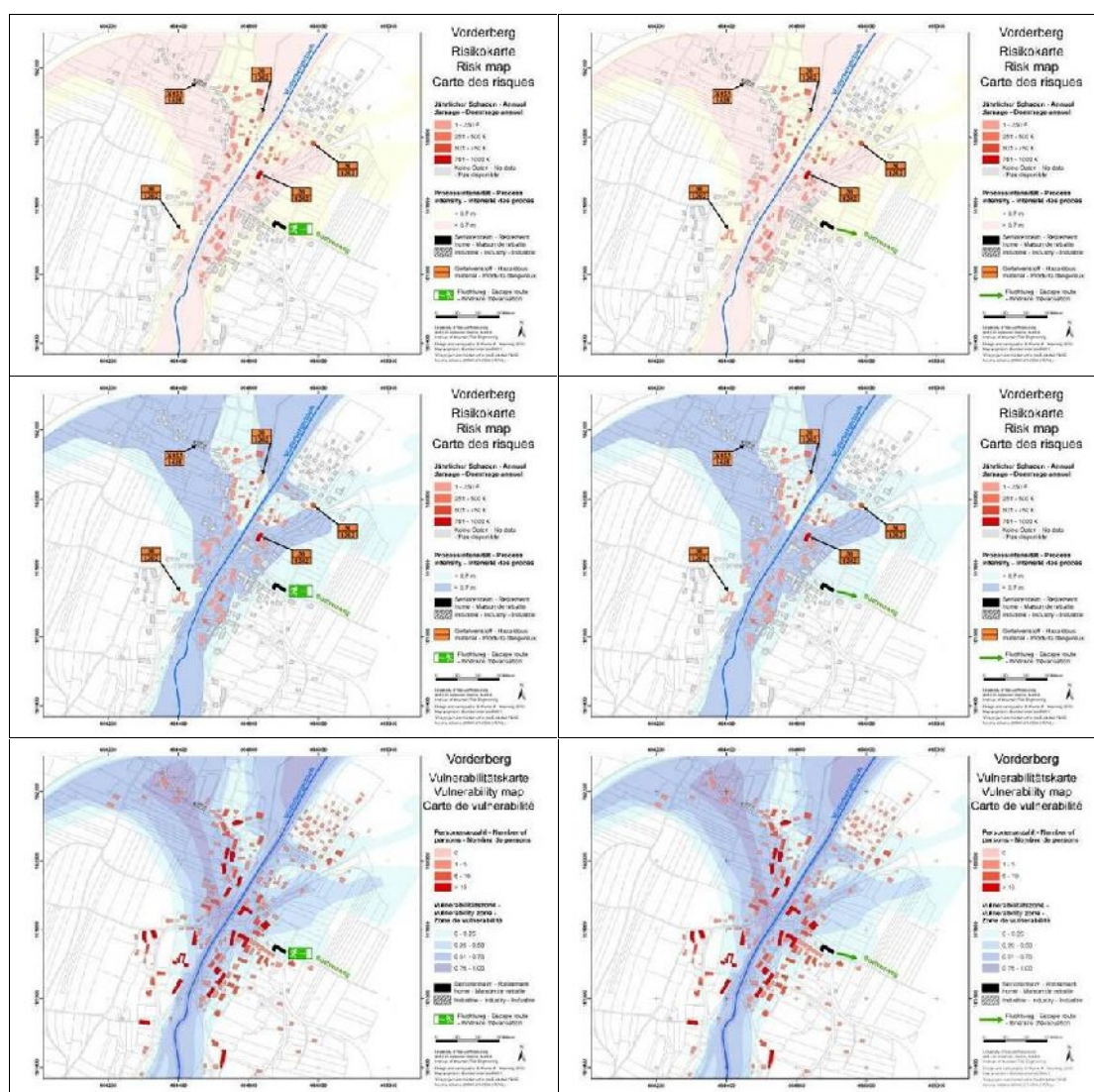


Figure 4.5: Risk maps for the Vorderbergerbach test site.

4.8 Interview findings

An extended interview was carried out with a representative of the Lower Austrian Centre for Civil Protection as an official emergency management body within the Federal State of Austria. The agency has already considerable experience in flood risk mapping within lower river catchments and emergency planning. Consequently, the focus of this interview was on the map content of such risk maps with respect to event management, e.g., the content necessary for emergency planning and evacuation. General findings from this meeting included the following items:

- Flood risk maps have to be compiled stakeholder-oriented with respect to different end-user needs.
- The design event necessary for a compilation of risk maps has to fulfil the legal national or institutional requirements of the respective countries. This means that for the Austrian case study, the hazard extent and the delineation of hazard information should be in accordance with the

Forest Law (Republik Österreich, 1975) and the Decree on Hazard Mapping (Republik Österreich, 1976) as well as the subordinated internal regulations.

- The map format has to be manageable in outdoor and emergency situations which means that flood risk maps as well as flood risk management plans (at least with respect to their application in the field) have to be adjusted to a scale that fits to usual folders, i.e., an DIN A4 or DIN-A3 format, preferable in a second set of maps also laminated. This restricts the content to be depicted considerably. Supplementary information can be converted in a non-visualised form, e.g., by tables or textual information.
- Different stakeholders need different information with respect to flood risk. Therefore, the overall data content of the maps has to be adjusted to these different needs, i.e., by including or excluding the number of persons at risk, or by including or excluding information on dangerous goods within the potentially flooded area.

4.9 Findings from the workshops in Austria

Two sets of workshops have been carried out in the Austrian case study, one workshop in July 2010 before the compilation of risk maps and the test series in Tours, and one March 2011 after the test series in Tours and after preliminary results of adopted risk maps have been submitted by the French project partner.

Participants of the first workshop included 18 representatives of the Austrian Torrent and Avalanche Control Service as directly responsible management authority in the test sites and concerned with the implementation of the EC Flood Directive; participants of the second workshop included 8 representatives of the Task Force of the Implementation of the Floods Directive in Austria under the umbrella of the Umweltbundesamt GmbH in Vienna.

The overall aim of the first workshop was to include specific needs of a specific end-user group in the RISK MAP project, while the aim of the second workshop was to confront the working group responsible for the implementation of the European Floods Directive into practice with the results obtained within the RISK MAP project, and to foster discussion of possible adjustments of the current suggestion for implementation.

4.9.1 First workshop

The first workshop was designed as a round-table discussion in small groups with respect to the following guiding questions:

- Which information should be included in risk maps that are necessary with respect to the implementation of the European Floods directive?
- Which information already included in the hazard maps of Austria can be used and adopted to the requirements of the European Floods Directive, respectively?
- How should risk information be visualised if your organisation would be responsible for the implementation of the European Floods Directive?

Based on the results of the discussion in small groups, presentations were held in a plenum and discussed with all participants. An overall general recommendation was developed based on these discussions.

However, the results of this workshop were rather poor compared to the expectations. Since the procedure of hazard mapping is legally laid down in the above-mentioned sources, the general recommendation from the first guiding questions was that information on elements at risk should somehow be included (without going into detail of whether or not to include values exposed, people exposed, critical infrastructure etc.). The workshop partners were quite divers in their knowledge on differences between hazard and risk, and in their willing to participate in this workshop (most of them were sent by the head of the Section to this meeting and not because of individual interests in the topic).

Accordingly, the answers to the second guiding question scan be summarised as follows: If risk maps are necessary, they should be compiled according to the colour scheme of the current hazard maps in Austria (i.e., red and yellow colours for higher and smaller risk). The participants did not agree on any suggestions with respect to risk but there were focusing on the hazard part of this information (which they know though tier daily business). Since the underlying information with respect to the delineation of a design event differs in mountain catchments from lowland rivers, an application of pure extreme value statistics was not suggested with respect to the underlying hazard scenarios.

With respect to the third guiding question (visualisation for different stakeholder groups), the overall recommendation of the participants was not to publish the risk information so that affected citizens or people concerned can get access to this information (which is not in line with the legal prescription of public availability of hazard maps) since “risk maps should be compiled by experts for experts and are therefore not understandable by non-engineers”). The latter sentence is typical for this first workshop since the experts (engineers of the Austrian Torrent and Avalanche Control Service) were not willing to think about the accessibility of their products (maps) for other planning authorities or other stakeholders involved (which, according to the legal regulations of land use planning, is more or less the procedure in Austria until now). As a result, there were no useable results with respect to the third guiding questions that could be used in order to design a set of risk maps. Instead, the results of the interview were combined with the recommendations of the RISKATCH project (Fuchs et al., 2008b, 2009b) in order to compile the set of maps necessary for the study.

4.9.2 Second workshop & case-study specific recommendations

A second workshop was held in March 2011 on request and with the support of the Task Force of the Implementation of the Floods Directive in Austria. The main aim of this workshop was to compare the preliminary results of the RISK MAP project with the draft recommendations for risk mapping compiled by this Task Force and to discuss some possible improvements with respect to visualisation.

Major outcomes of this second workshop include the following:

- Since risk maps have to be compiled stakeholder-oriented, and these maps will be used by stakeholders with different educational background, a set of at least three sets of maps have to be produced by using the same data as a basis: (1) Maps for experts in flood risk (e.g., engineers responsible for flood protection). These maps, as a consequence, can include detailed information on the hazard (design event: flow depths, flow velocities, etc.) and the elements at risk exposed (e.g., number of people concerned, values at risk, hazardous materials exposed, etc.). These experts will always have sufficient time to interpret the multi-layer information and to develop appropriate management strategies. (2) Maps for bodies responsible for event and emergency management. The members of such bodies are not necessarily experts in risk assessment, and need a set of information that is adjusted to their specific needs (e.g., number of people to be evacuated from individual buildings, and accessibility of these buildings in case of (design) floods). Therefore, the possible set of information should be reduced and adopted to these needs, and the scale of the maps has to fit to a possible analogous map format (Din-A3 to be used by an emergency team in the field). (3) Maps for dissemination of risk information to the general public. This information has to be aggregated to an understandable format (e.g., from probabilities of occurrence to “high”, “medium”, and “low” flood events). As a consequence, the information has to

be delivered in a way that it can be understood in an efficient manner during a short period in time (compare recommendations, section 10).

- Since contemporary techniques and methods for map compilation are GIS-based, these different information needs can be easily acknowledged by a well-defined set of map template focussing on different scales and multiple end-user interests.

5 Case study England

Sally Priest, Joanna Pardoe, Simon McCarthy

5.1 History of flood mapping

There is a long tradition of flood mapping in England and Wales. Table 5.1 illustrates the broad phases of flood mapping. This began with a local collection of observations of past flood events and the mapping based on geological deposits. Post 1970 there was a concerted effort to move towards trying to assess where flooding might occur and the extent of possible flooding. Originally the specification was for Water Authorities to undertake mapping as part of the Water Act, 1973. However, these authorities no longer existed post 1989 following the privatization of water companies and responsibility for mapping fell onto the agency in charge of flood defence; the National Rivers Authority which was to become the Environment Agency.

Table 5.1: The evolution of flood mapping in England and Wales

<i>Type of flood map</i>	<i>Description</i>
River Boards – Blue books 1940s to 1970s British Geological Survey	Paper maps prepared and drawn from the observations of flood events Digitisation of drift geology associated with riverine deposits such as alluvium.
Section 24(5) surveys Water Act 1973	Water Authorities -Systematic collation of information on flood extent up to the time of preparation, presented at various scales (usually 1:25 000 or 1:50 000).
<i>Beginning of the current flood maps</i>	
Section 105 Survey Water Resources Act 1991	Agency responsible for flood defence – Maps showing the predicted 1:100 flood boundary. Generally predicted using historic record data and computer simulation.
Institute of Hydrology 130 1999 Indicative maps	Boundaries generated using IH computer generated flood depth and OS DEM. Comprehensive national coverage of England and Wales using data from a number of the above sources.
2004 – Major update of the online maps	As well as a major update and redesign of the indicative flood maps. The NaFRA product was introduced.

5.2 Legislative context of flood risk mapping in England and Wales and the development of the current flood map and online information service

The Environment Agency (EA) was established as an England and Wales body under the Environment Act 1995 (established itself after the Environment Act 1995, and inherited a range of responsibilities flood defence responsibilities principally in the Water Resources Act 1991. These relate to defending against flooding from main rivers and the sea, and related activity including providing flood warnings and flood mapping. These powers are limited to 'flood defence' activities rather than a wider range of activity for managing flood risk. These relate to defending against flooding from main rivers and the sea, and related activity including providing flood warnings and flood mapping. These powers are currently limited to 'flood defence' activities rather than a wider range of activity for managing flood risk.

The original use of the current flood maps were originally provided to spatial planners and used within the EA to assist planning, but they were put online in 2000 in order to help raise public awareness of flooding and enable those at risk to take mitigation action. The current flood map information service delivered through the "What's in your backyard" (IYB) section of the EA web site had its origins in the on-line launch of the "indicative flood plain map" in December 2000, following political pressure relating to the catastrophic flooding in England during the Autumn of that year. Although the detailed timing was linked to a particular flood event, the need for an on-line service had already been recognised and a postcode-based real-time flood service had been launched just a little earlier (planned and driven by EA Corporate Communications). Ministerial pressure for definitive action resulted in the indicative map being launched without full user testing, since the complete launch process took only about 3 months. There were strong in-house misgivings about such a pressured initiation, and at a technical level these proved to be justified when the system crashed within its first hour and only 5% of the 1½ million hits on the first day were properly served. From the beginning, the popularity of the service was assured, even when it suffered technical or substantive problems, and IYB remains the most popular part of the EA web site on an annual basis, with periodic usage strongly correlating with heavy rainfall events, and daily usage being strongly predicted by the user hits in the period 09.00 to 10.00.

The current Environment Agency flood map is made up of two different data layers; the indicative flood map layer and the National Flood Risk Assessment (NaFRA) dataset. Both of these datasets are developed in different ways and have different advantages, uncertainties and assumptions. The indicative flood data is that which is presented on the map as a two-toned blue mapped layer, however, when the map was originally put on the Environment Agency website in 2000, the layer consisted of two colours, blue which indicated the areas at risk from river flooding (1 in 100 years) and green which indicated areas at risk from flooding from the sea (1 in 200 years).

5.2.1 Roles and responsibilities for mapping and users of the flood map

Figure 5.1 provides an illustration of the different roles and responsibilities of those producing the flood map and users of the associated online information service. It illustrates those different groups who are involved in collecting data, developing and verifying the current flood map.

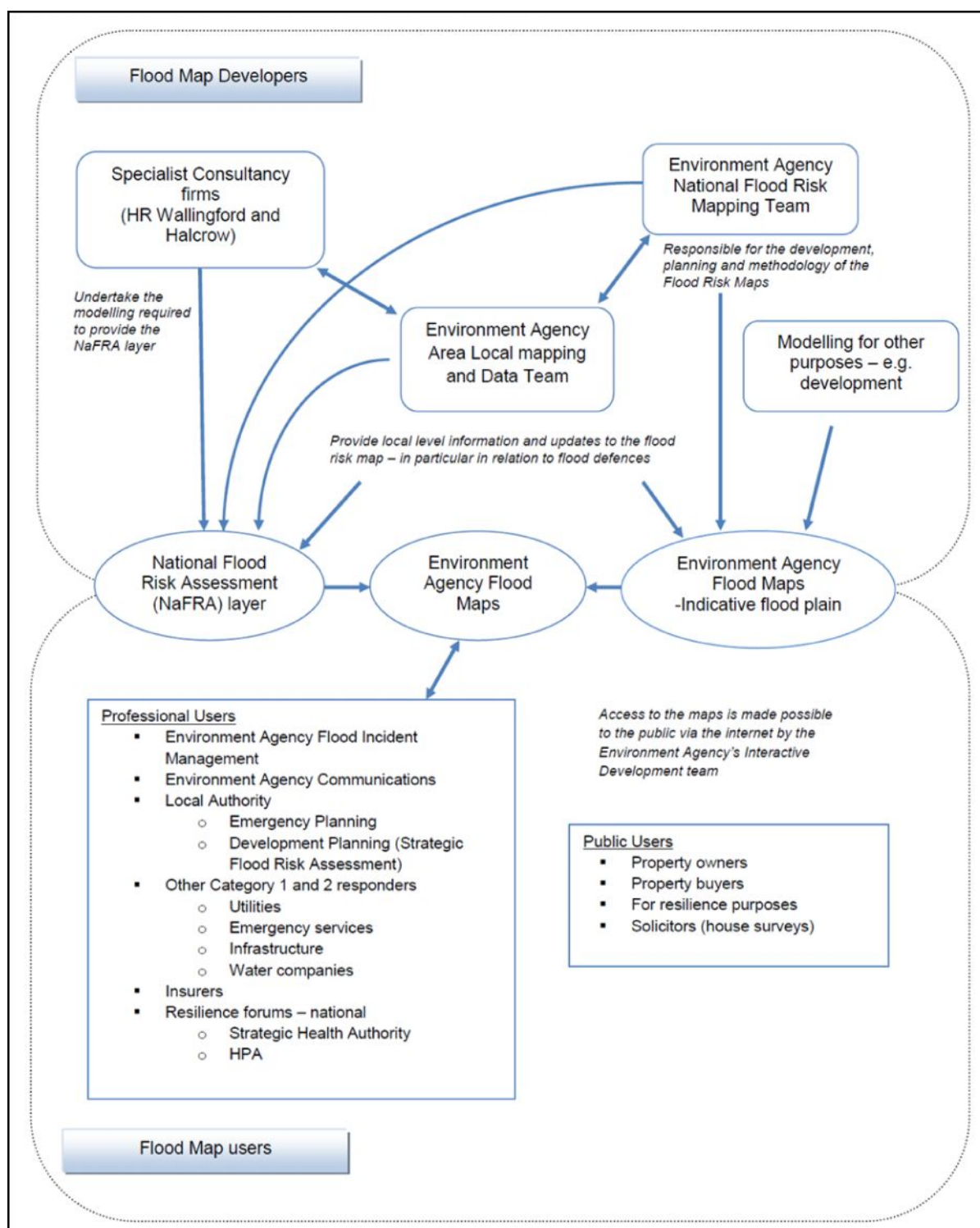


Figure 5.1: Developers and users of the Environment Agency flood map

It highlights the range of scales at which mapping activities are undertaken. Following the introduction of the Floods and Water Management Act 2010 and the implementation of the Floods Directive

responsibilities and the process of mapping is likely to alter. These developments are discussed further in section 5.4.6.2.

5.2.2 Uses and users of the flood map

Figure 5.1 also illustrates users of the map. These are split into two different groups; professional users (including among others emergency planners and those responsible for flood response activities) and the public. One of the primary functions of the flood map was to assist in planning and enable development decisions to be taken in the context of the flood risk to an area. This remains one of the key professional functions of the flood map.

5.2.2.1 Flood mapping and planning

The flood zones themselves are intimately linked with spatial planning and the flood extents have been produced in relation to the types of developments that are permitted at different levels of flood risk under Planning Policy Statement 25 (PPS 25). Planners and developers use the EA flood map data as a basis for the development of both Strategic Flood Risk Assessments and Flood Risk Assessment (which are development based) and Local and Regional Development Planning. However, they may also enhance this data with more specific local modelling and/or mapping to improve the mapped data for their area. Therefore, local flood maps for both planning and development purposes may exist but spatial coverage of these across the country is variable. However, there is evidence that people also use the maps for professional reasons use the online maps in particular for property conveyance.

5.2.2.2 Public uses of the flood map

The public might access and use the flood map for a variety of different reasons. Priest et al. (2008) in their survey (n= 1380) of online users of the flood map indicate that there were three main reasons for people to access the flood map the latter two of which are of most interest to public users: professional reasons for accessing the map (27%), concern about the flood risk to their own home (33%) and concern about the flood risk to a property they are considering moving to (15%).

5.3 Current flood mapping practices

Three different types of mapping are undertaken by the Environment Agency; the outline indicative flood map, historical flood map and the NaFRA product. However, only the indicative flood map (Figure 5.2) is currently provided on the web-based information system as a mapped flood layer, whereas the NaFRA although is technically held as mapped information (e.g. Figure 5.3) is only provided as information by clicking on the map to find out more information. The Historic Flood Map is distributed to Environment Agency Staff and professional partners such as local authorities to assist in emergency planning and for development purposes (Environment Agency, 2010).

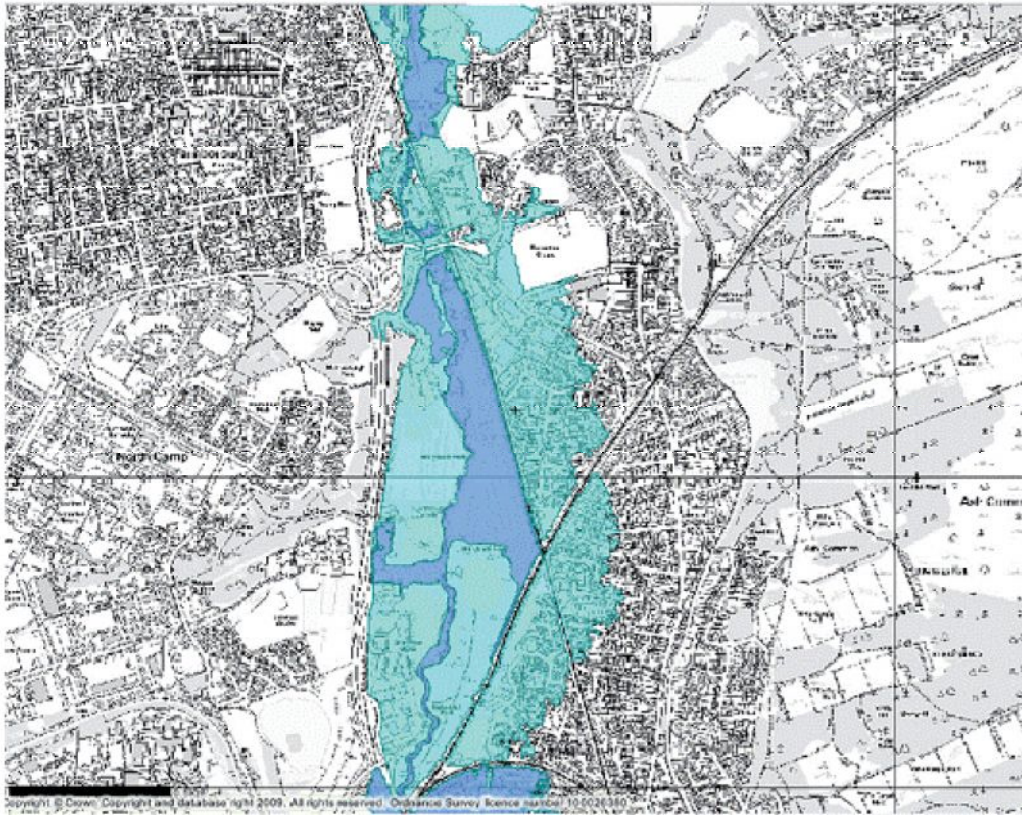


Figure 5.2: Example of the outline indicative flood map: Zones 3 (dark blue) and Zone 2 (light blue) (Environment Agency, 2010; 6)

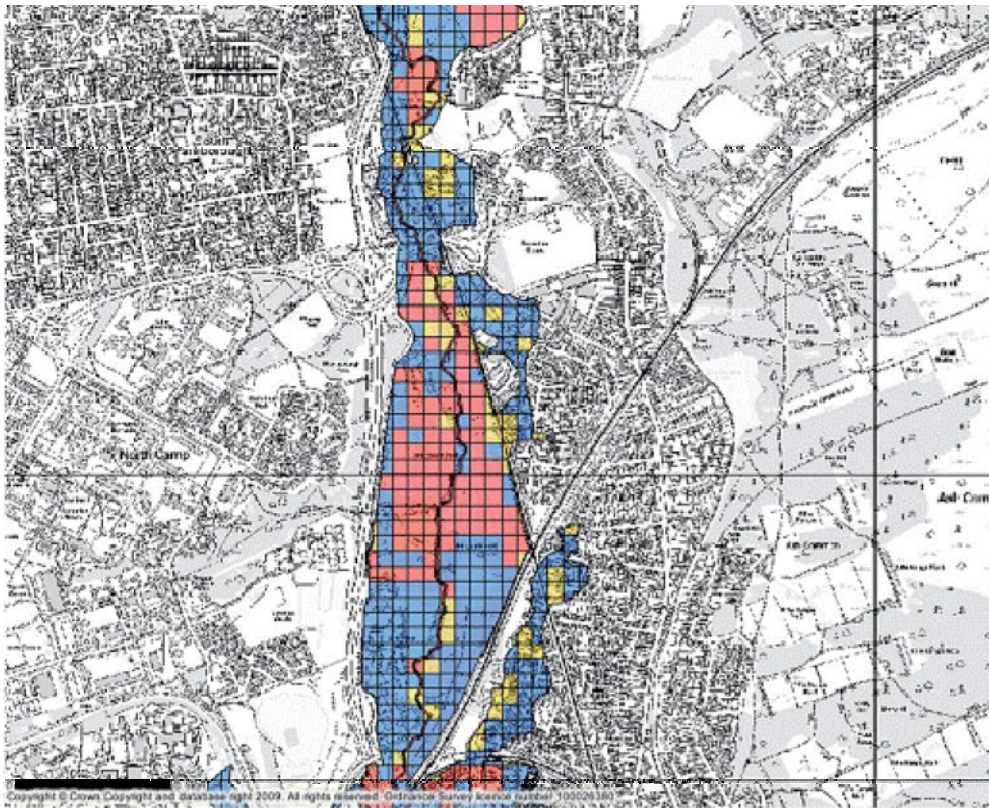


Figure 5.3: National Flood Risk Assessment showing significant (red), moderate (orange) and low (blue) likelihood of flooding (Environment Agency, 2010; 6)

5.3.1 Outline flood map

The map began life as quite a crude outline layer developed in 1996 by the Institute of Hydrology (now known as the Centre for Ecology and Hydrology). This was added to by detailed local survey data and information on historical flood events which aimed to refine the outline layer (Bradbrook *et al.* 2005). A deterministic approach has been adopted that has been used to define the two different layers of flood risk. Where possible detailed topographic surveys have been combined with river flow information (sea level and wave data in the case of coastal flooding). However, unfortunately not all areas have detailed information and therefore it has been necessary to employ an alternative methodology to identify and map flood risk areas. The Environment Agency (2006b) explains that for areas lacking data “national generalised modelling based on a combination of:

- a digital terrain model from Intermap Technologies (using IFSAR);
- detailed terrain mapping using more detailed LiDAR technology.”

They go on to explain that the NEXTMap Britain (DEM) generated using Interferometric Synthetic Aperture Radar (IFSAR) provides a horizontal resolution of 5m and has a vertical precision of + 0.5m to 1m. To produce the outlines with a 1 in 100 and 1 in 1000 chance of flooding in any given year the model J-FLOW (a 2D Diffusion wave model) has been used to input into the flood hydrograph for each 1km section and generate a flood outlines for the inflow point of the hydrograph. Each of these outline are then combined to produce the overall envelope of flooding (Bradbrook *et al.*, 2005). Validation and testing of this information was undertaken using both cross-sectional survey and historical flood outlines.

However, since the outline flood map was produced at a national level, more detailed modelling and model re-runs particularly in areas at higher risk from flooding have refined and updated the outline produced by the nationally consistent approach.

Table 5.2: Mapped zones on the outline indicative flood map

Flood zone	Mapped features	Description
1	Outside the mapped layer	The risk of flooding is < 1 in 1000 chance in any given year (0.1%)
2	Extreme flood event outline (light blue)	These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance of occurring in any given year.
3	Dark blue flood layer	from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening in any given year or from a river by a flood that has a 1% (1 in 100) or greater chance of happening in any given year.

Defence information is not taken into account when calculating the flood risk, however flood defences are presented on the map and the areas which are protected by the defences are also illustrated by black hatching. Damage data has also been linked to the flood map data most commonly used for CBA purposes. However this information is not currently available to public users.

5.3.2 Risk analysis and the National Flood Risk Assessment (NaFRA)

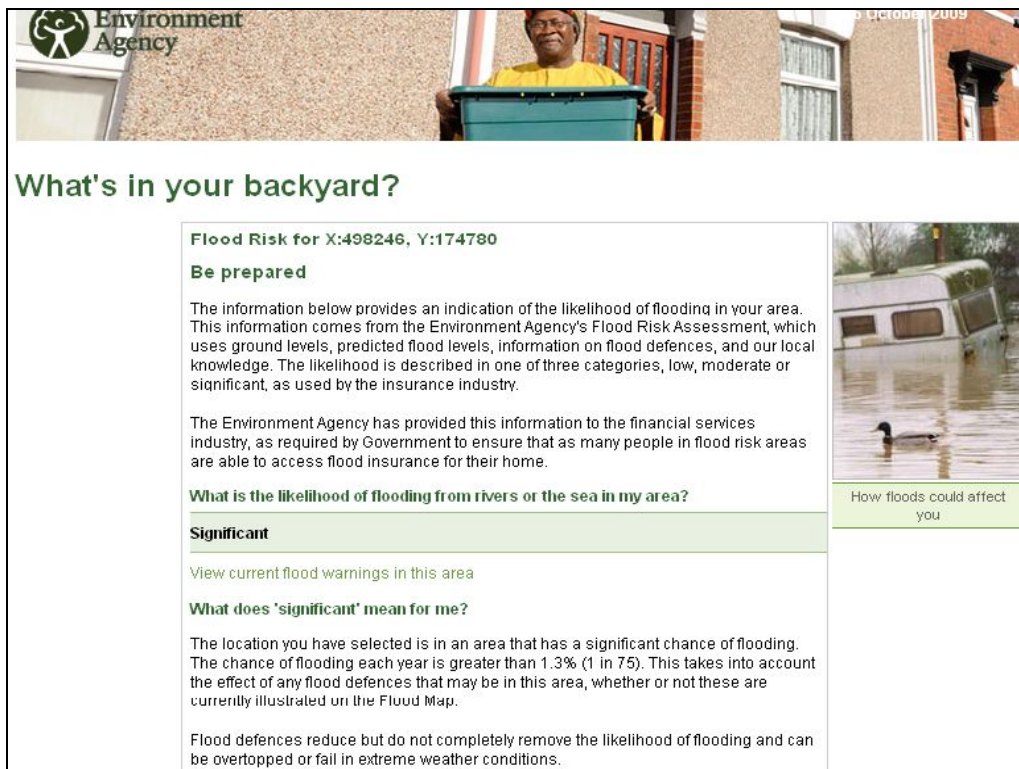
This information is presented as a secondary layer is produced using the Risk Assessment of flood and coastal defence for Strategic Planning (RASP) methodology is used. This methodology uses a “risk-based probabilistic approach to factor the location, type, condition and performance of flood defences into the risk assessment” (Environment Agency, no date accessed 2008) which then is used to produce the national flood risk assessment. This layer is used to provide a user more information about the distribution of flood likelihoods within each zone. The land is divided into smaller areas (known as impact zones) which are then refined to 50 x 50m cells known as impact cells. 37 different flood scenarios (from floods that might occur each year to extreme flooding) are then applied to the centre of each of the cells. These scenarios are calculated taking into account the topography of the area as well as the integrity of the flood defences – in particular whether they will be breached or overtopped. This allows developers to calculate whether the each cell will flood, under each scenario. This information whether the cell is flooded or not, together with the probability of each scenario, is the likelihood of flooding for each cell. This likelihood is used to allocate each cell to the three risk categories (Table 5.3). It is important to note that “It enables a comparison of the relative risks and their distribution within each of these catchments, rather than a detailed, local assessment of the risk at a specific location” (Environment Agency, 2006b, p3).

Table 5.3: Flood risk zones defined as part of the National Flood Risk Assessment

NaFRA zones	
LOW	The chance of flooding each year is 0.5 per cent (<1 in 200) or less
MODERATE	The chance of flooding in any year is 1.3 1in 200 to 1 in 75 per cent (1 in 75) or less but greater than 0.5 per cent (1 in 200)
SIGNIFICANT	The chance of flooding in any year is >1 in 75 greater than 1.3 per cent (1 in 75)

As stated above the information presented by NaFRA is not presented as a mapped layer, however is accessed by users of the online flood map by clicking on the map in order to ‘see how likely it is to flood at a particular location.’ An example of the type of information provided when this service is accessed is

provided in Figure 5.4. Since its inception, NaFRA has been updated on an annual basis with a new version being issued each year.



The screenshot shows the Environment Agency website interface. At the top, there's a banner with a person holding a blue bin. Below this, the heading "What's in your backyard?" is visible. The main content area displays flood risk information for a specific location (X:498246, Y:174780). It includes a section titled "Be prepared" with explanatory text about the flood risk assessment. A green box highlights the flood risk level as "Significant". Below this, there's a link to "View current flood warnings in this area" and a section titled "What does 'significant' mean for me?" which explains the likelihood of flooding. To the right of the text, there's a small image of a flooded area with a duck and a caption "How floods could affect you".

Figure 5.4: NaFRA 'learn more' information as presented on the Environment Agency website (Environment Agency website, Accessed 20.04.11).

Additional flood criteria information

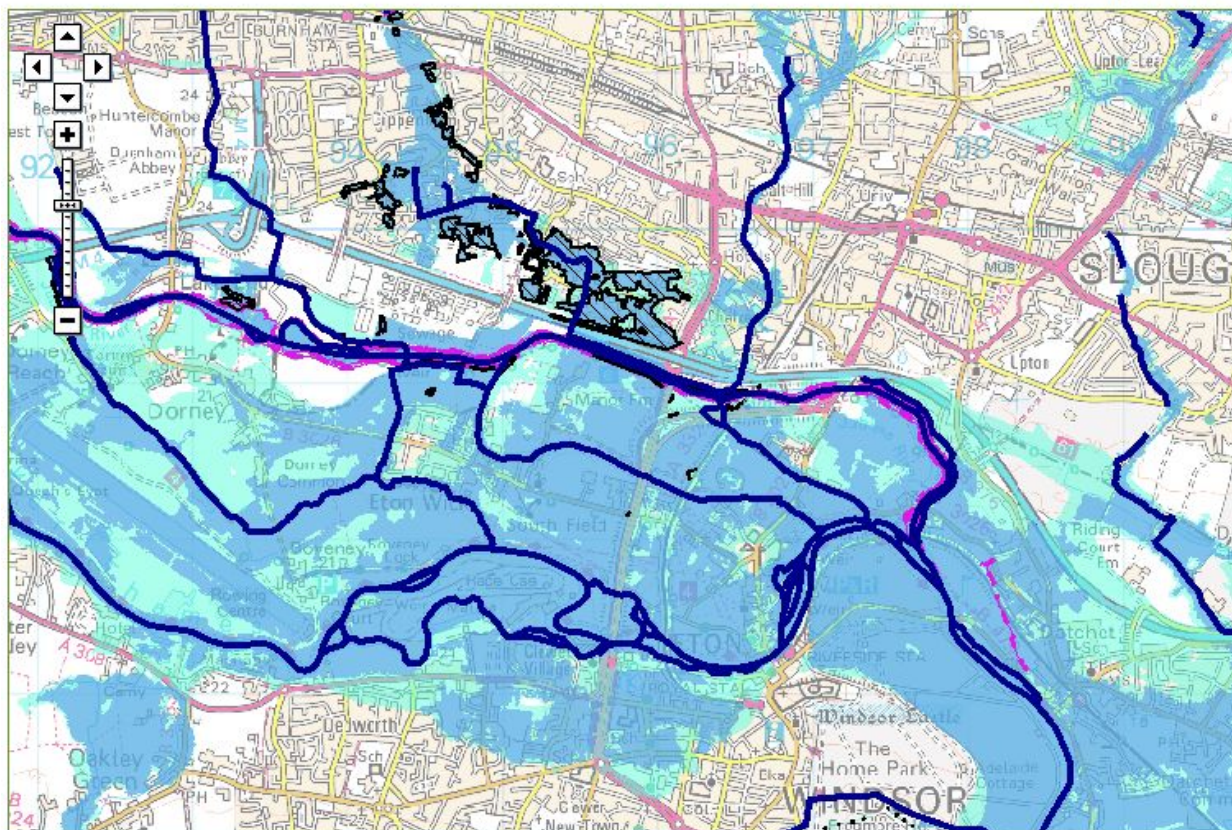
As described above currently only the extent of the flood hazard is represented on the flood map, although additional criteria (e.g. information on defences) is incorporated into the NaFRA data layer. No additional hazard information such as depth, expected discharge or flow velocities is currently mapped although this information might be available in some areas of England and Wales. There is also no additional information on either vulnerability to flooding or data on the consequences such as ecological or economic damages expected.

5.4 Map design

This section contains information on how the contents of the maps are visualised in terms of scale (detail), colour, graphic background and additional map data. The map as presented on the website has undergone a number of iterations since it was first presented in 2000, with some major changes being implemented in 2008 and again in early 2011. Figure 5.5 provides an illustration of how the map is currently presented online.

Windsor, Windsor and Maidenhead at scale 1:40,000

Text only version 



© Environment Agency copyright and database rights 2011.
© Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380,
contains Royal Mail data © Royal Mail copyright and database right 2011.

Figure 5.5: An example of the current Environment Agency flood map as presented on the Environment Agency website (assessed 05/09/2011)

5.4.1 Map scales

Mapping scale is one feature that has changed over the duration of the RISK MAP project and therefore this section will detail recent developments in mapped scale. It is important to note however that changes to the scale and graphical background of the maps occurred following the initial public workshop and so the previous scale information was presented.

Prior to early 2011, the map could be accessed at a range of mapping scales with users being able to use the zooming function in order to view the map in more or less detail. At this time the maps were viewable at scales of 1:650 000, 1: 100 000 and 1: 20 000. Therefore the most level of detail that was possible was 1: 20 000 which in some cases was not detailed enough for users to be able to locate their individual property.

Since early 2011, the mapping scales on the current Environment Agency map have been improved. Users have an increased selection of scales at which to view the map which now includes eleven different scales ranging from 1: 5 000 000 to 1: 10 000. This has made clear improvements to users' ability to

locate their property or other area of interest, both in terms of locating within a wider geographic area but in particular at the local scale whereby the degree of resolution has been doubled.

Although the mapping scale of the map is very important to a user's ability to locate their area or property of concern, this aspect of mapping also needs to be reviewed with consideration with the level of detail provided on the graphical background of the map. This is discussed in the next section.

5.4.2 Graphic map background

The map background is a coloured Ordnance Survey raster base map (Figure 5.6) that includes a number of characteristics including:

- road network
- rail network,
- built up areas including individual streets
- contour information
- field boundaries
- Large individual buildings

One of the key features to consider about the mapped background is the level of detail which is presented. At the beginning of the project (and therefore shown to participants during the exploratory workshops in May 2010) despite it being possible for users of the current flood map to zoom into a scale of 1: 20 000. The level of detail on the graphical map background is that more commonly shown for a map of scale 1: 50 000.

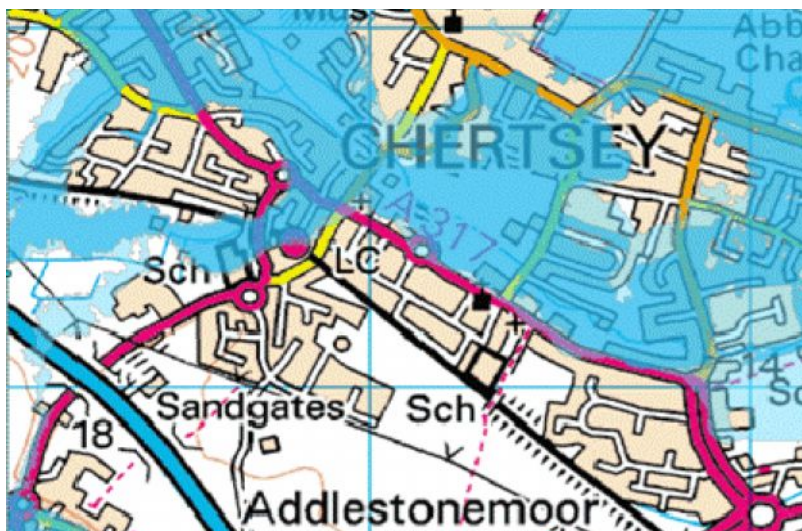


Figure 5.6: Map showing the example of background graphics provided on the current EA flood map until Early 2011 – background detail is that commonly viewed on maps of scale 1: 25 000.

The changes to the map in early 2011 also included additional detail in the background mapping which has been increased to include a much clearer presentation of roads and blocks of properties as well as larger individual buildings (such as industrial properties, schools etc). This is the background mapping commonly provided on maps of 1: 25 000 scale (Figure 5.7).

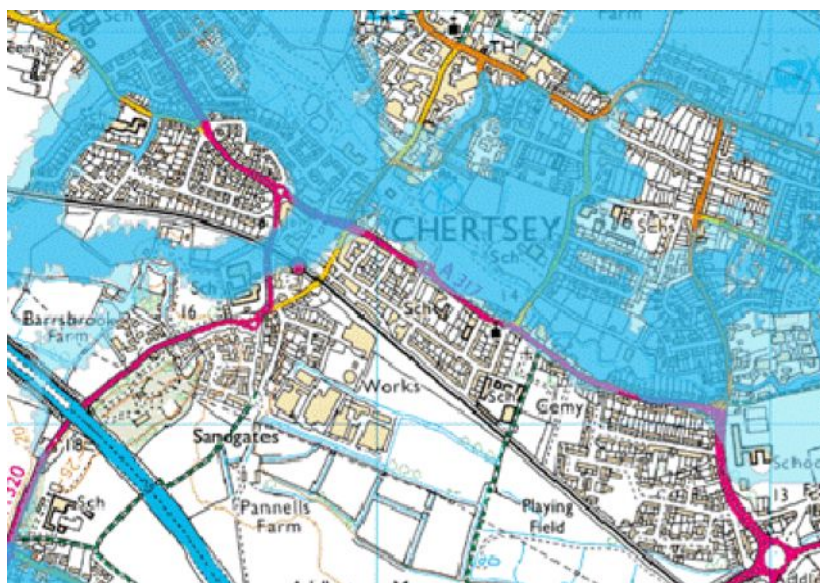


Figure 5.7: Map showing the example of background graphics provided on the current EA flood map from 2011 – background detail is that commonly viewed on maps of scale 1: 25,000.

5.4.3 Colour schemes

Figure 5.5 illustrates the colour schemes used to depict flood hazard information on the current map. The inundation information presented on the map is essentially two shades of blue; with a darker blue illustrating those areas at higher flood risk (> 1 in 100 chance in any given year for fluvial and > 1 in 200 for tidal) with a lighter shade of blue indicating those at the lower flood risk (> 1 in 1000 chance in any given year). Flood defences are presented with a purple line indicating their location, with black hatched areas illustrating those areas which benefit from the defences depicted.

5.4.4 Online presentation

As well as the design of the map itself, as it is presented online it is important to consider how the map is presented as part of the website. The map sits amongst a range of webpages providing information about flooding; including what to do if you are flooded, ideas on how to protect yourself, the roles and responsibilities of both the public and the authorities and current research being undertaken. In particular, there are a number of webpages and documents which relate to the map, how it was produced and how people should use it. Examples of these are presented in Table 5.4.

Table 5.4: Example of Environment Agency webpages and documents relating to the flood map

Web pages
○ Am I at risk from flooding – Flood Map and how to use it http://www.environment-agency.gov.uk/homeandleisure/floods/31650.aspx ○ What do we mean by flood risk http://www.environment-agency.gov.uk/homeandleisure/floods/31658.aspx ○ Flood likelihood explained http://www.environment-agency.gov.uk/homeandleisure/floods/56822.aspx ○ Understanding the flood map http://www.environment-agency.gov.uk/homeandleisure/37837.aspx ○ Flood map – terms and conditions of use - http://www.environment-agency.gov.uk/homeandleisure/56908.aspx ▪ Flood map – your questions answered - http://www.environment-agency.gov.uk/homeandleisure/31662.aspx
Documents
○ Environment Agency (2006) Understanding flood risk: Using our flood map – Identifying and understanding flood risk in England and Wales. http://publications.environment-agency.gov.uk/pdf/GEH00306BK1Y-e-e.pdf?lang=_e ○ Environment Agency Website, (2008) Understanding the flood map http://www.environment-agency.gov.uk/subjects/flood/826674/829803/858477/858535/?lang=_e ▪ Environment Agency (no date, accessed 2008) Understanding flood risk: Our National Flood Risk Assessment (NaFRA), http://publications.environment-agency.gov.uk/pdf/GEH00306BK1X-e-e.pdf?lang=_e

The online map is searchable by place name or by postcode and is can be navigated by using a zoom bar and by panning using the cursor. The map can be accessed via this webpage <http://www.environment-agency.gov.uk/homeandleisure/37837.aspx>.

5.4.5 Flood mapping issues

5.4.5.1 Individual-level flood risk assessment

The flood map does not provide a property-level assessment of flood risk. The largest scale of the map being 1: 20 000 is seen to act as a barrier to users pin-pointing the exact location on the map. The scale and coverage of the map are deliberately insufficient to allow ready location of individual properties, and the supporting information repeatedly stresses that high-resolution assessment is invalid. The restriction is generally justified on the grounds that the data and models used to create the flood map and risk assessment lack the precision and accuracy necessary to support property-level inference and that missing information about the flood levels of properties does not allow an individual property assessment to be made. The restriction of the resolution of the map might also be considered to be one mechanism for tackling the uncertainties that are inherent in the modelling of flood risk. Although this justification is understandable, Priest et al. (2008) highlight that this is the single greatest point of contention for users of the flood map; that their desire to obtain a detailed risk assessment for their individual property is confounded by the flood map itself.

5.4.5.2 Comparison of the different information and data sources

The use of the two layers of information; the outline flood map and the NaFRA dataset may cause confusion as they can present conflicting information. The mismatch may be due to the fact that the different datasets are actually presenting different data and the results of different methodologies. The Environment Agency (Flood Map – Your Questions Answered (Q15)) also offer two explanations, that users are selecting areas too close to a river or that the mismatch of information has been updated at different times (i.e. the extent layer has been updated, but the NaFRA layer was not yet updated) (<http://www.environment-agency.gov.uk/homeandleisure/31662.aspx>).

However, although the use of the two different datasets is advantageous by providing the benefits of both of the datasets; this confusion may be leading to the public to become confused about their flood risk or even become disillusioned by the data and their quality as they do not understand the reasons behind the differences (Priest et al., 2008).

5.4.5.3 Limited information

The flood map in England and Wales is currently limited by the fact that only information about the flood hazard is provided. Although the map has been evolving since its provision online in 2000 and has begun to provide a probabilistic, rather than a purely deterministic approach, and incorporate information about flood defences and their likelihood of failure, the information routinely provided is still limited. Other hazard information is not routinely provided to illustrate the likely depths and velocities expected. Additional information about the population at risk, vulnerability information (socio-economic data) or information about damages is not currently provided. In addition, information about likely future changes to flood risk due to climate change is not provided, nor is information enabling users to assess the uncertainty associated with the flood data. Despite this information not currently being presented in the currently available flood map, the RASP methodology is able to take into account socio-economic variables and economic damages within an assessment of flood risk.

5.4.6 Recent changes to flood mapping, legislative developments and planned improvements for mapping

The flood maps have been online in England and Wales for over a decade however they are far from a static product. As well as generally updating and improvement of the data as more information or additional modelling has occurred, there have also been significant changes to the map itself, the information held online around the map and additional information presented. This section will briefly explore these other products, changes in legislation which will impact flood mapping or mapping responsibilities and planned developments.

5.4.6.1 Other flood mapping or flood-map related products

Local variations in the quality of the flood map

The flood map that is provided online has a consistent methodology which is applied to all areas of England and Wales. However, it should be noted that locally there may be additional information that is mapped and held by local Environment Agency teams. These data may include information about depth and velocity and other criteria. Additional modelling might be used alongside the national methodology and historical data to refine the flood outline.

Areas susceptible to surface water flood maps and Surface water flood maps

Another recent initiative in England and Wales has been to try to define and map areas that are at risk from surface water flood events. These maps have been available since 2009 and have assumed that the drainage systems are full to capacity and therefore only model a single rainfall event (with a 1 in 200

chance of occurring in any year) and how it impacts the topography of an area. Buildings are also not taken into account.

More recently the Flood Maps for Surface Water have been developed to take better account of drainage conditions and buildings.. Two storm likelihoods (1 in 30 and 1 in 200 chance of occurring in any one year) have been considered and the maps are produced taking account of drainage conditions by using two constants for urban or rural land use (Environment Agency website, accessed 20/04/11). An example of these maps is provided in Figure 5.8.

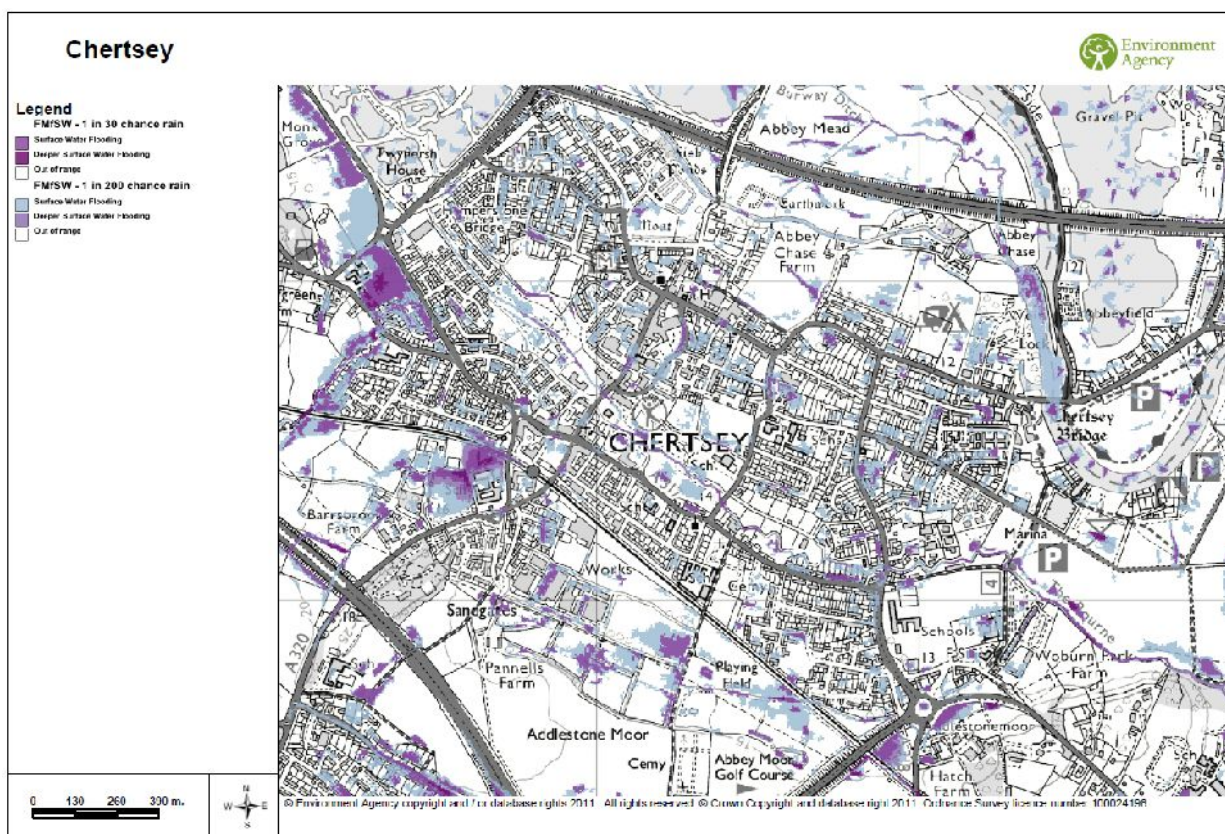


Figure 5.8: Example of an Area susceptible to surface water flood map.

Both of these new products have been created using a national methodology and therefore need to be further verified and if necessary refined at the local level. Due to this reason both of these maps are not currently routinely provided to the public as those handling the information believe that more information is available to users at a local level (i.e. via the local authorities) and therefore the maps should be viewed and interpreted alongside this additional information. The maps have been provided to those with responsibilities for responding to flooding (i.e. mainly via the Local Resilience Forums (Civil Contingencies Secretariat, 2011) and are used by LLFAs to assist in the preparation of PFRAs.

Areas at risk from reservoir flooding

Since early 2011 those areas at risk from flooding from reservoirs (excluding small reservoirs) has been mapped and presented on the website alongside the map of areas likely to be affected by rivers and the sea. These maps present the maximum area that would be flooded if a reservoir or multiple reservoirs failed. The maps only present an indication of the worse-case scenario in terms of extent and does not provide any information about the likelihood of an event occurring. When the map is clicked on, the mapped extent of areas at risk from inundation is also supplemented by information about the reservoir(s)

that would cause the flooding and the ownership details of the reservoir, which a user might contact to retrieve more information.

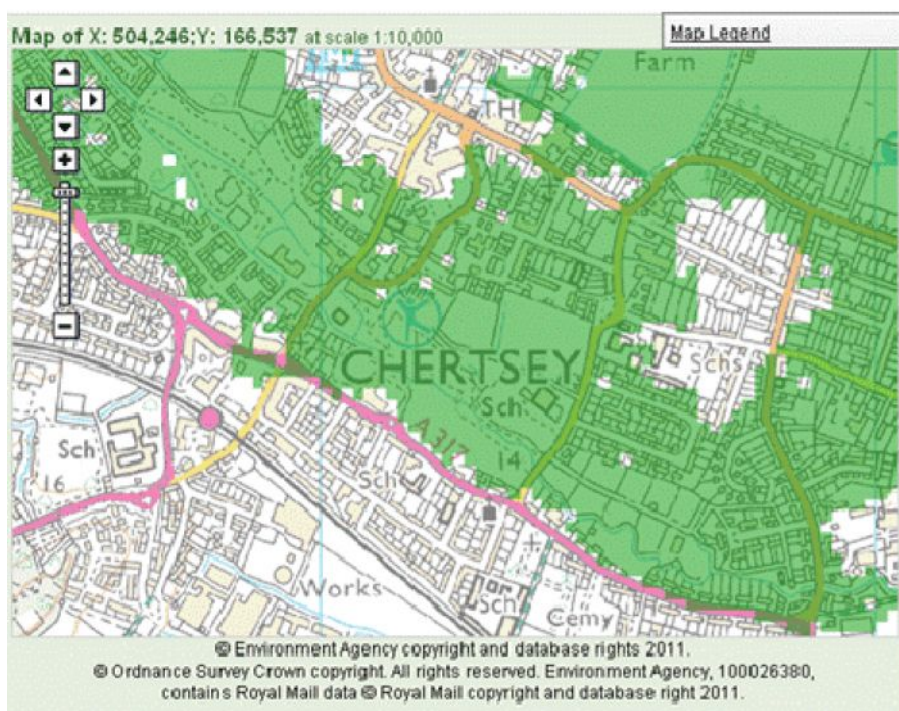
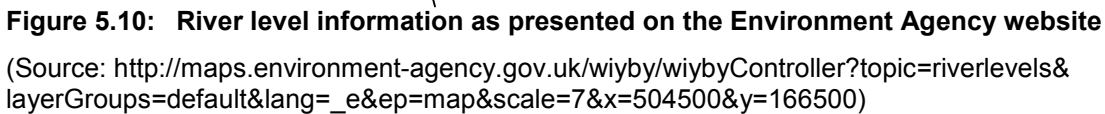


Figure 5.9: Example of the areas at risk from reservoir flooding in Chertsey (Environment Agency website; accessed 11/05/11).

River level information

Also since the beginning of 2011 information about river levels has been available adjacent to the flood map. Those locations with river level monitoring sensors can be viewed on the map as green circles, which can be selected to provide current information in which water levels are graphed (Figure 5.10). Data about the current water level is commonly updated on the website daily, although data are recorded at frequent intervals of 15 minutes and the system therefore has the capacity to be updated more frequently if required. In addition to the current water level, information about typical water levels and those likely to cause flooding are provided alongside the highest recorded measurement.



In England and Wales the Risk Regulations 2009 transpose the Floods Directive (2007) into domestic legislation. Under these regulations the Environment Agency retains the responsibility to preparing and reviewing maps for flood risk from the sea, rivers and reservoirs and 'national' risk, whilst local authorities are required to provide mapping from other sources and for 'local' risk. The Risk Regulations define both hazard maps and risk maps. The following table summarises the key points.

Table 5.5: Key characteristics of flood hazard and flood risk maps as defined by the Risk Regulations (2009)

Flood hazard maps	Flood risk maps
20. (1) A map which identifies flood risk areas and shows	21. (1) A flood risk map is a map showing in relation to each flood risk –
a) The likely extent (including water level or depth) of possible floods, b) The likely direction and speed of flow of possible floods c) Whether the probability of each possible flood occurring is low medium or high (in the opinion of the person preparing the map)	a) The type of economic activity likely to be affected in the event of flooding, b) The types of economic activity likely to be affected in the event of flooding, c) Any industrial activities in the area that may increase the risk of pollution in the event of flooding, d) Any relevant protected activities in the area that may be affected in the event of flooding, e) Any areas of water subject to specified measures or protection for the purpose of maintaining the water quality that may be affected in the event of flooding, and f) Any other affect on (i)nt protected activities in the area that may be affected in the event of flooding, g) Any areas of water subject to specified measures or protection for the purpose of maintaining the water quality that may be affected in the event of flooding, and h) Any other affect on (i) human health, (ii) economic activities or (iii) the environment (including cultural heritage).
(5) For the purposes of this regulation –	
a) The probability of a flood occurring is low if the chances of it occurring in any 12 month period are 0.1% or less b) The probability of a flood occurring is medium if the chances of it occurring in any 12 month period are more than 0.1% but not more than 1%, and c) The probability of a flood occurring is high if the chances of it occurring in any 12 month period are more than 1%.	

Despite the introduction of the Risk Regulations in 2009, no final decision has yet been taken (august 2011) about the specific products that are going to be produced and who will be able to access these maps. For instance, it has not been decided whether those maps produced in line with the Floods Directive guidelines will all be made publicly available or whether they will continue to have hazard maps similar to those currently presented.

Flood and Water Management Act 2010

The Floods and Water Management Act 2010 broadens the remit of, and clarifies responsibilities for, flood risk mapping in England and Wales. In relation to mapping there few clauses which specifically mention mapping, although maps are recognised as a part of activities such as “preparing, gathering and disseminating maps, plans, surveys and other information” that might be done as part of flood risk management activities.

The broadening of flood risk management activities to strengthen the management of other sources of flooding such as surface water and groundwater, as well as responsibilities for coastal erosion highlights the need for developing maps for these other risks. Some of these are already in progress and were discussed further in section 5.4.6.1.

5.4.6.3 Planned developments in flood mapping

Environment Agency FCRM Risk Mapping Strategy 2010-2015

This Environment Agency strategy sets out the mission for flood mapping in England and Wales, explains the previous developments of flood mapping and the reasons why flood maps have developed how they have and also sets out the future priorities in mapping. Following changes in legislation (both EU and domestic) and some major floods, some significant changes and improvements to flood maps in England

and Wales are planned. The commitments to mapping and changes are organised using 8 principles. These and the details of each are displayed in Table 5.6.

Table 5.6: Principles and activities in the EA FCRM risk mapping strategy 2010-2015

Principle 1: Mapping of flood and coastal risk from all sources will be available from one place <i>Consultation has shown that our customers want all this information to be available together.</i> A1.1 ensure mapping of flood and coastal risk developed by others, where it meets our standards, can be accessed alongside our own mapping; A1.2 present the information on flood risk and coastal erosion in a way that helps people to understand the risks, and where appropriate take action.
Principle 2: Our mapping, to meet a diverse set of needs, will be based on a consistent approach and a single set of data <i>We will base all our mapping of flood risk upon a single common set of data, produced using a consistent approach, to ensure clarity and consistency.</i> A2.1 update our current National Flood Risk Assessment (taking a probabilistic approach) using improved data and methods, where appropriate, and include more detailed, local mapping in higher risk areas (using the same probabilistic approach). This will be our primary source of data to communicate flood risk; A2.2 replace the Flood Map with mapping developed using probabilistic methods; A2.3 review and update the data, method and types of coastal erosion covered, to improve this mapping, where appropriate; A2.4 stop using the Flood Zones as our primary source for communicating the chance of flooding to the public, but continue to use it to support local planning authorities in their development planning role (to support Planning Policy Statement 25 in England and, through Development Advice Maps, Technical Advice Note 15 in Wales); A2.5 take a risk-based approach to collecting and maintaining this information, including its quality and detail, that focuses on meeting both our needs and those of our partners and customers; A2.6 continue to record information on flooding from rivers and the sea.
Principle 3: Uncertainty (including climate change) will be addressed in our mapping <i>This principle will help to meet recommendations within the Pitt Review about supporting probabilistic forecasting and warning, and predicting the effects of climate change; it will help meet the requirements of the Floods Directive to consider the effects of climate change; and it will ensure that uncertainty is communicated as part of how we present risk information.</i> A3.1 use uncertainty in a positive way as part of the way we communicate flood and coastal erosion risk and make decisions; A3.2 work with our partners and customers to ensure we display uncertainty in ways that make it most understandable to them; A3.3 map climate change and present this information in a way that helps us plan for the future.
Principle 4: A greater range of the impacts of flooding and coastal erosion, and the risk of flooding to a property level, will be considered <i>We need to look at the broad range of impacts that can occur from flooding or coastal erosion, both to help us get a better understanding of risk and to meet the requirements of the EU Floods Directive. Studies have shown that people want information about flood risk and coastal change to property level (i.e. their house) and often misinterpret our information as being property-specific already. We will assess whether we should now be mapping to that scale.</i> A4.1 develop a dataset that will include information about the sites affected by flooding and coastal erosion, including properties, significant environmental sites and sites of cultural interest. This dataset will be the single source which we will use to understand the impacts of flood and coastal risk; A4.2 investigate whether we can realistically assess risk to the property level in a cost-effective way, and, if so, determine whether we need to take a risk-based approach to the application of that method.

Principle 5: Our methods will give us a broader picture of risk and will be used by our partners

Key reports have shown how we need to use better risk assessment techniques which assess flood risk and coastal change more realistically. Whilst the methods themselves relate directly to modelling, part of this risk assessment involves mapping to further analyse these results and, in some instances, communicate them.

A5.1 work with our partners to produce guidance on using the outputs of our improved methods to map flood risk for all sources of flooding, and encourage adoption of this guidance;

A5.2 work with our partners and customers to ensure that, guided by research, we present the information on flood risk from all sources of flooding in a way that shows flood risk more intuitively;

A5.3 meet requirements for depth and velocity mapping (formerly termed hazard mapping) through our improved method of mapping;

A5.4 make sure that the way these new methods calculate risk is clearly understood and transparent to the users.

Principle 6: Where appropriate, we will advise our partners on mapping of flooding from all sources including those sources for which they are the lead organisation

As part of our strategic overview role in England and enhanced oversight role in Wales, we will develop guidance and advise our partners to help them meet these responsibilities. We will not ourselves map flooding in detail from sources other than rivers, the sea and reservoirs, or record information on floods from these other sources.

A6.1 work with our partners to produce guidance, standards and, where appropriate, tools for risk assessment of flooding for sources for which we are not the lead organisation. We

will encourage our partners to adopt these documents;

A6.2 maintain a national dataset of historic flooding from all sources, using information collected and recorded by our partners to our standards.

Principle 7: We will regularly review what we present and how it is being used

We provide information to meet specific needs, which is then often adapted for other purposes as needs change. This can lead to information being used in a way for which it was not originally intended and that might be inappropriate. By reviewing what we present and its uses, we will be able to adapt better to changes in customer need

A7.1 be clear what is the intended use of any information we present;

A7.2 regularly review the uses of the information we create, maintain and provide, and assess whether the needs of those using it have changed, or if there are new uses for it;

A7.3 accept that needs do change, and respond to these changes, either through support and guidance or by providing new products where appropriate.

Principle 8: Information will be published promptly and responsibly

We will continue to publish information in a timely way. We need to balance providing information promptly with making sure it meets a range of customer needs and does not hamper decision-making.

A8.1 ensure information meets identified needs before it is published;

A8.2 work with our partners to ensure the most appropriate organisation publishes the information;

A8.3 endeavour to highlight where information we provide has changed, and make available the reasons for those changes.

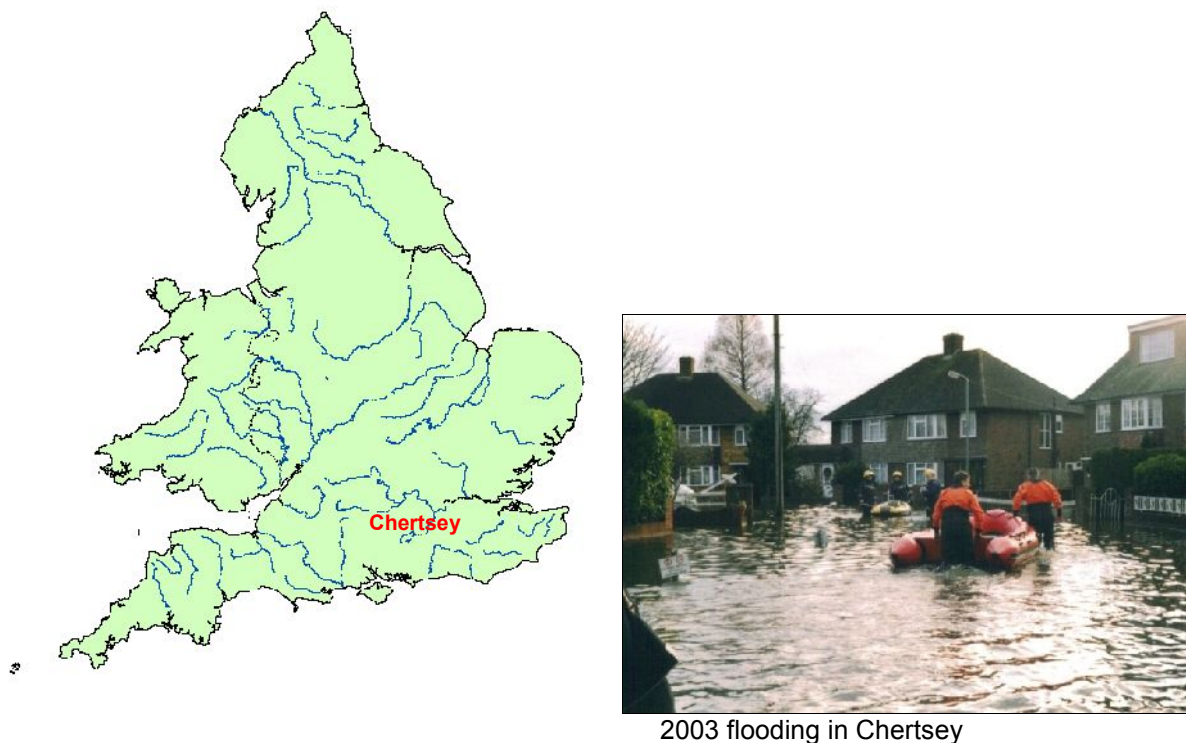
After Environment Agency (2010)

5.5 The case study area: Chertsey, Surrey

5.5.1 Physical geographic features

Chertsey is a small town located in the South East of England, just South West of London (Figure 5.11). The land surrounding Chertsey is made up of green spaces including small farms, woodlands and meadows. Indeed, 68% of the Borough of Runnymede, within which Chertsey is located, is designated Greenbelt land. Greenbelt land is open land that is protected from further development in order to prevent urban sprawl. The greenbelt in Surrey is part of 480,000ha¹¹ of greenbelt surrounding London.

¹¹ <http://www.communities.gov.uk/documents/planningandbuilding/pdf/mapgreenbelt.pdf>



2003 flooding in Chertsey

Figure 5.11: Map illustrating the location of Chertsey (photo courtesy of Kevin Burgess)

Chertsey is located within the Lower Thames catchment and the town lies in a wider and flatter part of the River Thames catchment compared to upstream Windsor. In addition to the Thames there are also the Chertsey Bourne and Abbey Rivers which contribute to the flood risk at Chertsey.

Of the three rivers affecting Chertsey, the Chertsey Bourne is recognised by residents as playing the most significant role in Chertsey's flood risk and past flood events. This may be attributed to the fact that the Bourne flows through the heart of town and its residential areas, almost cross cutting it, flowing from the North Western corner to the South Eastern corner. Under normal conditions the Bourne is a small tranquil river only around 3 to 5m wide at its most. However, it is reported that under flood conditions the river is hindered by main made constructions, in particular bridges which leave little clearance for the River which results in a backup of water during flood conditions.

The Bourne is a tributary of the River Thames which it joins at Shepperton Lock in Weybridge. The Thames flows around Chertsey to the North and East sides rather than through its residential areas, however, it is perceived that the Thames maintains the water table levels and is attributed to some of the flooding experienced in Chertsey. In addition to the two rivers the Abbey River also flows through Chertsey. This flows along the Northern edge of the main part of the town and is another tributary to the Thames, joining the Thames just East of Chertsey.

To the North of Chertsey there are several reservoirs and lakes such as Abbey Lake and St. Annes Lake. The abundance of such stores of water may contribute to problems that Chertsey experiences with flooding from groundwater sources, as the lakes and reservoirs retain a high water table level.

The topography around Chertsey is relatively flat but bordered by the North Downs. The town of Chertsey is also fairly flat, with no discernible land height difference when walking around the town. However,

Chertsey was originally two islands (The Isles of Cerotus¹²) where the two areas of land, not at risk from flooding are located. The surrounding land which used to be covered in water is now exposed and this is the area at risk from flooding (see Figure 5.12 below).

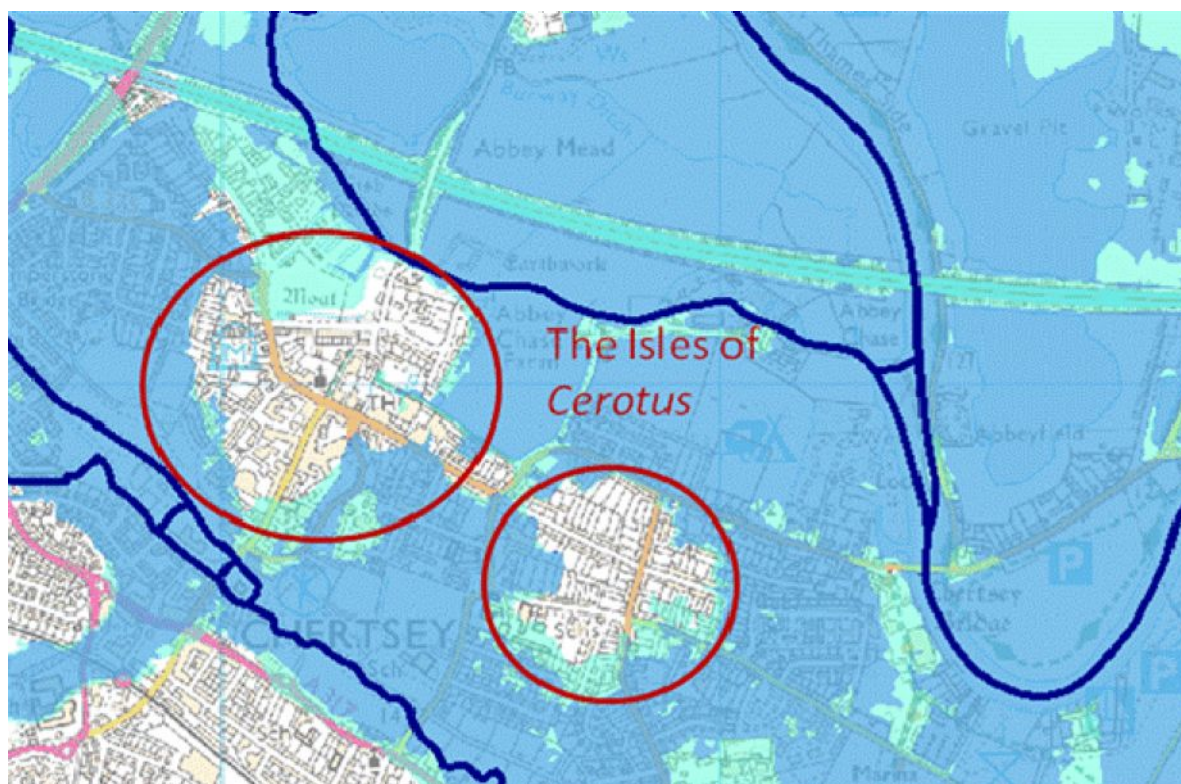


Figure 5.12: Chertsey flood map and the Isles of Cerotus

In terms of flood alleviation, there is a particularly long running project underway to develop flood defences in this part of the Lower Thames catchment, however, currently Chertsey does not benefit from fixed defences specifically. Upstream of Chertsey and protecting Maidenhead and Eton the Jubilee River has been developed as a flood defence measure to redirect surplus water. Chertsey, however, is not understood to benefit from this and some residents speculate that the existence of the Jubilee River may exacerbate their flood experience.

5.5.2 Human geographic features

Chertsey is a small town situated in Surrey, on the fringe of London in greenbelt protected land. The town has developed around the 7th century Benedictine Abbey, Chertsey Abbey, which became one of the largest in England.

The town of Chertsey is within the borough of Runnymede near to the towns of Staines and Shepperton. The town is located within close proximity to the M3 and M25 motorways and also has good links to London, enabling residents to commute to the city.

¹² <http://chertseylocal.co.uk/History/P3Chertsey%20HistoryRomansandAngloSaxons.php>

The Borough is comprised predominantly of green spaces comprising fields, woodlands, pond and meadows. In addition 68% of the Borough is protected as greenbelt land (land that is protected from urban development).¹³

Some houses in Chertsey, in particular more recent developments, have been designed to take into account and reduce the impact of flooding. These houses and buildings accommodate the flood risk with raised floor levels and void space between the foundations and first floors to make space for water.

5.5.3 Previous flooding experienced

Over the last 120 years Chertsey has experienced several major flood events. The largest flood events on record are the 1984 and 1947 events. The event in 1947 is considered the worst in living memory due to the scale of its extent. Since then there have been several further flood events, the most recent of which occurred in 2003, affecting an estimated 350 properties.

Chertsey is subjected to flooding from several different sources. Predominantly the area has experienced flooding from groundwater. This is felt to be related to levels in the local rivers and the nature of the permeable gravels upon which the town is built. In addition to groundwater flooding, which typically rises more gradually remains for days at a time, the town is also affected by fluvial and some surface water/sewer flooding. Fluvial flooding mostly originates from the Chertsey Bourne River which is a tributary of the River Thames flowing from the North West of the town through to the South East. Two other rivers, the Abbey and the Thames have also been known to be the sources of flooding in the town but to a lesser extent than the Chertsey Bourne. In addition to flooding from the rivers and groundwater, pockets of surface water flooding have also been reported.

Chertsey is located in the lower Thames and is part of the area currently being considered for flood alleviation measures under the Lower Thames Strategy. At an earlier stage in the Lower Thames Strategy, the Jubilee River relief channel was constructed to divert water from Maidenhead and Eton. This channel has been highly controversial since its inception and local residents in Chertsey demonstrate concerns that their flood risk may be related to and possibly exacerbated by the development of the Jubilee River. However, such theories have yet to be suitably substantiated.

5.5.4 Chertsey as represented by the Environment Agency Flood Map

The Environment Agency maps that are widely available on the EA website demonstrate that most of Chertsey and its immediate surrounding area are classed as falling within the 1 in 100 and 1 in 1000 year flood return periods (see Figure 5.13 below). This has resulted in a map that shows most of Chertsey in a swathe of blue when zoomed in. However, the expanse of blue is deceptive as much of the area encompassed is farmland with only a few scattered properties. Despite the extent, there are large proportions of the main residential area of the town that are not included in the EA flood risk outlines. The two central areas excluded from the 1 in 100 and 1 in 1000 extents are believed to have existed as the Isle of Cerotus centuries ago. Also excluded from the modelled extents are the properties to the south of the railway line.

The EA maps demonstrate modelled flood extents for fluvial flooding alone. However, there are reports of flooding from other sources such as surface water and drainage flooding. This information is not currently presented on the EA maps, however, the 1 in 100 extent does broadly correlate with the extents of previous events.

¹³ Runnymede Borough, Natural Environment report (2004)

The EA map highlights the three main rivers that influence flood risk in Chertsey. The Rivers are depicted equally as being shaded in blue, however, it is not clear from these maps which River is responsible for which extent of flooding.

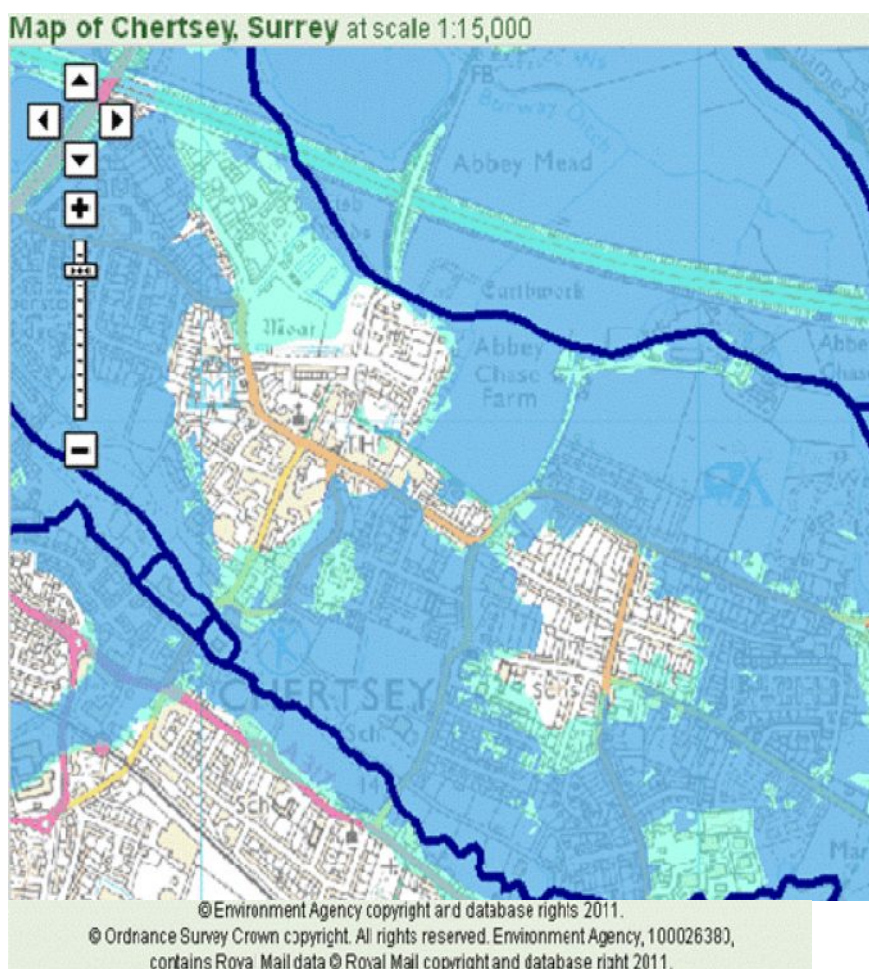


Figure 5.13: Environment Agency map showing flood zones 2 and 3 for Chertsey

In addition to presenting an almost alarming extent of blue, the maps highlight the potential for areas not affected by flooding (the two central areas excluded from the flood extents) to be cut off in such a 1 in 100 year event. The potential impact of flooding on access routes has been further investigated by the County Council (Surrey County Council). This has resulted in Surrey County Council producing its own 'wetspot' maps.

The wetspot map for Chertsey highlights roads and public highways that are particularly prone to flooding. The map showing such vulnerable roads in Chertsey is shown below (Figure 5.14), with the relevant roads highlighted dark blue. The aim of these maps is to show roads that may pose a hazard or inconvenience in the event of a flood.

As the wetspot map demonstrates, there are a few roads particularly vulnerable to flooding. Most of these roads run through the centre of Chertsey connecting the south east of the town with northern and western routes. The map also highlights that a flood event could cause residents in properties off these roads to become stranded.

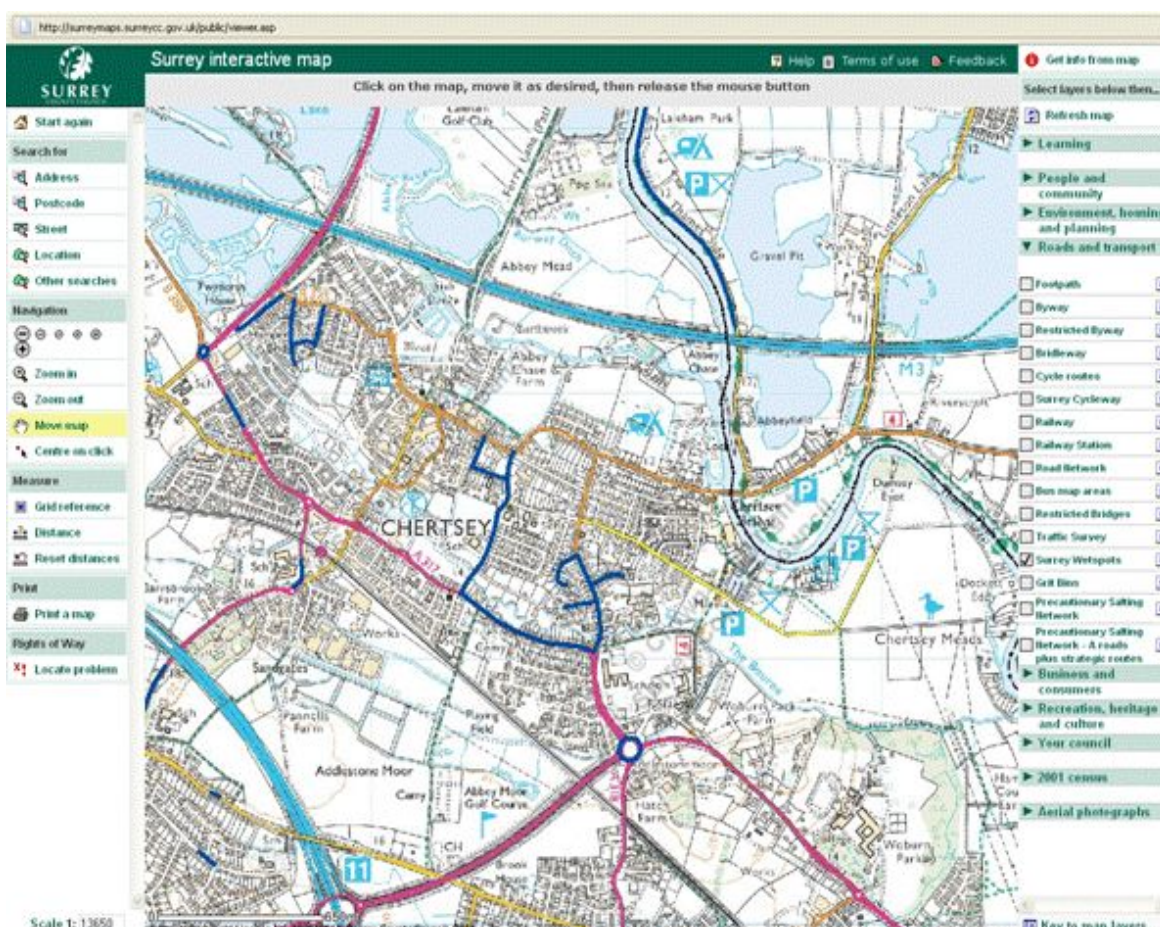


Figure 5.14: Surrey Council Wetspot Map of Chertsey. Wet spots are highlighted in blue.

Source: Surrey County Council online at <http://surreymaps.surreycc.gov.uk/public/viewer.asp>

5.5.5 Local Environment Agency mapping

An interview was conducted with the local EA mapping and data Team Leader. In particular the questions focussed on how the EA flood maps are developed and enhanced at the national and local level. The interviewee highlighted issues regarding modelling and calibration, ground truthing and participation along with a discussion of the intended use of the maps.

The interviewee emphasised that the EA flood maps have been designed and developed specifically in response to the Planning Policy Statement 25 (PPS 25). Under PPS 25 flood maps are to be used as a planning tool to screen proposed developments for flood risk. As such the visualisation and content of the maps has been guided by the requirements of PPS 25. For example, the EA has developed maps that demonstrate the flood probabilities that define the three main flood zones described in PPS 25. These are the 1 in 100 year or more frequent, the 1 in 100 to 1 in 1000 year range and 1 in 1000 or less frequent. However, the flood maps have been placed on the EA website to allow the public to access the information and learn about their flood risk. According to the interviewee this is problematic as the maps have not been designed for this purpose and she therefore felt that they were not able to provide the information members of the public would require.

Instead of the three zones defined by PPS 25, the interviewee felt that the public would require more specific information at the individual property level. She was of the opinion that this would be ideal for the public but would require considerable effort to achieve as the crucial to the maps effectiveness would be gathering data on the threshold of every individual property in the country, or more specifically in a flood risk area. However, the interviewee suggested that such information may not necessarily need to be presented in the form of a map. Her suggestion was that an alternative may be for the public to be able to type in their property number and postcode and the flood risk could be presented as a list of flood sources which would be accompanied by the return period expressed as % probability per year.

Regarding NaFRA, the interviewee commented that NaFRA would be of greater use to the public and agreed that this could be made public but it would require updating as it is currently 2-3 years out of date. In addition the NaFRA information is gathered at the national level which means that the resolution is greater and thus shows flood risk as areas covered in red, amber and green squares. This raises the problem that when communicating with the public, they may not understand why their property is partly covered by a square of one colour and partly by a square of another colour. With local mapping work such low resolution could be smoothed out or improved to make the map more understandable to the lay public.

In addition to NaFRA, the local EA mapping team have access to a wide range of alternative flood data for the local level. This includes, more frequent return periods, historical flood extents and even aerial photographs. Such data is used to calibrate the models and adds value to the data and mapping in this way. Although the team recognise that some of the information, particularly with regard to older flood events, may no longer be relevant as the conditions change and defences are erected. This additional information is not presented on the EA website in itself but is available on request.

To ground truth the flood maps the EA mapping team will go out into the field and explore the area to verify their modelling conditions. In addition to this the team also collaborates with Local Authorities, in particular with Spatial Planners and also the Emergency Services, as these groups have good local knowledge of the area. Involvement of such groups in the mapping process begins at an early stage and continues throughout the development and update of local maps. Consultation with the public however, does not normally take place routinely but if the local team has contacts within local flood groups and parishes they may liaise with these groups as well but this usually takes place at the end of the process and they are unlikely to update maps based solely on the feedback from residents.

5.6 Participation workshops

Aims of the public workshops

Two phases of workshops within the Chertsey study area were undertaken each with different purposes. Phase one was held in May 2010 when two workshops (henceforth known as Exploratory workshops A and B) with local residents were held, with phase two being held twelve months later comprising of a single Findings Workshop.

The Exploratory workshops had a number of aims:

- Explore participatory approaches to using flood maps for engaging the public about their flood risk and for raising awareness
- Discussing and exploring with participants their local knowledge which could be used to improve the flood maps
- Identifying public uses of the flood map and observing how users interact with the information on flooding
- Investigating public opinions on the current Environment Agency maps and identifying those aspects which cause misunderstanding amongst users.

- Identifying recommendations for improvement of the maps in terms of visualisation and content (including identifying a number of features for testing within the experimental graphic semiology work within the RISKMAP project).

The main idea of holding the second phase of research within the case study area was to provide the opportunity to update those members of the public who attended the Exploratory workshops about the findings of the research. The research team were also able to present recent developments and changes to the existing Environment Agency flood map and suggest how they might be able to use this information. It also served a number of other research aims:

- Provided the opportunity to present the maps which were tested in the experimental graphic semiology component of the research as well as updated maps based on the outcomes of the experimental graphic semiology
- Verify and clarify findings from the initial workshops in terms of visualisation and content preferences of the flood map
- Explore further ideas of engaging the public in a dialog process about the flood map as well as verifying ideas on participation generated from the exploratory workshop.

The following sections provide additional detail about the public workshops that were held and the findings from these workshops.

5.7 Exploratory workshops

5.7.1 Participants

Residents of Chertsey were invited to participate in the workshops via two main recruitment methods. The initial recruitment was conducted by a presentation of the project at the Chertsey Society, whereby the audience was invited to participate in the project. Further to this recruitment took place by leafleting around 300 households in the main affected areas of Chertsey. Some participants contacted us to sign up to the workshops and others agreed to participate during follow up visits to the houses leafleted.

In total 27 people participated in the workshops. 13 in the first workshop held on 20.05.10 and 14 in the second workshop held on 25.05.10. Of these participants, two thirds (68%) were male and one third (32%) were female. There was a good spread of ages from 21 to over 70. However, half of the participants (56%) were aged over 60 which raises the average age of participants to between 50 and 60 years old.

All participants spoke English as their first language and most had been resident in the area for over 10 years with 50% resident for more than 30 years and an average residency of 35 years. The vast majority of participants either owned their home outright (48%) or on a mortgage (44%). Just under half (44%) lived in a semi-detached property with one fifth (20%) in detached and the same again in terraced housing.

Two thirds (71%) of participants had been educated to the age of 18, with the remaining 29% having been educated longer. Income levels of the participants are divided by a gap with no participants earning between £400 and £600 per week. The majority of participants (55%) have a weekly income of £200-399. 5% earn less than this and the remaining 40% earn between £600 and £999 per week.

Flood experience

The vast majority (75%) of participants felt that they had experienced flooding, with two people specifying that this was in their gardens alone and one person highlighted that they had experienced flooding outside of Chertsey. The recruitment process targeted both those properties expected to have been flooded and

those not flooded but located in the at risk area. Due to the nature of the research and the request for participants to give up their time to participate, it is to be expected that those with a greater stake in the subject will be most likely to attend the workshops. For this reason, there was a uneven balance between experienced and non-experienced participants. Of those who had experienced, just under half (44%) had experienced a single flood event, with another 44% experiencing 2 to 4 floods during their residence in Chertsey. Most participants had been flooded most recently in 2003. However, four people stated that they had experienced flooding since 2003.

The main sources of flooding were cited as rivers (17 participants) and ground water (14 participants). A further 5 mentioned drains and 3 mentioned sewers. Participants were able to select more than one source.

Flood awareness

The vast majority of participants (74%) were aware that they were at risk of flooding prior to being flooded. When asked how they had become aware of the risk, the most common response was through talking to neighbours and other residents (40%) followed by previous experience (33%). When asked if they were aware of the Environment Agency flood maps prior to the workshops, two thirds (68%) affirmed that they had been aware of the maps and some had studied the maps to explore their flood risk further. Of these, the most common response to how the maps had been brought to their attention was through either a local flood risk action group, neighbours or when moving house. Only one participant had been made aware of the maps following Environment Agency publicity and two participants became aware following information in news and press.

5.7.2 Exploratory workshop design

The Workshops took place at (the Crown Hotel function room, Chertsey). This was deemed to be a suitable given its central location within the case study area. Large round tables were provided where maps could be spread out and participants were able to sit around the tables to view and debate the different maps.

Participants were recruited from the Chertsey area through two stages. The first stage involved attending a meeting of the Chertsey Society which is a local residents group that meets regularly to discuss local issues. One of the workshop facilitators attended the meeting and gave a presentation to promote the workshop and gauge interest. From these meeting some residents were recruited to participate in the workshops.

Further recruitment took place in the Chertsey area through leafleting households in those areas designated by the map as being at flood risk. The leaflets introduced the project and workshops and were then followed up by visits to the houses. Residents were also provided with our contact details if they wished to directly book a place in the workshops. Most participants were recruited in this manner.

5.7.3 Workshop activities

5.7.3.1 Blank map exercise

For the blank mapping exercise, the workshop participants were presented with virtually blank maps. There were three styles of 'blank' map. One depicted the roads only of the Chertsey area in focus, the second depicted the main rivers of Chertsey only and the third style depicted both rivers and roads together.

Participants were encouraged to demonstrate on the maps their experience of the recent floods or their perspective of flooding in Chertsey. The aim was to understand which aspects of a flood event come to the forefront of the mind without prompting from mapped flood extents or similar.

The participants seemed to find that task challenging, in particular when using the rivers only blank maps. As such, to assist where required, an Ordnance Survey base map was available for participants to view in order to help them orientate themselves.

5.7.3.2 Puzzle map exercise

The puzzle map exercise involved fourteen layers of mapped information on A3 transparencies. The layers each represented a different content or method of visualization. Participants were invited to consider each layer in turn and to ultimately choose their preferred layer(s) for the 'ideal' risk map.

The layers depicted the following (although some of the data below was presented more than once):

- 1947 flood extent (oldest)
- 2000 flood extent (largest extent)
- 2003 flood extent (most recent major flood)
- 1947 roads
- 2003 roads
- Depth
- Damages
- Places of interest
- National Flood Risk Assessment (NaFRA) data mapped
- Each of the current Environment Agency flood zones

5.7.3.3 Review of the current Environment Agency maps and views on participation

As a final task, the participants were shown the Environment Agency flood maps as currently available and presented on the website. The map was shown in several variations of scale and zoom focus. The participants were asked to consider the different maps and discuss the differences and their preferences. Participants were encouraged to check the correctness of the maps according to their experience and to mark on any changes they would like to see including adding additional information based on their local knowledge of the area and flood experience. In addition to this participants were also asked to describe their preferences in terms of public participation in the mapping process.

5.7.4 Exploratory workshop findings

5.7.4.1 Flood experiences: Capturing memories, information and experiences via mapping

The first task involved participants representing their flood experience and risk on three versions of a map of Chertsey. The maps were blank apart from key topographical information. Each of the three groups in each workshop was given one of three different types of map:

- a) showed just water courses – 'Rivers'

- b) showed just the roads and railway – ‘RoadsRailway’
- c) showed just water courses, roads and railway – ‘RoadsRailwayRivers’

Each map had a North compass bearing and a scale legend. Each table was also provided with a selection of coloured pens and stick notes which the participants were encouraged to use. No restrictions were set by the facilitators on how the maps should be marked in terms of colours, style or with the use of pens or stick notes. A facilitator worked with each group explaining the tasks, the maps and encouraging engagement in the tasks.

The dynamic of the participation

The key overall task of the workshops was to encourage and achieve participant participation. Participants were given time to settle into their table groups before the facilitator introduced the first task. The *forming* phase was facilitated by round table introductions. Although a research agenda had been set for the workshop how that facilitators approached the introductory dialogue was not set other than to encourage participation related to the task. This was intentional so that there was a relaxed flexibility of approach for facilitators to encourage and persuade involvement in the tasks. In analysis it presented the opportunity to observe the reactions of the group to different approaches. The groups were either asked to immediately start to represent the risk of flooding in Chertsey on the map or their experience of flooding generally or in relation to specifically the 2003 event. It is clear in analysis that despite the initial direction given to participants by the facilitator there was an overwhelming desire for those participants who had directly experienced the flooding to *tell their story* of the experience. This discourse appeared either immediately after the introductions before any marks were made by participants on the maps or invariably at some point during the task. It was observed that no action was undertaken by participants with regards to the mapping task while a story was being told by a participant unless the story was being used by that person as evidence of knowledge being written on the map. There was a respect by the groups for individuals’ stories even, as in one case, where that story was repeated a number of times. It was also observed that discussion and action in the groups was generally led by those participants who had experienced flooding or had in a few cases relevant in-depth professional knowledge. The facilitators found that rather than persuade engagement in the issues they had to manage participation of others by encouraging or creating space for their interaction. This may in part have been due to some participants being familiar to each other in the community generally or were friends or neighbours in similar affected roads and streets. It was also a subject with relevance to most of the participants. For those participants who had experienced the flooding the flooding discourse remains a significant part of their personal biographies.

Another challenge presented to facilitators, and anticipated, was getting participants to make the first marks on the map or get all members of the group involved in this activity. This hurdle was overcome with encouragement and reassurance that mistakes could be made marking the map and that any form of marks could be made e.g.: drawing cars and their houses. While not all participants could be encouraged to mark the maps they were able to inform markers of their knowledge to translate onto the map representations.

In terms of a participative and also research activity overall the structure of the workshops worked well and the time allocated to the workshop enabled all the tasks to be fully pursued in an acceptable time for the participants. The design of the workshops enabled a pace was maintained in activities so that the participants did not get bored or alternatively overwhelmed. The structure also allowed for interaction between participants and with facilitators not directly required to the tasks but necessary for engaging sustained participant attention.

Orientation

On presented with one of the three versions of the blank maps the participants immediately attempted to orientate themselves. The map was turned or moved and almost immediately discussion started between the groups of where familiar places were located on the map. The North compass heading was also used by a few along with familiar roads, road configurations or groups of buildings:

P: I could tell where I lived because I thought the railway is there and from the rail up to there that's where the Bell Road. On most maps which are fairly small, that shape is very similar on the other maps. So if you go and look at the point between the M23 and the M25, it's like a nut in a nutcracker. [WSB, RoadsRail]

For this participant it was the relationship between the roads and the railway that created the familiar shape he had observed in other maps that orientated him on his house. The location of participants' houses was a key goal in the attempt to orientate themselves. The participants verbalised their thoughts although they were not asked to perhaps to check, substantiate and gain help from others in the group that they were making the correct interpretations.

P: You go round there, and drive up. Oh it must be over here somewhere, let's put it here. Where are we putting it? Oh there, do a little house. [WSA, RoadsRail]

As in this case some participants described their imagined journey travelling along the roads to eventually find their house. They moved their viewing position around the table or moved the map to orientate their direction of travel with the map on that journey. For others more familiar information was required on the maps.

P: My house is about there and the stream runs about, down there and through there. The Bourne comes round here somewhere. [WSB, RoadsRail]

Where familiar landmarks were not provided they were, as in this case, imagined. Here the participant referred to a map with only roads and rail information. They confirm the location of their house both to themselves and the group by transposing the imagined familiar shapes of watercourses into the space available on the map. Once the mapped shapes successfully slot into position the participant is satisfied he is orientated correctly.

The workshop experiment of providing different versions of the blank maps indicated that for most participants the roads were a key component to enable orientation. For those provided with just the watercourses there was a determined effort to draw in the roads. Time was devoted by these participants to locating roads for the purposes of orientation. Such effort was not observed devoted to drawing in the watercourses in the groups with just a road and rail map. This could be due to a greater participant familiarity with the road system and road orientation to their houses. Once orientation was achieved the activity of locating areas of flooding or participants experiences of flooding was also closely associated with the roads.

*I: Firstly if you can locate where your experiences of flooding have been
P: We don't know because we haven't got Drill Hall Road in, [WSA, Rivers]*

P: So I've got to picture where I've been, where it's been flooded. Without roads it's a bit difficult isn't it! Have you got a map with roads? [WSB, Rivers]

Rather than identifying topographical areas of flooding, most participants needed the roads to be drawn in to enable them to locate the flood events. In the case where roads, rail and rivers were all represented in the map it was clear that participants could very quickly orientate themselves and in some cases help others in the group.

*P1: This us here
P2: There's the Bourne there
P3: Where are we?
P2: There, I think that's Paddocks Way, that Mead
P4: Where's Paddocks Way?
P1: Right hand bottom corner.*

P4: This one? [WSB, RoadsRailRivers]

It was interesting to see that not all participants actively did this orientation at the start of the task but they kept quiet. However, it was noted they also confirmed with the group their assumptions of orientation when providing information further into the tasks.

It appears that orientation is required when interaction with the map is required and for an individual the start of the task was not the only time the process of orientation took place. Individual participant or shared group orientation could take place at any time during the task re-orientating when a new location on the map or activity was brought into discussion or undertaken.

Indicates: Ease in search functions to locate their house. Importance of named roads, clear watercourses and railways. The ability to rotate maps. The ability to maintain the orientation or location of their house during further manipulations of the map.

The role of experience

Past social research highlights the importance for flood affected residents of the opportunity to relay their flood experience. The telling and retelling of their flood experience over time refines the content becoming a *story* which can be retold again and again. This story in turn can become a point of reference to locate other events. This workshop was no exception in this behaviour and was anticipated with time planned to allow participants to tell of their experiences. The first task was dominated by participants recounting their experience. Telling their story both contributed to forming and norming activities in the group dynamics and was also used by individuals to anchor events with credibility temporally and spatially on the map. The participants provide credibility to their observations through their status as participants and direct observers of the event.

As one example the participants' ability to access roads and houses within the narrative of their experience when relayed to the group substantiates the extent of the flooding and places the flooding occurred within a time frame.

P1: Down here was bad, one of these little roads, but I can't remember ... I just remember the houses

P2: Did you have stepgates? That was slightly higher.

P1 :Yes it's slightly higher because we parked our car, initially, moved the car right away and these roads were ok

I: Where did you move your car to?

P1: Um, not far, only sort of a road or two away but it was higher than our road so it was dry [WSA, RoadsRail]

The extent of flooding is revealed by participant's recollections of their movements on the day of the event anchored by reference to the map and familiar locations like relatives' homes, familiar fields, chance meetings and specific photographs.

P: Yes we flooded in our garden and I've got a photo of my son going round our garden in a canoe. [WSB, RoadsRail]

A few participants brought photographs with them to the workshop or claimed to have them at home. One participant anchored their location on the map by remembering bumping into a TV crew on one road and the resultant photograph of a relative that appeared in the newspapers. Other events during the flooding were used by others in the group to help them orientate themselves on the map:

P1: Well we moved you out, didn't we really, so you were evacuated, to Aunty Sue's which was over here

P2: Oh yes, I remember. Back with your Aunty Sue

P1: Here, I'm going to put my children as well

P2: I don't think she's on the map, oh no, it would be up here by Abbey fields.

P1: No, no she wasn't there she was at ... That would be down here there wouldn't it [WSA, RoadsRail]

Again as can be seen in the example above orientation on the map is constantly occurring in relation to the task at hand.

Representing the risk and flood experiences

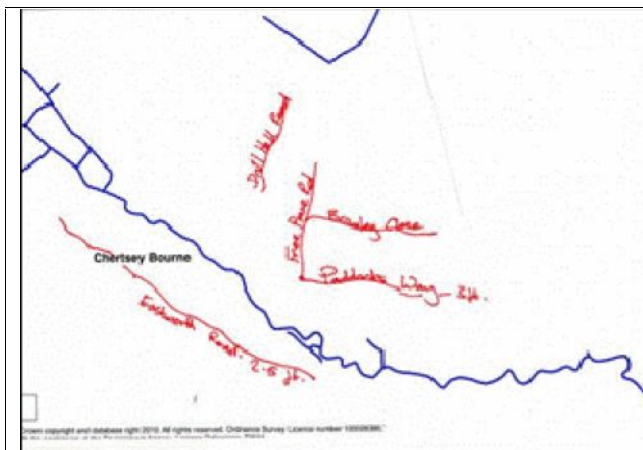
Figure 5.15 to Figure 5.18 are some illustrated examples of annotations made by participants during the blank map exercise.



- The river is roughly drawn in green.
- Flood risk is associated with roads
- Flood risk is drawn in red
- Flood risk of an area is indicated.
- Events are written in such as a chance meeting with a TV crew and the associated boat is drawn. The cars which had to be moved are drawn.

Personal observations are added as comments including where flooding did not affect an area with 'life goes on as normal'.

Figure 5.15: Task 1 WSA Roads and Rail map



Key flood affected roads are located and drawn in red.
Flood levels are added to some roads.

Figure 5.16: Task 1 Workshop A Rivers map

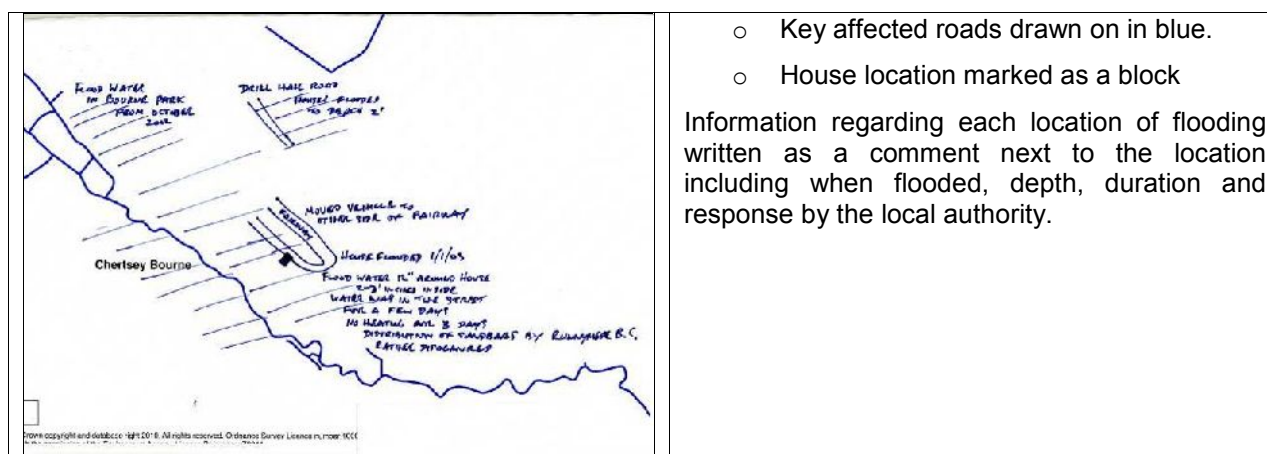


Figure 5.17: Task 1 Workshop B Rivers map

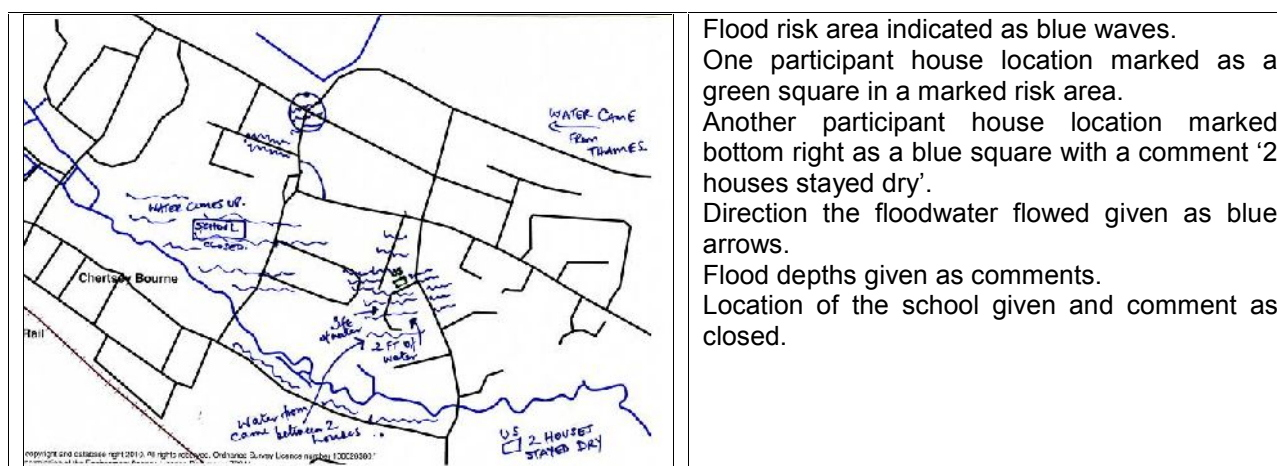


Figure 5.18: Task 1 Workshop B Roads Rail and Rivers map

In terms of the risk of flooding the participants in these workshops proved to be very knowledgeable about the history and mechanisms of flooding in their locality. Some participants had been resident in Chertsey for decades and had experienced a number of flood events. One participant was able to recount her experiences in the floods of 1947, 1968, 1974 and the most recent 2003. The lady complained that the 1968 flood was often left out of discussion because it had a different origin and was more like a flash flood. It was commonly commented on throughout the workshop that floods in the locality took a few days to rise allowing residents time to take action such as moving valuables. There was a tendency for participants to focus on the most recent flood event in the locality and then reference to the larger event in terms of topographical inundation. Most participants were able to talk about the flooding in terms of changes in the water table or ground water, the breaching or overtopping of banks and possible causes in terms of changes in the management of the water courses or uses of the land.

P: Groundwater, it goes up and down like a yo-yo, you dig a hole and some days it's dry and sometimes it's all up. [WSA, Rivers]

One participant used the map connected reduced dredging and clearing water courses with increased risk of flooding. Another focused on the road features on the map:

P: The runoff from the M25 and M3 find their way into the Bourne and the run off from all that acreage of tarmac is a decent amount I can tell, every time there's loads of rain, I know it's all coming off the M25, because my stream turns a funny colour. [WSB, RoadsRail]

In this case personal observations of the river system and its tributaries were used by the participant to substantiate cause and effect. Participants also demonstrated a wider knowledge of both the flood plain and flood related activities such as alleviation schemes constructed and under consideration such as the Jubilee River and the Lower Thames Strategy respectively.

For the participants the risk of flooding was deterministic grounded in past events and did not venture beyond those areas and properties that had historically flooded. The level of detail represented on the map in relation to the risk was very important for the participants. Which individual houses and roads which were flooded was carefully discussed and agreed in the groups before being marked on the maps:

P1: The blue one, for water

P2: There's thirty one houses in Paddocks Way, is that right?

P1: The Green is at 24, I think, what number are you?

P2: 20

P3: Then there's the green here, then there's, 26, 28 so 32.

P4: 32, so every house was flooded bar two [WSB, RoadsRailRivers]

The sensitivity of assigning risk was apparent in the groups.

P: Our house, just circle our house. Not flooded. I can only go by neighbours, he's said it's not flooded there [WSA, RoadsRailRivers]

The issues of risk were situated in discussions about insurance premiums, inability to get insurance and possible housing blight. It was recognised by participants that the allocation of risk to a particular house had wider connotations dependent on the use and user of the information. These issues were discussed further in the second task.

Representing detail on the map included discussion regarding getting the flood depths agreed for the water entering the houses that were affected. The sources, direction and sequence of flooding was also discussed and in some cases attempts were made to detail the information on the map:

P: It burst through the back which is the Bourne, so it came through and it hit your end of the road first.

Because it came up to us last, because we're at the end. [WSB, RoadsRailRivers]

P: I'm going to draw red arrows from the Bourne towards the Fairway because the Fairway was flooded also and Meadhurst Lane was it not? [WSB, RoadsRailRivers]

Participant's ability to represent the issues they considered important on the maps generated a heightened engagement with the maps. Actions in the form of personalisation and the addition of their local knowledge appeared to generate some ownership. In terms of personalisation this could locate the individual on the map.

I: Do you want to draw your car on there?

P1: Oh I can do! [WSA, RoadsRail]

P1: Oh I like that wave, that's fantastic

P2: They look like birds [WSA, RoadsRail]

Drawing in their car, their own and relatives homes helped link themselves and others in the group with the mapped information. Marking the map was shared between participants. Not all participants marked

the map but usually the abstainers from marking informed the markers of their knowledge to be translated onto the map. In addition to personally related associations being marked on the map familiar structures such as bridges and groups of houses were drawn to help orientate that particular individual.

One participant explained the history of Chertsey has meant development over the last few hundred years.

P: You've got the island of Chertsey, it's the island of Cerotus. So the piece round here (points to the Church on the map) roughly doesn't flood because that's the original island. [WSB, Rivers].

The addition of local knowledge could take the form of detailed topography.

P: I'll put the amount of flooding from the top of the road to the bottom of the road. So mine was 1 inch and you can then say that the bottom of the road was about 3 or 4 inches. [WSA, Rivers]

*P: He was lucky because he was on high ground and there's a dent. There is, it's all to do with contours and dips
And of course it doesn't show up on a map. [WSA, Rivers]*

Some participants appreciated how small differences in ground level could affect the risk of flooding and wanted changes in topography represented on the map so that they could trace out the risk on the map. A few participants commented that there might be a range of risk dependent on the severity of the flooding and they wished to represent the risk as a gradation of colour if shading was employed. There was some discussion in what form risk should take. Should it be frequency, period between events or percentage likelihood. Other local knowledge that was thought could provide useful information on the map was the locations that are used to indicate imminent flooding.

P: Fortunately there's a house very near us with a garage which is below surface level so you can just watch surface water coming up. Yes, very good indication. Even the Council use it, they drive past and look. [WSA, Roads]

P: We have a signal. We have water in the playgrounds and then it comes up by the curbs and if it keeps rising and laps over the white line, we're all in deep trouble. [WSB, RoadsRail]

When asked if the participants would be interested in such locations being represented on the map one participant said yes but explained that such locations were sensitive to change or work being carried out and so may not be reliable enough to map.

There were a number of other characteristics of the flood event which participants mentioned but were unable or did not attempt to represent on the map. These were:

- Period between warning and inundation.
- Speed of inundation.
- Duration of the flood waters.
- Depth of flooding.
- Stages in which areas flooded.
- Sources of flooding.
- Story of the recovery.

All were considered important in conveying and understanding the risk of flooding in the locality. Participants, although not using the terms or structuring their discussion as such, were describing both the likelihood and impact of the risk. But overall the difficulty of conveying the experience of flooding was found to be difficult in a mapped format.

I: You just draw whatever sticks in your mind, depict the 2003 flood or tell your story of the 2003 flood on the map.

P: Oh I'll just go boom [imitates explosion][WSA, Roads]

Indicates: The medium of the static map is limited in conveying the different characteristics of a flood event and the corresponding risk. However, there are opportunities for more dynamic visualisations that allow interrogation of the data. Ownership of the map is facilitated by involvement of participants in its construction, personalisation and localisation through knowledge. Local knowledge is biased to historic events but it is not to say extrapolation to changes in the future is beyond participant's ability taking into account the strength of their knowledge. It was just not tested in this workshop. The sensitivity of the information was apparent at this stage in the workshop.

Constraints of communication

It was immediately apparent from the participant's response that the experience of flooding is more than just the flood event. Participants tell their story of experience focused on disruption and loss. Mirroring past social research the participants explain how their greatest disruption was considered to be the long recovery that follows the event. If conveying the experience of flooding informs persuasion the mapping exercise perhaps highlights the challenges that face communication that attempts to persuade. To some degree participants recognised this limitation of mapped information. Participants who suggested additional material to the maps should be provided in the form of advice preparation leaflets which should be distributed to all the houses at risk of flooding. There was discussion about negative and positive communication in terms of not frightening recipients but rather providing constructive communication giving advice and sources of help. This may have been coloured by participants concerns about how and who would be using the information. Should prospective purchasers be frightened away from Chertsey or insurance premiums increased. But also there was recognition that the utility for living in Chertsey and people's memories of flooding were short. When asked if knowing about the flooding would have deterred one participant from moving to Chertsey:

P: it might have made a difference if we'd known but it's funny, you just carry on. Although it's awful at the time.

Houses have sold, several times down our road, it obviously doesn't put people off but maybe you need to experience something like that before it would put you off. I would certainly think twice about buying a house in a flood area again.

I: But it doesn't make you want to move?

P: It did at the time. I was saying 'we're moving, we're moving' but actually, it all goes away and we weren't affected anything like A and B were. It's the frequency of the flooding, it's about every 20 years. We got flooded in 47, this road.

It was 30 years since the last, well almost to the day in 2003. So if we get another 30 years, I won't be here then, 29 years comes and I'm off! [WSA, RoadsRail]

P: I think we moved in 1989 and I think someone told us, oh yes we were flooded 10 years ago. So as far as awareness is concerned, we were aware that there was a risk. However, human nature being what it is, the risk seemed to recede along with the timeline but it was always vaguely there, but as time goes by, one gets used to, sort of the risk goes away from your mind. Then of course we were there when we were flooded in 2003. [WSB, RoadsRailRivers]

P: what does all this mapping stuff do to stop if flooding? [WSA, Rivers]

These participants remain in Chertsey despite awareness of the risk and having experienced flooding. However, participation in the workshop had revived memories:

P: It's a good exercise in remembering, I'd forgotten all this bad... [WSB, RoadsRailRivers]

In this sense the mapping exercise refreshed awareness, enhanced understanding and perhaps would increase a sense of ownership for the mapped information in comparison to alienation particularly with the sensitivity of the information for the residents.

5.7.4.2 Mapping and visualisation preferences

This discussion draws together the results from the second workshop task which required participants to design their own flood risk map and the third task which involves exploring and commenting on the current Environment Agency flood maps. During the second task participants were presented with a range of different mapped flood information as described in section 5.7.3.2.

The map layers not only depicted a range of different types of flood information but also demonstrated this information using a variety of visual techniques. The participants were invited to discuss the layers and decide which features and representation they liked or disliked and why. The discussion surrounding this task highlighted important messages on residents' requirements and preferences.

Availability of the map

This first section considers the very basic premise of a flood map being available to the public at all and the type of information that is made available.

Map availability – damages

One key question raised during the workshops surrounded the target audience for maps. The residents recognised that different end users require different information. Residents frequently highlighted that features that they would appreciate being able to see on a flood risk and equally highlighted features that they would not be interested in but believed a different type of stakeholder (in particular the insurance sector) would be interested in the information depicted. This emphasised the need to tailor maps to particular audiences rather than using one map for all.

In particular, participants felt that the information presented on the 'damages' map would not be of interest to them, recognising the wide variations in damage costs from household to household. Instead they felt that this information would be very useful to insurance companies. As one participant highlighted:

"Insurances are the ones footing the bill, so they're the ones that would be interested in it".

Another participant felt that prospective new residents may be interested in the damages information:

Q. "Would this be something that would be useful to you [damages]?"

A. "not personally, but if it's for people coming from outside it is, because then you know what's the prospect of damage to your houses, the cost of repair".

Map availability – publicly available

One of the major questions surrounded the effect of maps being made available to prospective new residents. Generally speaking residents felt that they would want to have access to the information presented on the maps, however, there were variations in opinion concerning prospective residents. Some commented that the information would be useful for prospective new residents and that they would want to know about the risks should they be moving house. However, they accepted that they would not want prospective purchasers of their properties to be aware of the maps in case it put them off the property. This attitude was summed up by several residents:

*"I know it's helpful if you're moving, but it's not that helpful if you're living there" and "now that might be a problem if you've got a house you want to sell" and
"When we get to 2047 and we haven't flooded, then put us on the map"
"If I was a bit selfish, I'd say no [to public availability] but if I was buying a house I would say yes. It depends which side of the fence you're on" and "If people aren't wanting to sell or move to Chertsey, this is a good visual for them to see in perspective, but then again if you are wanting to buy or sell it's the other way".*

However, despite reservations about placing the maps in the public domain because it might affect residents wishing to sell their properties, when discussing house sales since the floods, it became clear that many of the participants knew of examples where houses flooded in 2003 have since sold. The residents believed that there was probably little discount on the sale price despite its flood history.

Overall, residents accepted that the information presented would be useful but hoped and understood that it would not prevent prospective residents from moving to the area. On balance, residents felt that the town offered enough attractions to outweigh the flood risk for prospective residents:

*"If a house is in a reasonably desirable area, it's schools nearby and shops nearby and it hasn't been flooded for 15 or 20 years people will say, well it's 15, 20 year without (flooding)"
"people forget".*

On the other hand, those with direct experience were particularly conscience of the risks and felt it important to be able to understand the risk when buying a new property. Some of these residents would prioritise researching flood risk before moving to a new property: "We're considering moving house so a flood map we would definitely look at for our next purchase, without a doubt" and this might put them off a property: "If I was looking to buy and I'd look on there and was interested in a house on there [points to greater risk], but on the other hand I'd write that off and I'd really want a house there [points to lower risk]". However, others accepted that flooding is just one of many potential risks: "but realistically, wherever you buy a house in this country you could have a potential hazard, it could be a landfill site, a mining works, it could be anything".

Content of the flood map

Personal risk

The most striking theme in the discussions across the table and groups was how participants considered the maps and information from an individual perspective. At the beginning of each task, the first thing all participants did when presented with the maps was to try to orientate themselves in order to locate their individual properties. Although this might be a natural place to start, participants therefore concentrated on the very small scale. In many cases they had a very narrow focus and although commented on the wider area, were very much less concerned about flooding in these areas. Following the identification of their properties, participants would generally then consider what each layer was saying about their property, whether they agreed or disagreed with it and whether the information was valuable.

This resonates closely with experiences of the floods, as some participants commented that during the flood they were only concerned with their property and street, where the rest of the town that hadn't been flooded was able to continue as normal "You went up London Road and it was like just another day in Chertsey".

Observing how real users handle, interact and interpret the flood mapped information is critical to understanding how the maps are utilised. The extremely narrow focus of most users (i.e. their interest in only one or a handful of locations) is a key feature of interest that those providing maps should consider. It is important to recognise that unless maps provide information that is interpretable at this level of interest the impact that they will have on flood awareness and ultimately on action will be limited. This narrowness in focus and the production of maps which permit individuals to understand flooding at a household level is a theme common to many of the research findings. It is clear that participants preferred maps that appeared to present information in greater detail, even if the information being presented is essentially the

same as that of current maps, suggesting that the scale of interpretation is as important, if not more important than the content of the maps.

As a result, residents preferred maps that appeared to present information in greater detail. In particular the maps showing the roads flooded were of great interest. When information on just the roads that would be affected was presented to participants, they often reacted very positively. The initial aim of presenting this map had been to highlight escape routes and whether normal main routes were prone to flooding, however, the residents were interested in these maps for a different reason. As roads were highlighted, rather than giving a large flood extent, it pinpointed areas at risk. The more focussed appearance of the mapped risk particularly appealed to the residents with one comment summing up the general consensus:

"It gives you the gradient of it and not just blanketing the area, you can go down it road by road, literally" and another "not as scary, but it might say exactly the same thing. You can see which roads instead of the whole area".

Flood history

The participants were presented with three historical flood extents: the most extent of the most recent flood- 2003, the 2000 flood which was also a large extent and within the last 10 years and finally the 1947 extent which was the largest available.

One of the most popular map layers was the 2003 flood extent. Generally the flood extents of historical maps were preferred to the probability based risk maps such as the 1 in 100. Participants preferred the historical maps as they demonstrated a smaller overall risk area that appeared to be more realistic than the 1 in 100 extent which effectively placed a blanket over the whole area.

Participants liked the 2003 extent as it showed a recent flood and therefore a relevant flood. They felt that in contrast, the 1947 extent showed a flood that occurred too long ago to be relevant. The residents argued that they would not be interested in the 1947 flood extent as "Chertsey has changed a hell of a lot since '47, look at all the new houses" and "there have been so many changes since then- building, the river, roads changing". The residents agreed that they would be more likely to accept that they are at flood risk if they are presented with a map that demonstrates that the town has experienced in flooding in those areas before.

The older flood extent (1947) in effect demonstrates the problems with current flood maps and awareness. The extent still falls within the modelled extent but residents are able to negate the risk by convincing themselves that the risk is not current and may therefore be questioned in terms of its accuracy. Of course in places unlike Chertsey where recent historical events are not available, such layers are unable to provide an advantage.

Flood depth

Whilst the participants were particularly keen on the recent flood extent of 2003, they highlighted that information on extents alone is not necessarily sufficient enough to be useful to them. What the residents were most interested in was whether or not the flood waters at that extent would cross their property's threshold.

As one participant highlighted, the large mapped extents (in particular the Environment Agency current maps) do not depict the subtle variations in topography. Whilst small changes may seem pedantic to pursue the residents highlighted that they can make a crucial difference to whether a property is flooded. As one participant commented it's "hard to get a map to discriminate between half a metre over Chertsey- it's going to be meaningless, but half a metre in this instance can make a hell of a difference" and "it's really important... if my garden gets flooded every day I don't care but if it comes into my house [I do]" and "you don't mind a couple of inches but you don't want a couple of feet".

The participants agreed, therefore, that depth information would be important to qualify the extents. They also felt that showing depth variations would enhance the flood extent maps to show that the area was not

one large pool of water and would prevent people from assuming the worst, that the whole place was under water- as some participants first impressions suggested might happen: “look we’re all under water!”.

Delineation of the flood hazard/risk information

On a similar thread to the presentation of historical extents on the flood maps, participants were interested in seeing different flood probabilities also represented. This was partly as a reaction to the situation described in previous sections, but also because they felt that the 1 in 100 year flood should not concern them: “*Anything over 1 in 100, you do seem to turn off a little bit*” and “*1 in 100 doesn’t sound too bad and 1 in 1000 is nothing to worry about*”. Part of this argument is centred on the misunderstanding of participants about how to assess the information provided by return periods. Similar to other research findings (Bell and Tobin, 2007) many participants shared the misperception that a return period represented a regular period of time between floods rather than a statistical average.

However despite this misconception, most participants did appreciate that the return periods were useful in distinguishing areas of higher and lower risk and suggested a preference for a greater delineation of flood risk; if only to be able to demonstrate that other properties were at a greater flood risk than their own. The presentation of additional return periods or flood events would also go some way to reducing the blanket flood map which is currently seen for Chertsey and described above. Participants also suggested that the knowledge that their property was located in one of these higher risk areas (i.e. greater than 1 in 30 year or 1 in 50 year) might be more likely to lead them to taking actions to mitigate flooding; whereas the current flood risk depicted is not refined enough to be able to allow them to make that decision. Maps such as the historical outline may be a compromise between the desire to see frequency of flooding and extent. The historical outlines emphasise those flood events that did occur and within living memory. Where multiple historical outlines are available, this may help residents better understand how flood extents vary depending on the severity of flooding.

Real time/predictions

A number of participants mentioned the value of predictive/forecasts to be accompanied by or part of the flood risk maps. The participants felt that it would be ideal to receive predictions of flood depths and highlighted that these would allow them to better anticipate the consequences of the flood event. For example “you want to know, how quickly the water’s likely to rise and is it going to be 2 days away, 3 days away and is it going to be over your threshold, because you know how quickly to panic or not panic as the case might be” and “wouldn’t it be lovely if you could get your house with a prediction of what level the water would be from the foot of your house?... That’s a representation that people can understand.” However residents understood the challenge in providing such information: “you cannot tell me what the weather’s going to be tomorrow”.

Visualisation

Language of risk

Whilst compilation flood maps are typically dominated by considerations of the distinctly visual aspects such as colours, shading and textures to demonstrate flood hazard and risk, flood maps are often accompanied by text such as in the legend and title. The text helps to explain the map content and when it comes to flood risk, effective text is crucial to effective communication.

Preferences on language varied considerably. Residents commented that they like probabilities, return periods and low, medium, high. However, it appeared that participants interpreted probabilities and return periods (in particular) to mean different things. The potential for widely varying interpretations can result in a confused message and opportunities for at risk persons to utilise the lack of clarity to help them dismiss the severity of the level of risk they face.

Using descriptions such as High, Medium and Low were popular alternatives to probabilities, however, for some this description would be too vague. In this respect such labelling is even more problematic than probabilities, as people are more likely to be able to believe that key is attempting to scare monger and therefore may be describing a reasonable level of risk as high.

Colours

When considering colours, participants highlighted the need to depict different levels of risk by employing distinctly different shades or colours. Some participants felt that the different colours used in the current maps were too similar which made interpretation more of a challenge. As an alternative, some demonstrated a preference for distinctly different colours, such as traffic light colours (green, amber and red).

When considering colours, participants were generally split between preferring shades of blue or purple (as in current maps but more distinct) or traffic light colours (as in the NaFRA layer). Some argued that blue was preferable as it holds connotations of water, thus aiding a quick understanding of the map subject. However, others disliked the blue on the Chertsey map as the blue shades were too extensive and thus gave an impression “that the whole of Chertsey is under water” For many participants the blue extents on the current maps provoked strong initial reactions, “you look at it and you think oh my god” and “It’s the deep blue sea”.

Many participants that disliked the blue shades preferred instead the use of traffic light colours, deeming these more appropriate to represent danger or intensity of risk. Whilst not necessarily benefitting from the connotations of water that blue holds, traffic light colours were felt to be easily understood as an almost universal code for danger (red) and safety (green). One participant commented that “everyone understands traffic light colours” and another said “the kids could understand it” and “you can’t get any more simplistic can you”. However, some residents felt that the intensity and boldness of the red and amber was worrying. They commented that “it seems so extreme and scary at first”, however similar to the blue extents, this might be related to the extent of red on the Chertsey map; “red is ok but when there is so much of it, like in Chertsey then the mass of red is almost too much, gives a frightening picture” but that “it makes you think though, doesn’t it”.

One participant commented, for instance that they liked purple as “it’s quite a calm colour”, however, from the perspective of sending a message to promote action this would not be effective. Instead, traffic light colours might thus be deemed more appropriate for sending a message to promote action and blue colours perhaps more suitable for emergency and spatial planners and others who use maps for a different purpose and would be less likely to require eye catching visualisation to encourage consideration of the map and its content.

Mapping scale and level of detail of background mapping

The current EA flood map is accessible online and as such a zoom function can be used to access a range of scales; with the largest scale (in May 2010 when the workshops were held) being 1: 20 000. An ability to zoom in further is a limiting factor, but perhaps more restrictive is the low level of detail of features such as roads and properties displayed on the background map. The graphical information on the background mapping was that more commonly used on a map of scale 1:50 000 and depicts for example only the boundaries of urban areas, rather than individual properties or groups of properties and the general paths of roads, rather than all of the changes in direction. The scale and coverage of the current map are deliberately insufficient to allow the pinpointing of individual properties, and the supporting information repeatedly stresses that high-resolution assessment is invalid. This restriction is generally justified on the grounds that the data and models used to create the flood map and risk assessment lack the precision and accuracy necessary to support property-level inference and that missing information about the flood levels of properties does not allow an individual property assessment to be made. Through this the restriction of the map resolution is one way to tackle and represent the uncertainties that are inherent in flood risk modelling. Although this justification is understandable it has been highlighted that this is the single greatest point of contention for users of the flood map and users desire to obtain a detailed risk assessment for an individual property is confounded by the flood map itself.

Scale was something specifically addressed during the workshops, through the presentation of the current maps at different scales and with different levels of background detail. This lack of detail for some made locating their own properties or other locations of interest problematic and most participants agreed with the expected finding that the level of detail of the background mapping was not sufficient. When presented

with more detailed alternatives there was a clear preference for a map which enabled them to clearly locate their properties (i.e. where blocks of properties were located) but was not too detailed (i.e. each individual property depicted) thereby making the map confusing overlaid with flood risk information.

Being unable to locate their property effectively (and in some cases efficiently as if users are not able to find their properties quickly they may give up) is a rather fundamental barrier to raising flood risk awareness. Participants also suggested that more detail was required in order to promote mitigation action. This issue of scale has been addressed to some extent in the recent update of the Environment Agency's flood map. The map is now visible at a mapping scale of 1 in 10 000 and with a level of detail of 1 in 25 000 (at which blocks of properties are now visible, rather than just the outline of the urban area) and has been thereby altered in line with the preferences and arguments of the workshop participants.

Mapping Chertsey specific flood risk

One of the key themes of discussion throughout the workshops on this task was consideration of how to accurately reflect the experience of flooding in Chertsey. Although the general focus of participants was on the flood risk to their own properties, they did want to put their risk in context with other areas. With the current EA flood map this is quite difficult because the modelled data suggests that most of the town is a 1 in 100 year risk of flooding. As such, the current flood map depicts most of Chertsey as being within a flood risk area and is covered by dark blue. This was of great concern to many workshop participants who believed that depicting large areas of the town at the same risk was unfair (and inaccurate) as in their experience, past flood events had tended to centre on a few streets and particular properties within those streets. Participants were concerned that flood maps that depicted a larger extent would label non-flood affected properties with the same level of risk as previously flooded properties. One participant commented that:

“going back to the point about houses on one side of the road flooded and not the other, it doesn't allow for any of that really. It's just a blanket coverage of this area here. One set of houses might be higher on one side of the road than the other. So to give them all a blanket large orange blob is probably not enough detail”.

The 'blanket' effect on Chertsey is further enhanced by the fact that large areas of open land surround the town (possibly as natural floodplains) and these areas are included in the mapped extents of the current EA maps. This enhances the impression of a large swathe of blue. It would take considerable inspection to discover that the number of properties covered by the 'blanket' is actually not as significant. For this reason, the question of whether open land should be included in the mapped extent was raised. As a result of the debate, it became clear that different ways of visualising the flood extent should be used to reduce the potential for end users to dismiss the maps for being too vague and broad. Thus residents wanted to see a more specific breakdown of flood risk that demonstrated the wide variation in risk that residents perceived. For this reason, the flood maps depicting the most recent flood event and maps showing risk to streets rather than land area were most popular. The residents felt that these maps painted a fairer picture of the reality (as they perceived it) of flooding in Chertsey rather than the hypothetical.

Participants recognised the considerable difference that variations in land height and thresholds can have on whether a property experiences flooding during a specific event. It was considered to be a major failing that the current 1 in 100 year map 'blankets' the area in blue and appears to ignore these variations and that the information was too general to be of relevance to them. Instead they requested a more detailed depiction of predicted flood risk. Although many felt that having information about individual property height was desirable, participants did recognise that the level of detail they would ideally wish to see on maps would not be realistically possible given the amount of work it would entail. Providing information about the depths of water that might be expected was considered to be appropriate as not only would it allow individuals to have some idea of the likely impact of flooding experienced, but if they had some knowledge of the threshold level of their property they might be better able to interpret the information.

The presentation of properties on a map which did not take into account threshold level, thereby blanket labelling all properties at the same flood risk remained a concern. Different options were recognised as alternatives to coloured envelopes of flood risk extent. In particular, the maps showing only the roads flooded, rather than a blue envelope covering areas at risk, were of great interest. When the roads maps were presented participants often reacted very positively. The original aim of showing participants the map had been to highlight escape routes and whether normal main routes were prone to flooding. However, residents felt that rather than placing individual properties within a mapped envelope of risk, mapping the flood risk on the adjacent roads was a good alternative as at a glance, the flood risk area appears more detailed and it would require those viewing the map to interpret the information and consider the flood height of their property when assessing their own likelihood of flooding.

In some cases where the maps did not match previous experiences of flooding participants rejected the correctness of the maps. It was important to explain to participants that although the mapped data did not match the experiences of many residents it does not mean that it is necessarily incorrect. The extent of the flooding depicted on the current map may be outside of the experience of residents and although the differing heights of properties will have an impact on those that flood in less severe events, properties unaffected in lesser events might still become affected in more severe events as illustrated on the flood map. Therefore, a clear finding here is that although flood experience of the residents appears to be an important factor influencing awareness of flood risk and in determining any action taken as a result of awareness, when viewing mapped information of a specific design event it may lead to the over-estimation or under-estimation of the flood risk. This is a common risk perception finding [6] and reinforces the need to review how flood extent data are communicated with users of the map. One option would be to also depict the extent of historical flood events onto the map as this would allow those with experience to contextualise their personal flood knowledge.

Photographs

The groups were presented with a set of photographs of flooded parts of Chertsey both recently (2003) and in the more distant past (1894). General opinion towards including the photographs on flood maps was negative, with residents finding the pictures of interest but feeling that they would not want them included on a publicly available map. The residents commented that they thought the photographs “might give the wrong impression” and that most residents would be aware of the recent floods and would not therefore require photos. However, some participants recognised that it did demonstrate the reality of the flood risk and commented that “well it is the truth” and “people want to know the truth”. However, others commented that end users “might think the picture shows a weekly occurrence”.

The photographs show the reality of the risk which many participants did not want to be presented. Perhaps this demonstrates an underlying hope for those with properties in the area that by showing flood risk as ‘probabilities’ and general outlines, prospective new residents have an opportunity to dismiss the risk which makes it more likely that they will bargain over whether the ‘potential’ for flooding is serious enough to put them off. However, if the aim of a map is to inform and prevent dismissal of the risk, then photos may be a good way to achieve this.

Layers

Discussed above is the idea that the content of flood maps should vary depending on the end-user. During the workshops, residents highlighted information that they thought would be useful to themselves and information that would be of value to others such as insurance companies. In addition, some participants wanted to have access to more information on flood risk than others. Given the range of information that could be presented to a range of audiences residents expressed the view that a layered approach would be preferable. The participants felt that to be presented with a basic map which you were then able to select additional layers of information would be ideal to resolve the problem of different requirements in maps whilst retaining a simple and clear looking map. They felt that such an approach would be well suited to presentation on the computer, similar to the current EA maps as they are available online.

In addition to presenting this information, further details regarding map calibration and modelling techniques could also be made available without cluttering the map. Some residents in particular were

keen to understand how the map and flood risk information had been developed, giving the impression that without this information they would be more likely to dismiss the map and ignore its message.

Representing uncertainty

When the issue of uncertainty was raised, some residents agreed that it was an important feature that would need flagging up on a map. The solutions that were proposed for representing uncertainty focussed on the expectation that uncertainty can be considered as a narrow band. One participant commented that they would like to see a “plus or minus value...or at the 95% confidence limit” or that “you would have a margin that would be plus or minus...that would give you some kind of indication”. However, participants failed to recognise that the bands of uncertainty could be considerable and that modelled extents are currently up to the 1 in 1000 year flood, but a 1 in 1001 year flood could exceed that boundary. Despite this, they felt it important to highlight that the map was uncertain and not definitive: “need to state some sort of uncertainty- otherwise people will get very uptight but the reality is your data measurements are not that good”.

5.7.4.3 Engaging the public within a dialogue process: Participation for substantive and instrumental reasons

As described in the aims of the workshops the final component explored to the use of participation for both substantive (i.e. gaining additional knowledge about the flood risk in Chertsey which might be used to improve the maps) and instrumental reasons (i.e. raising awareness and increasing understanding about flood risk). Findings related from participation come from a number of the activities in the workshop: including observation of the dialogue and interactions of participants during the workshops, explicitly asking participants about an engagement process (e.g. whether they would like to be involved in a mapping process, how and when) as well as a post-workshop questionnaire evaluating the workshop as part of a participation process.

Participation findings from a substantive viewpoint

The substantive rationale recognises the benefits of participation as enriching and enhancing decision making by providing a greater breadth and depth of knowledge and information for consideration. The view of the authorities as experts and the public as lay people is one that is becoming increasingly challenged, particular in the sphere of flooding. This is particularly important to the realm of flood risk mapping in England and Wales and there is much to be gained in adopting an approach which allows the integration of knowledge from both local citizens and those with responsibility for mapping. During the workshops held in Chertsey, many residents were happy to share their experiences of flooding and the knowledge and when asked to map their experiences (see section 5.7.4.1) many interesting pieces of knowledge was gained.

Firstly, additional information about recent events was gained. This included specific information about the flood event about the depths of flood experienced and which properties escaped flooding due to a higher elevation. Although some of this information might be collected during post-event surveys conducted by the Environment Agency, this information might be used to verify mapped data. Information was also provided about the type of assistance that they required when flooded and where resources were most needed and therefore might be deployed following flooding. This might be fed back into flood incident management plans. Additionally, although not necessary a substantive finding this information was providing further context for residents enabling them to better understand and interpret the map. Discussing this kind of information from experienced residents and enabling inexperienced ‘at-risk’ residents to engage with this information (e.g. in the form of data which is presented, in terms of testimonials or through face-to-face dialogue) may also make the flood risk seem more real.

The locally-flood engaged population are able to provide very detailed knowledge about the specific flood risk issues in that location and those aspects that those undertaking flood mapping need to pay particular attention to. Some local people also showed a long-term knowledge of the hydraulics of the local situation; for instance which areas flood first and then the sequence of flooding experiences. This again is of interest

to emergency professionals, but also might be investigated to attempt to reduce flood risk. For instance, in the workshops there was some talk about drains that were filled in decades previously and there is the concern that this is exacerbating flooding and a couple of participants stated that they would like to discuss this with flood managers. A number of participants suggested that they believed that in many cases the memory, knowledge and experience of local people was much longer than that of the flood management authorities who they perceived to be quite transient and not in post long enough to have established a similar wealth of knowledge. This perception was also influencing in cases their views of the accuracy of the flood map.

In addition to hydraulic information and the positioning on water related infrastructure, workshop participants were also able to provide quite detailed information about sequences of flooding and those environmental cues which were precursors to flood events. This information was often quite localised, however may be of interest and use to other residents in the locale and indeed to local emergency responders or warning authorities as the information could be used to calibrate or add information to the usual data they utilise to forecast flooding.

Complementing the substantive flood related information provided by residents attending the workshop participation also provided some examples of locally-specific information about the use of the flood map. In the Chertsey case study, one such aspect is the 'blanket' coverage of the area and the lack of ability of residents to make any further distinction between areas of higher or lower flood risk. This recognises the fact that there is the need for a flood map to recognise the nuances of the different locations and if possible reflect this within the mapped presentation.

Local knowledge may be used in different ways and some outcomes or products from the engagement process might be for instance:

- The collection of local flood testimonies – which could be linked to or added to the map in order to provide a different type of information.
- Historical event information (e.g. photos, depth information or calibration of event) which could add to or calibrate the 'officially' collected data.
- Identification and representation of local environmental cues (i.e. provide information about observable or measurable changes within the local environment to give residents and/or the local authorities advanced warning of flooding).

Although there might be much information provided by residents, some caution needs to be expressed in relation to this and how it might be used. Information provided during the Chertsey meeting tended to be extremely localised, for instance residents were able to provide detailed information for their own streets and those within the immediate vicinity, but many had little idea of what was happening a few streets away. In many cases therefore a comprehensive and complete view of the flood is not obtained.

Verifying some of the information is also quite difficult and therefore caution needs to be taken when handling and labelling this type of data. In some cases confirmation may be possible if the same information is reinforced by a number of residents or through further investigation, but in some cases this may not be possible. Therefore this raises the question about whether the information should be presented on an 'official' flood map in the same way as modelled data. In many cases the type of information captured would be very difficult to be added to a static paper map (unless information led to the re-drawing of a flood extent boundaries, which is unlikely in the majority of cases) but would be easier to record in a more dynamic GIS-type approach to capturing data.

Increasing flood awareness and understanding: participation findings from an instrumental viewpoint

Observations of the Chertsey exploratory workshops indicated that the process had clear benefits from an instrumental perspective and the value of engaging residents about the flood map. Residents commented that they had changed their views on the map as they spoke about them and asked questions related to

what they were showing and their production. Many commented during discussion that they felt the maps better represented the flood risk in the area better than they thought it did and now believed the maps had a greater legitimacy than prior to the workshops.

The workshops that were held clearly had an impact on flood risk awareness and understanding. Many of those who had not experienced flooding or who moved to the area since the last flood commented that they now knew more about their flood risk, but also expressed they knew more about what to expect from a flood and some idea of what action to take. Part of this was through the discussion of the map, however much was from speaking to more experienced residents.

By including the public in the discussion and refinement of these maps a two-way process of social learning may be facilitated, whereby the public are able to understand the intentions behind the maps and the importance of the information conveyed. In addition, the 'experts' producing the maps will be able to learn how the public interpret and evaluate the information and what action (or inaction) that results in. Such a process of social learning can foster greater understanding and therefore greater trust between the stakeholders involved. This instrumental rationale recognises the benefits of participation as fostering the building of networks and trust and this was reported by participants of the workshops in Chertsey. There were a number of 'higher profile' residents present at one of the workshops who commanded a kind of 'expert status' amongst other participants in relation to their knowledge of flooding. Many of those at the workshop argued that even if they were not involved in reviewing or engaging with the flood map, if some of these local residents who were considered 'more qualified' to do so then they would have more faith in the map. Therefore by engaging these more experienced, as well as other local residents, may have an impact on gaining some local endorsement for the map and increasing its credibility amongst other 'at-risk' residents.

Public views of participation in flood mapping

The theoretical benefits of such participation are widely advocated however there is the need to be realistic about the implementation of participation in practice; both in terms of what is achievable within the resource constraints but also in terms of public motivation to be involved.

When residents were explicitly asked in discussions about their desire and preferences about being involved, there was a clear divide in the views of residents about the value of public participation and their involvement within the flood mapping process.

Many felt that engaging the public was beneficial, with some thinking that it is essential if this information is to continue to be presented to the public online. Involved in the group there were clearly a number of very engaged citizens who clearly wanted to be involved in the future development of the map and that members of the public had something to add to the development of the map:

There needs to be a combination of things ...if you are going to get a realistic interpretation on the map you need to go out and talk to people really.

One quote reflected that some people felt that they had a right to be consulted about this type of information;

It should be every single household (to get involved) should they be interested to do it.

Other residents presented a less positive view of being involved in public participation around the flood map. They expressed that in reality with many conflicting issues competing for their time and attention they would only be interested in commenting on the map if the mistakes/misunderstandings affected them directly. Examples of this were suggested to include if they wanted to sell their house or if they were unable to obtain insurance. Therefore motivation to be involved in participation is clearly a major issue.

Until it is really urgent...or affecting you financially...there is no motivation

Unless it is going to tell me next week that it is going to flood then I don't think that a lot of people would be interested.

Despite, many people suggesting that at a personal level they have higher priorities than being involved in public participation about the flood map, there was a general consensus from both workshops that they would want someone locally to be involved in the mapping process in some way.

Post workshop evaluation of participation

Upon completion of the workshop activities, the participants were asked to complete a survey to evaluate the workshop from their perspective. The survey comprised of seven questions and explored participants satisfaction with the process as well as their input and learning experience.

Analysing the results of the evaluation surveys, it is clear that the vast majority of participants found the workshop a beneficial and enjoyable event. Of those surveyed, 93% commented that they had learnt something new by participating in the workshop event. When asked what they had learned specifically, the most common response was a greater understanding of the risk that their property and more generally, Chertsey as a whole, are vulnerable to. They felt that they learned more about what the risk levels mean and how great the modelled flood extent is. In addition, others commented that they had learnt about the value of public participation in mapping and the importance of events such as the workshop to raise awareness of the risk more effectively. Most participants felt that they had learned from the workshop materials (36%), the workshop organisers (31%) but also from fellow residents (26%). The high proportion of responses that felt they had learned from fellow residents highlights the effectiveness of the workshop in terms of enabling residents to share their local knowledge to learn from each other. Learning from the workshop materials (the maps), supports the finding that the mapping tasks were effective in raising awareness of the flood risk in the area.

As a social learning exercise, the evaluation survey demonstrates that the workshops were effective in bringing together residents to share their local knowledge with each other and to learn from fellow residents and workshop organisers. On this theme and from an instrumental perspective, the evaluation survey asked participants whether they had made any new connections with other participants that might be useful in the future. Responses to this question showed that more than half (60%) of participants had made new connections. Of these the vast majority stated that they had made one or two connections and only 4% had made 'lots' of connections. The low result for lots of connections is likely to be related to the small group sizes in the workshop. The participants were divided into group of on average 4 participants which limits the potential for many new connections to be made. In addition, the remaining 40% that had not made new connections can be explained by the pre-existence of connections prior to the workshop. Indeed, many participants already knew each other prior to the workshop. This again limited the potential for new connections to be made but demonstrates an already well connected population.

An advantage and the objective to having such small groups in the workshop was to allow all participants to communicate and participate fully. The evaluation survey results highlight that this strategy was effective as 92% of participants felt able to communicate the ideas and opinions that they wanted to during the event. More specifically, almost two thirds (60%) of participants felt that they were 'always' able to communicate their opinions and ideas and 28% felt mostly able to communicate as they wished. All participants felt that their opinions were valued suggesting that the format of small groups with a facilitator was successful in allowing plenty of time to communicate. Some participants commented specifically that the workshops provided "a good overall discussion and open forum" and that "everyone was free to comment and all comments were taken on board as valuable."

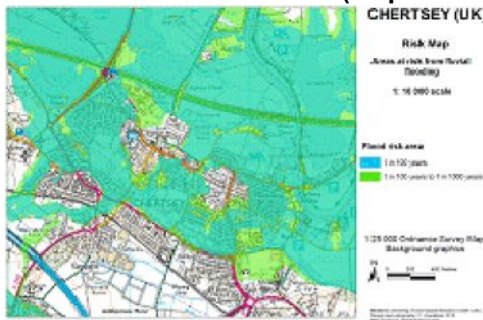
From a substantive perspective, the workshops were successful in provided a platform for social learning. When asked what participants felt they had contributed to the discussion, comments covered a range of features. Some felt that they had been able to add information on their personal experience of flooding and they felt that this was important to share or capture. Others felt they were able to add ideas and opinions on visualisation and content preferences and some were able to add additional information, such as background information on geology and history.

Most participants could not think of ways to improve the participation process. The few comments that participants made were suggestions to involve more people in the workshops or to provide exercises or tasks with more interactive elements or using computer technology.

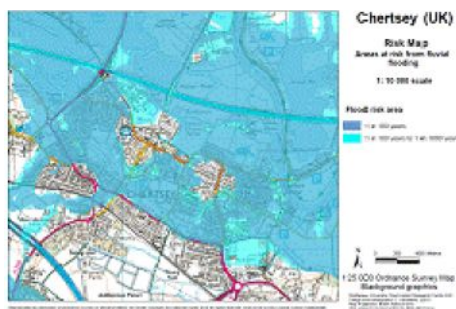
5.8 Alternative mapping: Exploring mapping preferences with experimental graphic semiology

The Exploratory workshop identified a number of map content and visualisation related questions, needs and preferences as described in Section 5.7.4.2. Some of these were taken forward and tested using eye-tracking as part of the experimental graphic semiology component of the RISKMAP project. More details about the process of this component and the results can be found in section 3.3 and 9.3. Following the results of the experimental graphic semiology these maps were refined. Figure 5.19 illustrates the original maps and their refinements. These maps were then presented to participants at the Chertsey Findings Workshop.

CURRENT FLOOD ZONES (Maps 1A and 1B)



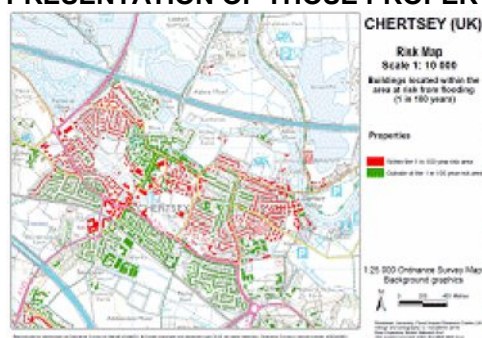
Experimental graphic semiology tested



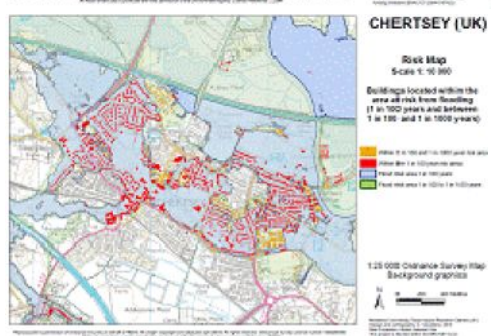
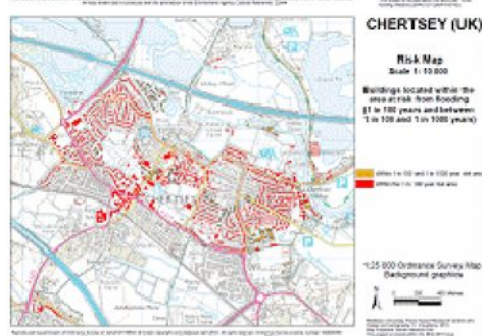
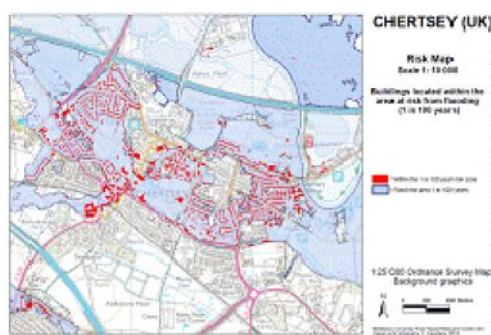
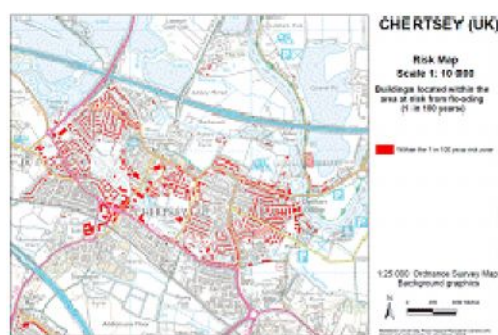
Revised following testing

Figure 5.19: Chertsey maps tested during the experimental graphic semiology and their revisions post-testing which were presented in the Findings workshop

PRESENTATION OF THOSE PROPERTIES AFFECTED 1: 10 000 SCALE (Maps 2A to 2E)



Experimental graphic semiology tested



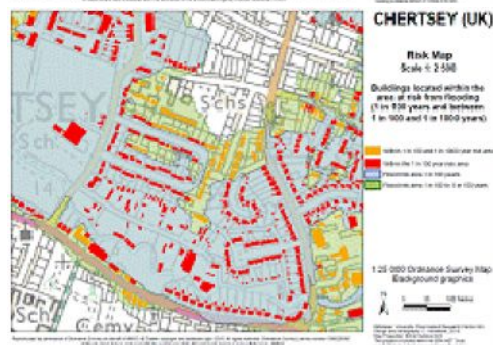
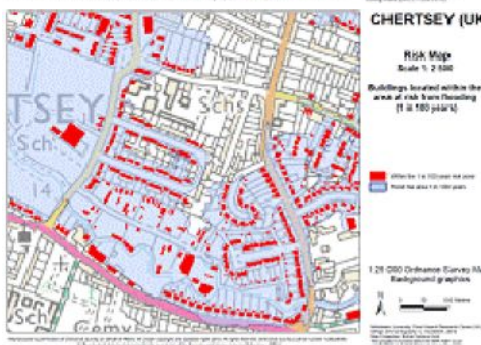
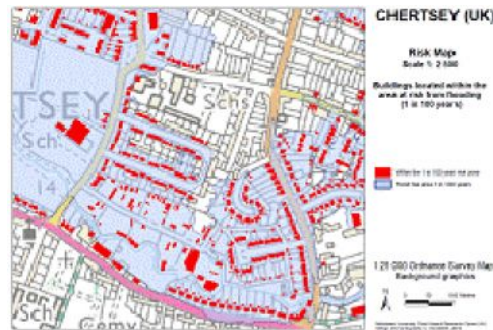
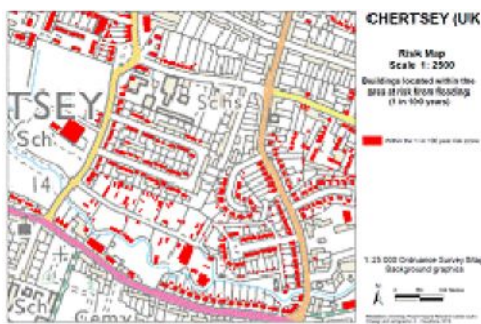
Revised following testing

Figure 5.19: Chertsey maps tested during the experimental graphic semiology and their revisions post-testing which were presented in the Findings workshop (continued)

PRESENTATION OF THOSE PROPERTIES AFFECTED 1: 5000 SCALE (Maps 3A to 3E)



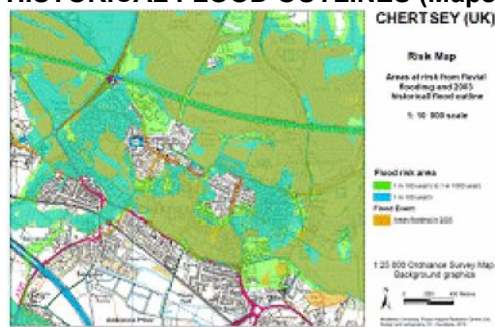
Experimental graphic semiology tested



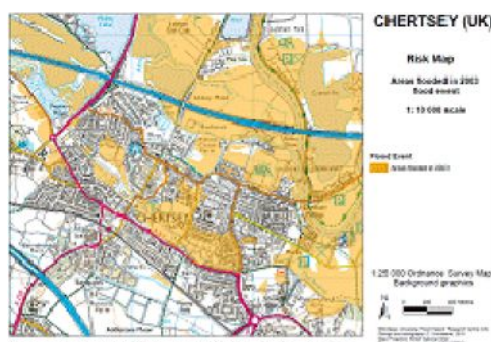
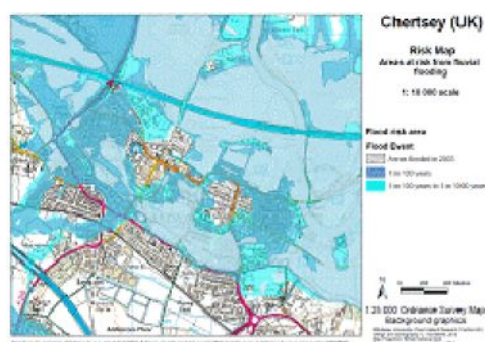
Revised following testing

Figure 5.19: Chertsey maps tested during the experimental graphic semiology and their revisions post-testing which were presented in the Findings workshop (continued)

HISTORICAL FLOOD OUTLINES (Maps 4A to 4C)



Experimental graphic semiology tested



Revised following testing

Figure 5.19: Chertsey maps tested during the experimental graphic semiology and their revisions post-testing which were presented in the Findings workshop (continued)

Source: the maps above were created using Environment Agency data under license ref Z2644 (2009). The base mapping is reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2011]. All rights reserved. Ordnance Survey License number 100026380.'

5.9 “Findings” workshop

5.9.1 Participants

Participants for the findings workshop were recruited by contacting all residents who had participated in the exploratory workshop and who indicated at that time in May 2010 that they would be prepared to be involved in a second workshop. This resulted in seventeen invitations being sent out by both e-mail and post and in addition all those participants who did not attend the first workshop but who participated in the experimental graphic semiology exercise in Tours were also invited. Response from participants was relatively limited with the findings workshop having a total of 9 participants with a mixed experience of contributing during the project. Six participants had attended the exploratory workshop of whom three had also participated in the experimental graphic semiology testing, one participant had only participated in the experimental graphic semiology testing and for two participants this was their first contribution to the project (they were members of a local society and had shown interest and attended in lieu of another participant).

Most of the participants were aged over 70 years old (55%), however, the rest of the participants covered a broader spread of age ranges from 31 to 70. There was an even balance between male (56%) and female (44%) in the participants and all were British speaking English as their first language. In terms of income, there was a considerable and even spread across the income brackets from £100 per week to £1000 or more. Equally participants had been resident in the area for a range of years. Two participants have been living in the area for more than 70 years, three for 40 to 50 years and 3 for 15 or less years.

The majority of the participants (75%) had experienced flooding, although one commented that this was only in their back garden. The most common source of flooding cited was river and ground water flooding. However, 2 participants also mentioned flooding from drains and sewers. Two thirds of the participants were aware of their risk prior to being flooded and one participant highlighted the Environment Agency maps as the mechanism through which they became aware. Other responses included observations and local knowledge. Of those flooded, most had been most recently flooded in 2003 (83%) and one person was last flooded in 2000.

5.9.2 Workshop design and activities

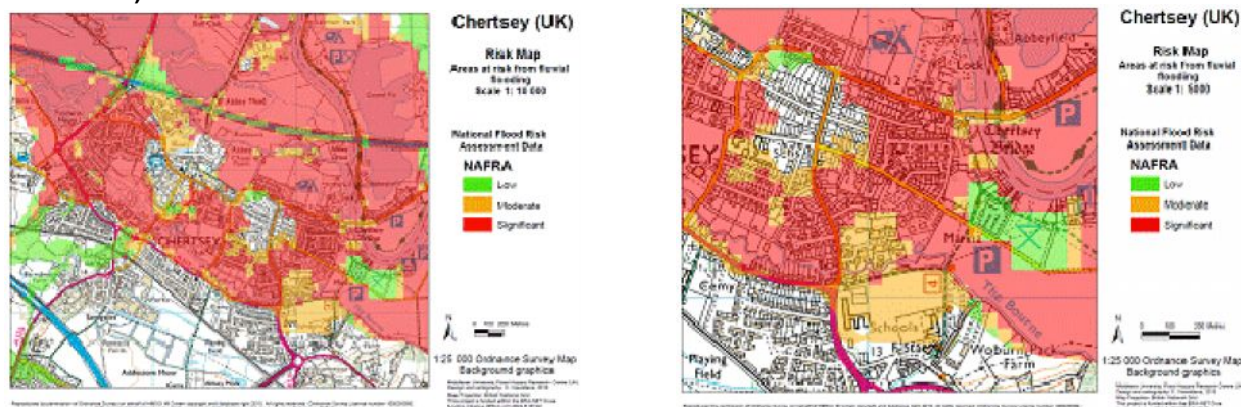
The second phase of the workshop process within the case study was composed of one workshop held in the same location as the exploratory workshops in May 2011. Activities centred on two elements: confirming the results in relation to mapping (i.e. in terms of user needs and preferences for visualisation and content) and requirements and preferences for visualisation. The design and style of this second set of workshops different from the exploratory workshops as additional time was dedicated to the presentation of results from the first workshop. Following a short presentation on the results from each element (mapping and participation) workshop participants were engaged in structured group discussions.

Mapping discussions focussed on presenting participants with maps which were created from analysis of the findings of the first workshop (and in some cases tested by experimental graphic semiology) as well as those then further refined following results of the experimental graphic semiology (Figure 5.19 and Figure 5.20). Participants were asked to provide their preferences about if the maps were an improvement or how they further should be altered.

The participation discussion simply focused on whether they believed that our interpretations of public engagement preferences represented their views (and if not how and why not) and explored with them if they had any additional views in relation to participation.

Users were finally asked to complete a post-workshop questionnaire which intended to clarify and capture individual views about these two elements.

NATIONAL FLOOD RISK ASSESSMENT (NAFRA) PRESENTATIONS AT DIFFERENT SCALES (Maps 5A and 5B)



CURRENT FLOOD MAPS WITH ICONS DEPICTING HYPOTHETICAL LOCATIONS OF ASSISTANCE DURING FLOODING (Maps 6A and 6B)

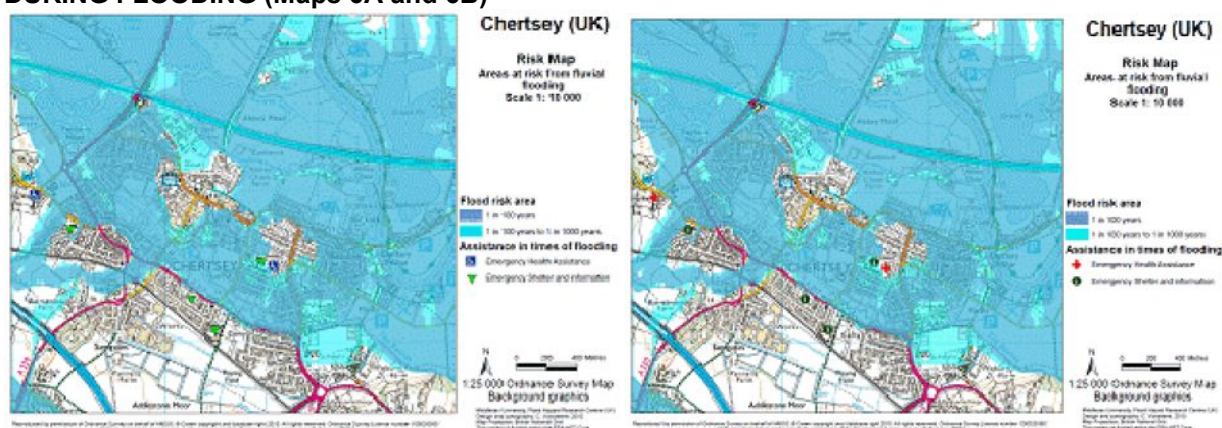


Figure 5.20: Other maps presented at the Findings workshop that were not tested during the experimental graphic semiology workshop outcomes and evaluation

5.9.2.1 Findings related to mapping visualisation and content

The second workshop, returning to Chertsey, presented a range of new maps developed using the results of both the first workshops and the findings from the Tours EGS. The aim of the workshop was two-fold. Firstly the workshop aimed to present the new maps to the previous participants highlighting how their input had been valued and taken into account. Indeed, all participants felt that their comments from the first had been either fully (43%) or partially (57%) taken into account. In addition, 86% of participants felt the maps presented in the findings workshop were better than the current Environment Agency maps and all participants were satisfied with the latest maps presented. In this way the workshops assisted the achievement of an element of instrumental rationale. The second aim of the workshop was to gain the participants perspective on the new maps- what did they feel was an improvement, what was not valuable and what was still missing? The findings from the workshops provide some answers to each of these three questions.

One of the most prominent findings from the first workshops was the participants' interest in a personal level of risk. This finding informed changes to the maps for the EGS which in turn provide information for further refinement. The maps presented at the second workshop took all of these findings into account to produce new maps that highlighted personal level of risk in a range of depictions:

- Buildings at risk of 1 in 100 only, depicted in red (Maps 2B and 3B)
- Buildings at risk of 1 in 100 (red) and 1 in 100 to 1 in 1000 (yellow) (Maps 2C and 3C)
- Buildings at risk of 1 in 100 (red) with 1 in 100 extent (blue) (Maps 2D and 3D)
- Buildings at risk of 1 in 100 (red) and 1 in 100 to 1 in 1000 (yellow) with 1 in 100 (blue) and between 1 in 100 and 1 in 1000 extent (green) (Maps 2E and 3E)

The findings of the second workshop reinforced the participants' interest in their personal level of risk, however, the participants highlighted that need to place this personal level of risk into context. As such, they felt that the zoomed in maps were too far zoomed in to be able to locate their properties. The first workshop highlighted the need for maps to provide easy orientation and the participants felt that the zoomed out versions were more successful in facilitating orientation. They commented that it would be best to begin with a zoomed out version which they would then appreciate being able to zoom into.

Further to putting their personal risk into context, the participants highlighted the need for the information of buildings to also be put into context using the flood extent information. So whilst they preferred the new maps which highlighted buildings at risk rather than simply providing an extent of flood risk, they felt that the more effective maps in this series were those that put the buildings into the context of the flood extent. One participant commented that it was important to be able to understand why one building was at risk when the next building wasn't. All agreed that by including the flood extent on this map the issue is resolved. Indeed, participants felt that the red buildings alone also lacked this ability to provide context as there was too great a contrast between the red 'at risk' and the non coloured 'not at risk' buildings. There was agreement that this failed to emphasise the uncertainty and variations in flood extents that naturally occurs and as such preferred the maps with buildings in red and yellow which highlighted variations in levels of risk.

On a similar path of thought, the participants explored the 2003 extent. They commented that this was still very important as demonstrating the reality of flood risk in the area and the relevance of the extent as a recent flood incident. However, they were concerned that showing only the 2003 extent neglects the notion that flooding in the future may be greater than this extent. As such they felt that the 1947 flood extent which demonstrates a larger extent would be valuable to have on the maps. However, comparing this discussion with the findings from the first workshops, it appears that the 1947 may not be suitable as many participants felt it irrelevant due to the changes in the area that may have affected flood risk since that time. As a compromise, it appears that a suitable solution would be to present both the 2003 extent along with the modelled 1 in 100 and 1 in 1000 extents.

The idea of layering information and providing composites of both information on buildings and flood extents was once again highly popular. Participants commented that presenting maps in layers that could be applied and removed at the will of the user was an ideal solution to the problem of catering for different audiences. During the workshop the participants discussed the idea of different audiences and different levels of interest in maps, highlighting that whilst some are interested in detailed information, others may only want to take a quick look. As such, participants felt proving the opportunity to present more or less information through layering would be a good solution. However, when asked which map should be the first map that is encountered there was considerable debate.

Some participants felt that the first map should be the NaFRA layer which presents risk in terms of bold colours with a simplified key of 'low, medium or significant' risk. However, others commented that this layer may be too frightening and instead preferred the layers with buildings in red and yellow with the blue and green extents. The participants recognised that there was a need to strike a balance between worrying and comforting people at risk and that the map chosen depends on whether the map is intended to spark people into action or to provide information more reassuringly.

Most of the interest in the NaFRA datasets lay less with the presentation of risk in bold traffic light colours and more in the descriptions of risk in the legend. The participants overwhelmingly agreed that the use of

words such as 'low', 'medium' and 'significant' were far more effective and easy to interpret than the return periods. This finding clearly supports the results of the first workshops with comments such as the meaninglessness of the 100 or 1000 year return period being repeated again at the second workshop. As such participants reinforced the idea that risk should be described in as simple terms as possible, agreeing that the low, medium and significant descriptions act as such. Furthermore, the participants agreed that it might be necessary to qualify the low, medium and significant with numerical descriptions such as the 1 in 100 year return period to again provide more context to the legend. However, they felt that it would be sufficient to place such information more discretely on the map, say at the bottom as a small note. The participants felt very strongly that it is vital to have a simple and easy to interpret legend and were comfortable sacrificing scientific accuracy (i.e. the 1 in 100 flood) for more general but uniformly understood terms (i.e. low, medium and significant).

In contrast to the first workshops, the participants were much more interested in the emergency service information presented in this workshop. During the first workshops participants felt this information was unnecessary as being residents they would already know where to go for information and shelter. However, following the recommendations at Tours, the maps presented at the second workshops included this information to which participants were much more supportive of this time. One participant commented that despite living in the area, he was unaware of the location of emergency information and shelters and felt the presentation of this information on the flood map was "vital" as "it makes you feel more comfortable...you can think 'oh look, I've got this [shelter] near me". The conclusion that can be drawn from this is that such information needs to be presented correctly. In the first workshop it was not clear that the points presented concerned emergency information and was therefore more easily dismissed. In the second workshop the participants felt the information was useful but again highlighted that finding a suitable way to present this information was essential as they were very supportive of the presentation of information that 'stood out' and not supportive of the same information presented in colours that blended in to the other map features.

In terms of components that remained missing from the maps presented in this second workshop, participants again highlighted the value of depth information. They reiterated that this would be an important component to qualify the extents and aid interpretation of the severity of risk. However, they remained understanding that this was difficult to attain in practice and hoped that improvements in the future would enable the information to be presented in future modifications to the maps.

In conclusion, the second workshops highlighted the value of returning to Chertsey. The new maps presented have reinforced and also challenged some of the initial findings, contributing to a better understanding of how maps can and should be tailored to public participants. The workshop has emphasised the most important features in maps and provides another perspective of the information collected in the first workshops.

Table 5.7: workshop findings

1 st workshop findings	2 nd workshop confirmation
Orientation is important- it should be easy	Zoomed in maps are harder to orientate using, zoomed out would be best to begin with as they provide context: "that one doesn't give you an idea of where you are". "If you were moving into the area and you didn't know the area at all, you could pick this up and get an idea" (discussion on the zoomed out map)
Personal risk- small scale, local view	Participants do not want a map too zoomed in as they struggle to orientate themselves on such maps. However, they did want to be able to zoom in further once initially orientated: "To be honest you do need a larger space of Chertsey to orientate yourself"

Personal risk- their property vs. 'blanketting'	The participants liked the map highlighting buildings at risk and not at risk. However, one participant commented that it was not necessarily clear that they were buildings. This needs to be emphasised in the key. The extent is important to give context to why some buildings are highlighted but others aren't- to understand why one is red and one yellow: "why would this one flood and this one not?"- it's hard to get the context without the flood extent.
Not interested in escape routes, liked roads for specificity	The vast blue extent wasn't as much an issue, this may be because it had a lower impact as a result of a busier map (i.e. having houses highlighted, is more focussed and blue green extents are less prominent).
Not interested in emergency information	Participants were more interested this time in emergency info. The first workshop findings may have been result of visualisation and code system used being less clear. Participants felt this information was useful as "it makes you feel more comfortable" to know that emergency shelters etc. had been thought about and were nearby. But they have to be bold on maps rather than the green and blue shades which blend in too much with the rest of the map.
Historical flood extent- 2003 most popular	"this is real life, it's actually happened", "they can relate to when it actually happened" However, the 2003 extent might be mistaken for the flood plain: "that's what happened then so that's what you should expect next time but it might be much more than that next time". As such the 1947 extent was also popular, much more so than in the first workshop.
Depth information helpful to qualify extents but hard to achieve accurately	Participants still want depth information and had a discussion about the challenges in mapping this information effectively.
Delineation- 1 in 100 meaningless, 1 in 70, 50 or 30 as alternatives	They still mentioned wanting greater delineation, arguing that 1 in 100 was still pointless. A case was made for 1 in 75 as the threshold for insurance and also 1 in 50 "The 1 in 50 is the most graspable in the head".
Misunderstanding and difficulty interpreting return periods- observed	Participants continued to have difficulty interpreting 1 in 100 explicitly mentioned "but if you give the 1 in 100 years, you might only be staying for 5 years" "forget the 1 in 100 because, well by that time I will be dead". "really 1 in 100, it's a bit irrelevant isn't it because it might happen tomorrow"
Real time predictions- warnings (what will the weather do, when will it next flood?)	Not discussed
Map availability-mixed views on how open and accessible the maps should be	Discussion was less on whether maps should be available and more on what content should be available and how best to present the maps (striking a balance between informing and worrying)
Low, medium, high- popular alternatives to 1 in 100	Low, medium, high very popular still, but accept that greater explanatory detail may be required to qualify this: "there could be a note at the bottom; red represents 1 in 75". 1 in 100 was

	hard to comprehend on the legend and the word 'buildings' was missing which would have been better. Low, med and high were seen as much clearer on the legend. "that key is easier rather than trying to interpret what that means"
Colours: traffic light popular as being more distinct than shades of blue	More distinct blue and green shades were popular but traffic light colours were less (although still to some degree) popular. "I can understand the blue is sea, I also can understand traffic lights, it's a graduation"
Colours: blue, popular to represent water but not popular for the blanket effect	Blue very popular as it represents water – traffic lights "that to me looks like bush fires", but the blue isn't a large extent, it's qualified by the buildings in red and yellow
Layers- present a basic map with additional information layers that can be added for those who want greater detail	"Isn't that the best way" First layer- the green-blue/red-yellow but with the low, med, sig key "because unless you know the 1 in100 it might be lost on you" But NaFRA: "at least if you look at that one you can see 'danger, danger'" but "then you wouldn't come here at all"

The comments during the discussion were backed up by the results of the survey following the workshop. Participants commented that useful features in the maps were emergency service information, previous flood extents and a "general level of information which can be zoomed in to clarify details around individual properties and zones". In terms of visualisation, the surveys highlighted presenting greater delineated information (such as the 1 in 75 year extents rather than 1 in 1000) and providing a key or legend with "simple wording" such as "low, medium and significant".

5.9.2.2 Participatory findings

Participants in the findings workshop were presented with the key findings on participation from the first workshop and were asked to comment whether they believed researchers' interpretations of the outcomes were correct. In addition to this participants were explicitly asked to discuss the answers to a number of key questions:

- Who should be involved in participation?
- What activities should be undertaken?
- How often is engagement/participation necessary?
- When in the mapping process should participation be carried out?
- What is the most important reason for participation about the maps?
- Who should be responsible for participation?
- What information you think you might be able to add to the map?

The majority of those attending the Findings workshop confirmed the feelings from the initial workshop that there should be some degree of participation in relation to the flood maps. They expressed that they saw the value in and enjoyed participation and saw it as a:

"chance to put across your opinion"

There was a general consensus that the experience of people who have been flooded was important and there should be the chance for this to be captured. Similar to the first workshop it was further expressed that it was important that those who had lived in the area a long time or who had experience of flooding

were critical to the participation process and that it did not matter who it was, as long as local people who have experienced flooding were involved and included. Participants commented in the survey that “local information, particularly from people who have experienced flooding is invaluable” and that “they have knowledge that can be passed on”.

However conversely, one participant in particular argued that not everyone would be able to contribute in the same way and that they may not have valuable information to add to the map. From a substantive rationale about the content of the map (e.g. whether the flood map accurately depicts the level of flood risk) this might be in some instances true, however from an instrumental perspective or about the ease of use of the map all those at risk may have valuable contributions to make. From an instrumental perspective engaging those who have less understanding of flood risk will potentially have a larger impact that exclusively engaging those who have particular experience or knowledge to impart. This reinforces the notion of clearly articulating the purpose of the participation and whether groups with very different experiences should be engaged in the same way and together. Additionally, another participant felt that participation should be undertaken with other authorities and should not be performed by the community for the community. It was considered important by this participant that those running participation had some training and therefore had the authority to act in this capacity. It was believed that experts would be more impartial, whereas public participants might create too many personal arguments and that it was the role of science to balance these arguments.

Despite a number of participants questioning the role of the public in participation and argued that on the whole participation within a mapping process should remain with the experts and professional flood managers, it was still recognised that the public does have a role to play and should still have the opportunity to provide feedback. The vast majority (78%) of survey respondents agreed that local residents should be invited to consult on flood maps. It was felt that the official maps should be launched and people have the opportunity to provide comments via a web platform and then those involved in map production would be able to sort out those comments through to be ‘*silly*’ or ‘*irrelevant*’. There were further comments on the type of participation. One participant commented that they would not want a drop-in session with the authority in charge of flood mapping as they were not impressed by them and had limited faith in their ability. This re-emphasises the importance of good local relationships to the success of participation and opinions about the products that they produced.

Other participants were more positive about having face-to-face participation and the benefits that may be provided. In the survey, 78% selected workshops as a preferred way to involve local residents such as themselves. However, opinions about who should organise and run these workshops varied. For instance, some felt that it should be the local authority and the Environment Agency, whilst others saw a role for local people and that it should be led by local flood groups. Additionally, others saw the role for independent facilitators in order to reduce bias in the process and provide a more professional basis for leading the participation.

In addition to workshop-type participation, it was also suggested that other types of communication and engagement should also be explored and that there would need to be multiple methods to reach different people with different levels of interest. A leaflet providing information about the flood map was suggested as well as providing information about participation activities and in this way it may act as a recruitment tool as well as raising awareness of the existence of the map or mapping updates. It was also suggested that a questionnaire might be circulated with open questions which people might use to provide their knowledge and information which might be followed up if any clarification was needed. Although in some circumstances this would provide a useful tool and arguably less resource intensive than running workshops, using this type of data gathering on its own may elicit less information than more in-depth face-to-face discussion and does not provide the two-way dialogue and social learning opportunities that a discussion involving both members of the public and mapping professionals would permit. Moreover, in-depth dialogue is considered to be fundamental to the drawing out of implicit knowledge; the type of knowledge that might be considered to be most valuable for improving or verifying flood map content.

When asked at what stage in the mapping process participants should be consulted, participants selected on average three stages. This emphasises the desire to be involved in an iterative process. One third of participants selected that they thought residents should be involved 'before the first draft'. This suggests that they are keen to be involved as part of initial decisions. Seven out of the nine participants also said that they wanted to be involved when an initial draft was available. Five selected involvement when the refined map was available and only three chose involvement at the stage of the final maps presentation. This suggests that engagement is seen as most desirable when the maps are drafted so that they have something to work from, but the process is still very much open. In contrast, participants may be less interested in the final maps as this stage provides little opportunity (if any) for their input to be influential. The findings workshop can be seen as representing the refined maps stage as recommendations will still be considered and some changes can still be made.

There were some additional positive comments about the map being a product of a participatory approach and that it made a difference to how they felt about the map. For instance, during the Findings Workshop, some of the initial outputs of the RISK MAP research were presented. This was considered to be very important and participants expressed that they were pleased that they had been listened too, even if their input was small. This reinforces the need to provide a follow-up to any participatory activities. This of course might not necessarily be a second round of workshops but will depend upon the specific purposes of the second round of communication. For instance, this might include the presentation of an updated map, a further justification about an update or further consultation about the content or visualisation of the map.

It should be continually recognised that as with many instances of participation it may be difficult to engage those who have had little experience and to maintain interest. This is potentially reflected by the lower numbers at the second workshop with only relatively enthusiastic participants attending. In addition it should be recognised that for the Findings workshop it is only a small number of the keener participants who are providing preferences on participation and are likely to have a more positive viewpoint on participation and the need for it that the more general at-risk and flood unaware populations. Despite this, the workshops and in particular the Exploratory workshops, provided researchers with the opportunity to observe interactions between at-risk individuals and survey participants about participation and useful insights were gathered.

5.10 Case-study specific recommendations

5.10.1 Recommendations for mapped content and visualisation

5.10.1.1 Level of mapped detail

From the results of the workshops, it is clear that residents require flood risk maps that are as personal and specific to them as possible. Their ideal flood maps would depict property specific projections of flood risk, however they do understand the challenges involved in producing such maps and accept compromises. If maps take the current mapped extents or even historical flood events but present them by highlighting houses or streets instead of large areas, this creates an impression of being more specific. Ideally a property-level of detail was considered to be the minimum, anything vaguer was seen as too inaccurate and enabled residents to either deny or ignore the maps based on an impression of inaccurate modelling and representation. Residents involved in the findings workshop appreciated the efforts of flood mappers to provide additional scales of view for the flood map, the provision of the flood map at the larger scale of 1:10,000 and the increased level of detail in the background map. Whilst they appreciate the difficulty in representing greater detail to give property specific information, they did feel that this should at least be attempted.

- **Recommendation 1: Detailed information is crucial to understanding flood risk and taking action. Explore ways in which individual property level flood risk can be depicted on maps or assist users in making their own assessment (i.e. a step by step process),**

5.10.1.2 Mapped presentation

Preferences for colours were contrasting with some favouring blue for its connotations of water and others preferring traffic light colours. Both colours were deemed easy to interpret but would have a different impact on end-users. i.e. blue would demonstrate water but would not necessarily promote action as it is a relatively 'calm' colour. In contrast, traffic light colours would be interpreted as representing danger which might be more likely to attract attention to the map and then promote action, but would require greater time to understand that it represents danger from water/flooding specifically. In the second workshops, the use of both blue hues for extent and red and amber to highlight properties was a popular solution to incorporate both preferences.

- **Recommendation 2: Consider combinations of blue hues to represent water with traffic light colours to capture attention and promote action. Ultimately colour choice should match the objectives of the maps and raising risk awareness.**

5.10.1.3 Information presented on the flood map

With regards to content, overwhelmingly popular was the incorporation of information about flood depth. Residents highlighted throughout, the value of having flood extents that correspond to depths as this adds the additional detail that helps reduce dismissal of risk. Information about flood depth will allow for a better assessment of flood risk to individual properties. For instance, there are likely to be many properties which are depicted as being within a flood risk area, but due to their raised position or higher threshold level are unlikely to experience flooding.

- **Recommendation 3: Provide information about the potential depths of flooding that would be experienced in different flood events.**

Other than information on flood depths. A handful of residents suggested that they found additional locations presented on maps (such as where to go in case of a flood) useful or comforting, but there was no real consensus on this issue. Furthermore, there was a clear indication that public users were only really interested in information about the hazard (i.e. including flood extent in terms of likelihood and depths); there was no clear desire to have access to information about flood *risk*. However, some workshop participants recognised that for other groups (e.g. emergency responders, local authorities) risk information would be valuable additional information.

- **Recommendation 4: There is a clear preference amongst the public for flood maps with improved hazard rather than risk information.**

5.10.1.4 Improved use of historical information

It was observed, and in addition, many residents reported assessing the reliability and accuracy of flood maps against their personal flood experience and observations. Where the maps did not match previous experiences of flooding participants rejected the validity of the entire map even though the map may be presenting information outside of the experience of residents. As such, residents responded more favourably to the presentation of historical floods on the maps rather than hypothetical floods. Despite some of the issues that may occur with the presentation of historical events, in all workshops flood experience provided valuable grounding and context to discussions about flood risk and therefore a greater use historical information and the experiences of residents would assist in raising awareness. The presentation of this information alongside the flood map may improve credibility and trust in the mapped

information as it would illustrate the difference between the historical flood event (with a designated flood depth and event) and modelled return periods; thereby reducing confusion about what is being mapped.

- **Recommendation 5: Identify ways in which historical flood event information can be presented on flood maps alongside standard reference extents such as the 1 in 100 and 1 in 1000 year events (with clear explanations to differ it from the modelled flood risk) to assist in the contextualisation of flood risk.**

5.10.1.5 Increased delineation within the mapping of flood risk

The research found that risk also needs to be presented in a manner that those at risk can engage with. The use of the 1 in 100 year and 1 in 1000 year flood events as reference events do not provide users with the ability to assess the severity of their risk in terms that encourage a mitigation response. In some areas (and particularly in areas with a similar 'blanket' coverage to Chertsey) More delineation of the flood risk is required for users to appreciate that some areas are at much higher risk and thereby justifying a response. Using delineations of years within a lifespan such as 1 in 50 or 1 in 75 year is likely to receive a stronger response.

- **Recommendation 5: Revise the flood map so that a greater delineation of flood risk is provided**

5.10.1.6 Language of Risk

The ease with which the 1 in 100 and 1 in 1000 year reference events may be misinterpreted and misunderstood is a key concern. In addition, these events are seen as too infrequent and therefore extreme to be of sufficient concern for residents to prepare for. Greater delineation of mapped risk would help improve the impact of the flood extents on end-users, however, participants felt that using terms such as 'low', 'medium' and 'significant' as in the NaFRA layers, would overcome the problems associated with the terminology of the reference events.

- **Recommendation 6: Language used to describe risk should be clear and easily interpreted. Using terms such as 'low', 'medium' and 'significant', for example, are preferable to more complex terms such as the 1 in 100 or 1 in 1,000 year return period. The flood return periods used as reference events should be 1 in 75year return periods or less as this can be conceived as occurring within a lifetime.**

5.10.1.7 User-specific flood maps

As the research demonstrates, flood maps designed for spatial planning and development control are not suitably tailored to raising public awareness and motivating public responses to flood risk. The prime reasons for this lack of effectiveness with the public relates to two main problems; the delineation of risk and level of detail in the background layers. The public require flood maps that inform them about the risk that they face as individuals. As such participants were most interested in maps that allowed them to assess the level of risk that their properties face. Being able to identify their individual properties on the maps was crucial to this.

- **Recommendation 7: Different users (even within public groups) have different requirements from a flood map and therefore a layered approach should be investigated whereby information can be turned on and off and explored at will.**

5.10.2 Recommendations for participation in the Thames case study and England and Wales

5.10.2.1 Overcoming barriers

Engaging with residents to discuss the flood maps promoted a greater understanding of the level of risk residents face, how and why the maps are produced as they are and how they may help residents. Residents require reassurance that maps are accurate and relevant in order to give the risks serious consideration. The participatory process raises awareness of the issue and allows residents to seek answers to their queries over map production content and accuracy.

- **Recommendation 8: Seek ways to engage with residents in at risk locations to improve risk awareness and responses to flood maps.**

The case study workshops highlighted that there are many different benefits to be gained from participation, both from a substantive and instrumental perspective. However it is important to recognise that participation requirements may vary at different times within the process of flood mapping (e.g. development of new maps or updating information) or the preferences of different users. In addition, mapping updates should be used as an opportunity for re-publicising the existence of a flood map, encouraging residents to find out about their flood risk and for public participation.

- **Recommendation 9: The methods of participation need to be flexible and incorporate mechanisms for feedback and comments on the flood maps in addition to facilitating more intense and in-depth engagement when maps are revised.**

5.10.2.2 Recruitment

Recruitment of participants should be open to all residents in order to maximise the breadth and depth of knowledge to be considered. Recruiting participants from the at risk groups that have not been affected by flooding directly proves to be particularly challenging, however, by contacting local community groups it is possible to gain access to an audience that may be more supportive and trusting of the project. Using such 'gatekeepers' can be an important tool in promoting the project and attaining legitimacy.

- **Recommendation 10: Stakeholder recruitment should be open and inclusive. Using a variety of methods such as 'gatekeepers' is helpful to access a broad range of stakeholders**

5.10.2.3 Neutral facilitation

Neutral facilitation is important for maintaining the focus of the participatory process on the issue to be discussed. Participants frequently deviate and a facilitator needs to be able to balance wider discussions on flood experience for example, with the specific subject matter. Neutral facilitators are also important for mediation where participants may begin to dominate discussion.

- **Recommendation 11: The presence of an effective neutral person to facilitate and mediate discussions is important to ensure a focussed discussion where all participants are able to contribute effectively.**

5.10.2.4 Evaluation

Observation of the participatory process enables facilitators to gain an understanding of the effectiveness of the process and the impact that it has had on participants. However, by conducting an evaluation

survey, it is possible to enhance and verify this observation by gaining access to participant opinions of the process more directly. A survey can be an effective tool for capturing participant opinions and comments on the process.

- **Recommendation 12: Capture an evaluation of the process and opinions from the perspective of the participants through the use of tools such as a survey or questionnaire.**

6 Case study Saxony

Jochen Luther, Volker Meyer, Christian Kuhlicke

The rationale of choice was to select a test site that serves as a typical lowland river floodplain but with flood generation mainly in higher, mountainous parts of the catchment. The Vereinigte Mulde River met these criteria and was heavily affected by the flood in August 2002, causing high damages in many towns and villages along the river. In the towns of Eilenburg and Grimma, many research activities were already conducted (FLOODsite IP, FLOOD-ERA): 1) A survey with residents in Eilenburg and smaller villages on risk perception, preparedness and social vulnerability (Steinführer & Kuhlicke 2007), 2) the development and test of a multicriteria risk mapping tool for the Vereinigte Mulde River in Saxony (Meyer et al. 2008), 3) an investigation of involved decision makers in flood risk management and the decision context, and 4) the evaluation of exemplary flood risk reduction measures at the Mulde River (Schanze et al. 2008, Meyer et al., submitted). In this context RISK MAP could rely not only on profound empirical knowledge but also on existing contacts to decision makers, experts and other stakeholders in the region, such as the Saxon Ministry for Agriculture and Environment (SMUL), the Saxon Dam Authority (LTV), and local decision makers in the municipalities of Grimma, Eilenburg and Zschadras.

6.1 The case study area

6.1.1 Physical geographic features

Due to the flood event in 2002, the extensive activities and research in its aftermath and the easy accessibility Saxony and specifically the Mulde River was chosen as a case study site for RISK MAP. During the interview phase, the focus was further narrowed down to the City of Wurzen and the Municipality of Bennewitz bordering the Vereinigte Mulde ("Joint Mulde River", see Figure 6.1 & Figure 6.2).



The Mulde River is a non-navigable river in Saxony and Saxony-Anhalt, Germany. It is one of the main tributaries of the Elbe River and, as most of its affluents, feeds into the Elbe from the left. The 124 km long course of the Vereinigte Mulde is formed by a western branch, the Zwickauer Mulde, and an eastern branch, the Freiburger Mulde. Both rivers originate in the upper Ore Mountains in Saxony, draining a considerable portion of their northern slope. The Zwickauer Mulde, 128 km in length, has its source in the Western Ore Mountains (770 m), runs through the Vogtland region and the city of Zwickau. Its main tributaries are the Schwarzwasser and Chemnitz, both from the right. With a length of 124 km, the Freiburger Mulde arises from several streams in the Czech Republic (855 m). Near the city of Freiberg in Saxony, its valley is 100-200 m deep incised into the plain of the Eastern Ore Mountains and its foothills. Besides the smaller tributaries Bobritzsch and Striegis it is the Zschopau River that yields the largest influx.



Figure 6.2: Detail of a topographic map 1:50,000 showing the City of Wurzen and the Municipality of Bennewitz.

Source: Landesvermessungsamt Sachsen

From the confluence of both branches near Colditz (to the southeast of Leipzig), the Vereinigte Mulde runs northwards through the Cities of Grimma, Wurzen, Eilenburg and Bad Dübau. It then enters Saxony-Anhalt, passes Bitterfeld and Dessau and joins shortly thereafter the Elbe River. The upper part of the valley of the Vereinigte Mulde represents a sort of a gorge. In contrast, the much wider lower stretch starting downstream from Wurzen is part of a glacial valley that even the Elbe might have used occasionally.

The highest elevations of the catchment are the Klinovec (CZ, 1.244 m), the Fichtelberg (D, 1.214 m), and the Auersberg (D, 1.019 m), all lying in the Ore Mountains. The lowest point is to be found at 60 m above sea level just before the Mulde enters the Elbe River near Dessau / Roßlau. The catchment area as a whole covers about 7,400 km². The respective shares are 1.138 km² (15%) for the Freiburger Mulde, 1.847 km² (25%) for the Zschopau, 2.361 km² (32%) for the Zwickauer Mulde, and 2.054 km² (28%) for the Vereinigte Mulde. In the lower reaches, no relevant inflow occurs further downstream of Bad Dübau, where the medium annual discharge is 64 m³/s. The discharge regime is largely influenced by rainfall and snowmelt in the Ore Mountains. Therefore discharge normally peaks in spring and then decreases continuously until October / November. Often this regime is interrupted by the effects of strong summer rains. In the mountainous regions its course is characterised by steep valleys and high flow velocities whereas the lowland river Vereinigte Mulde forms wide floodplains with many meanders and oxbow lakes.

A number of reservoirs for flood control and drinking water supply are located on the upper Zwickauer Mulde and the Zschopau and their tributaries. One dam ponds the lower Mulde near the city of Bitterfeld.

In terms of flood risk, the Mulde River system represents both flood source areas in the uplands with high discharge dynamics including flash floods and receptor areas in the lowlands. Especially the foothills of the Ore Mountains as a traditional area of medium-sized industries are densely populated and potentially vulnerable. This industry was based on the century long mining in the area, which has left a considerable amount of contaminated sites. In the lower reaches of the Vereinigte Mulde, large active and inactive open pits for brown coal exist. This makes floods especially worrying.

In August 2002, an extreme flood caused severe damage along many Czech and East German rivers. Discharge reached approximately 2,600 m³/s at the gauge in Golzern (see Table 6.1). Especially the cities of Döbeln (on the Freiberger Mulde) and Grimma suffered from the damages of the Mulde flood. The 2002 flood event also endangered the UNESCO World Heritage Site "Dessau-Wörlitzer Gartenreich", a large landscape park. Apart from this site, other cultural monuments of "lower" prominence as well as ecologically valuable flood plains along the lower Vereinigte Mulde exist. Damage potentials are especially high in the settlements and the industrial zones (buildings, roads, bridges) whereas agricultural damage is probably more marginal (mostly natural areas and grass lands). Special attention is needed because of chemical pollutants floods may release, convey, and deposit. The main hydrologic features are shown in Table 6.1.

Table 6.1: Peak discharges (Q in m³/s) and peak water levels (W in cm) for the City of Wurzen (km 54,654 upstream from the mouth of the Mulde River near the bridge in Grubnitz)

MQ	MNQ	NNQ	MHQ	HHQ	HQ(25)	HQ(50)	HQ(100)	HQ(200)	HQ(500)
At present									
61.9	13.5	1.4	518	2,600	1,160	1,490	1,910	2,480	3,520

Source: LfULG

Table 6.2: Alarm stages and corresponding water levels for the local reference gauge at Golzern 1, Vereinigte Mulde River

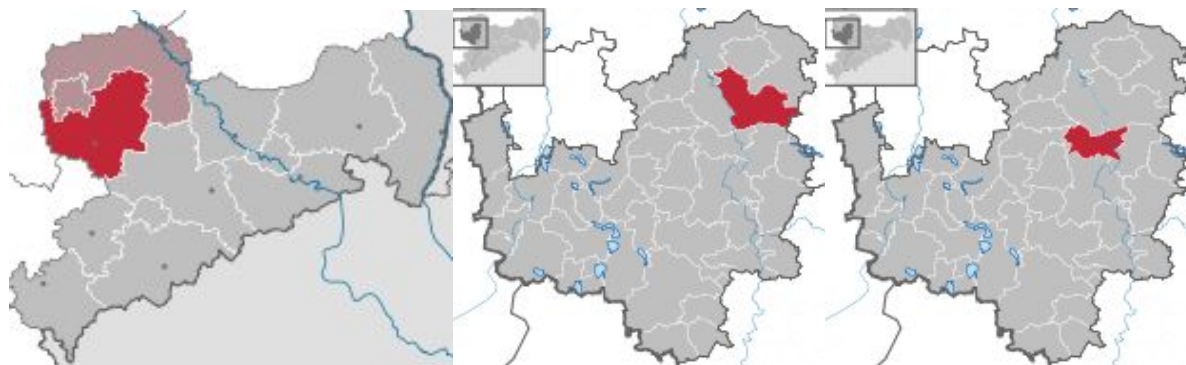
Alarm stage (Alarmstufe)		Flood reporting water level [cm] (2002)	Flood reporting water level [cm] (2010)	Corresponding discharge [m ³ /s]	Statistic placement
1	Information service (Meldedienst)	320	320	??	HQ
2	Controll service (Kontrolldienst)	390	400	??	HQ
3	Surveillance service (Wachdienst)	490	480	??	HQ
4	Flood defence (Hochwasserabwehr)	560	600	??	HQ
13.08.2002	(Disaster alarm)		905 (868)	2,600	HQ260??

Source: LfULG

6.1.2 Human geographic features

The relevant administrative entities in the case study area are on the regional level the Direktionsbezirk Leipzig (one out of three in Saxony, seat in Leipzig) and on the district level the Landkreis Leipzig (seat in

Borna and Grimma south of Leipzig). On the local/community level the focus lies on the City of Wurzen and the Municipality of Bennewitz (Figure 6.3).



Source: Wikipedia ()

Figure 6.3: The Landkreis Leipzig (district, dark red) within the Direktionsbezirk Leipzig (light red) and their location in Saxony (left); location of the City of Wurzen (centre); location of the Municipality of Bennewitz (right)

The City of Wurzen includes apart from the inner city the former villages of Dehnitz, Nemt, Roitzsch, Kühren-Burkartshain with Birkenhof, Burkartshain, Kornhain, Kühren, Mühlbach, Nitzschka, Oelschütz, Pyrna, Sachsendorf, Streuben, Trebelshain and Wäldgen. The municipality of Wurzen is made up of the villages Bennewitz, Schmölen, Pausitz, Bach, Rothersdorf, Neuweißenborn, Deuben, Grubnitz, Nepperwitz, Al-tenbach, Leulitz and Zeititz.

Relevant population numbers are summarised in Table 6.3. As in many areas of (particularly Eastern) Germany, the population has significantly decreased since 1990 and is expected to do so in the future. However, developments still take place due to changing living demands and impulses from the nearby City of Leipzig.

Table 6.3: Population for the administrative entities of the case study area

Name of entity	Area (m2, on 31.12.2009)	30.06.2009
City of Wurzen	68,788,296	16,908
Municipality of Bennewitz	46,657,609	5,211
Landkreis Leipzig	1,647,079,554	270,756
Direktionsbezirk Leipzig	3,964,000,000	(321.12.2008) 998,298
Saxony	18,415,510,000	(31.08.2009) 4,173,000

Source: Statistisches Landesamt Sachsen

6.2 Background information

6.2.1 History of flood hazard and risk maps

After the catastrophic flood in 2002 along the Elbe River and its tributaries in Sachsen – among them the Mulde Rivers – the German Federal Government as well as the Government of the Free State of Saxony

launched a number of initiatives. On the federal level, the Working Group on water issues LAWA¹⁴ published guidelines for forward-looking flood protection already in 1995, and for flood hazard mapping in 2006. The latter are currently being updated and adapted to the requirements of the Flood s Directive (not public, personal communication with members of the LfULG).

Furthermore, in 2000 the Standing Conference of Federal and State Ministers Responsible for Spatial Planning MKRO¹⁵ published its recommendations for preventive flood protection measures. Apart from the general chapters on principles, etc., the document contains a number of practical recommendations for the handling of the following tasks in connection with regional planning:

- Protection and extension of flood plains,
- Retention of rain water in the area in which it occurs,
- Reduction of the potential dangers.

With this publication, the MKRO for the first time made concrete recommendations regarding the integration of the preventive flood protection measures in spatial planning maps. According to the MKRO, the instruments, objectives and priority zones as well as the principles and priority/reserved areas are to be applied in order to improve flood protection. These recommendations have since been taken on board by most Länder, for example in the amendment of their planning laws, and in their regional plans and state development plans.

After the flood of August 2002, the German federal government adopted a 5-point programme in which it laid down the main tools for effective preventive flood protection. Interstate action plans for the various river areas, cooperation in the field of preventive flood protection at European level, implementation of the European cooperation, assessment of the bank reinforcements and similar constructions and the environmental impact of inland navigation, as well as short-term measures for the protection against floods and improved coordination and crisis management are considered core measures of the programme. Other activities concern protective dykes, adaptation of land use in flood plains, the preservation of wet meadows and water retention capacities, renaturation of rivers and lakes and the improvement of the water retention and seepage capacity of the ground. This programme provides the framework for all measures that are the responsibility of the Länder and for the relevant transnational activities in this field. It also formed the basis of the Flood Control Act of 2005.

As flood protection is primarily the responsibility of the Länder, they have developed a number of strategies and concepts. After the flood of August 2002, the state government of Saxony decided to develop an overall concept for all 1st order water courses and for the Elbe River, which formed the basis of the subsequent reconstruction of the water management infrastructure and for the implementation of preventive flood protection measures. Between 2003 and 2005, a total of 47 flood protection concepts were developed under the auspices of the State Ministry for the Environment and Agriculture and adopted as the basis for future water management planning measures. They provide guidelines for the actions of public bodies and land use planning.

The State Dams Administration LTV assessed a total of about 1600 proposals for flood protection measures with regard to their priority and feasibility. The prioritisation was based on the criteria of expected damage, cost/benefit ratio, water management effects and vulnerability, which were all weighed equally. 268 measures were assigned high priority, while 780 were of medium and 548 of low priority. It is envisaged that 172 measures will be implemented or at least initiated all over Saxony by the end of 2008. The relevant flood protection concepts for the case study area is the "Hochwasserschutzkonzept Mulden im Direktionsbezirk Leipzig" with the hazard maps for the City of Wurzen Wurzen (with OL Wurzen and Dehnitz and the hazard maps for Bennewitz (with the OL Nepperwitz, Grubnitz, Deuben, Bennewitz, Schmölen, Pausitz, Bach and Rothersdorf).

¹⁴ German Working Group on Water Issues of the Federal States and the Federal Government represented by the Federal Environment Ministry (Bund/Länder-Arbeitsgemeinschaft Wasser – LAWA)

¹⁵ Ministers Conference for Spatial Planning (Ministerkonferenz für Raumordnung – MKRO)

6.2.2 Relevant legislation, strategies and programmes

The national flood protection law is a complex law affecting a wide range of different legal areas. Spatial planning as well as the protection of certain areas are of crucial importance for effective preventive flood protection. The concerns of flood protection and risk management are referred to in various pieces of legislation, e.g. nature and soil protection laws, legislation on agricultural land use and forestry, building law and water acts.

Federal Water Act (Wasserhaushaltsgesetz – WHG, 2010) and Act to Improve Preventive Flood Control (Gesetz zur Verbesserung des vorbeugenden Hochwasserschutzes, 2005)

Planning issues concerning water rights are regulated by the Federal Water Act (Wasserhaushaltsgesetz – WHG) and the State Water Acts (Landeswassergesetze) of the various federal states. The WHG used to be the federal framing law that together with the State Water Acts formed the core of German water-related legislation. After the reform of the federal organisation of the German States, when the framing legislation competencies of the Federal Government were abolished, it is still in force. However, the Federal Government now holds the concurrent legislation which means that the individual States may deviate from the federal regulations for water issues (except for pollutants and constructions)¹⁶. In its latest version from 1 March 2010, the WHG regulates the protection and use of surface and ground waters as well as prescriptions on training works and water management planning.

The benchmark of a protection against a 100-year flood (HQ100) is based on the flood protection plans according to article § 31d WHG and the plans drawn up in accordance with the Water Framework Directive (WFD), of which the main objective the protection of the water quality but which also make reference to flood protection measures.

With the Act to Improve Preventive Flood Control of 3 May 2005 (Gesetz zur Verbesserung des vorbeugenden Hochwasserschutzes, a so-called omnibus bill), the statutory regulations for flood protection in Germany were updated in many laws, including the Federal Water Act the Building Code (Baugesetzbuch – BauGB), the Federal Spatial Planning Act (Raumordnungsgesetz – ROG), the Federal Act on Waterways (Wasserstraßengesetz – WaStrG) and the Weather Services Act (Gesetz des Deutschen Wetterdienstes – DWDG).

Saxon Water Act (Sächsisches Wassergesetz – SächsWG, 2004)

The legislative appraisal of the flood event in 2002, the implementation of the European legal documents on state (Länder) level and administrative reforms resulted in an amendment of the Saxon Water Act (SächsWG).

The Saxon government regularly publishes legal ordinances – meaning laws/acts in the material sense. The Ordinance on Flood Information and Flood Warning regulates how water levels in flood-prone areas are measured, assessed and passed on. They aim at enabling early and effective protection measures, especially in private households.

The Ordinance on Flood Notification is based in § 10 of the former and is an administrative regulation by the Saxon Ministry of the Environment and Agriculture that specifies the requirements of the Ordinance on Flood Information and Flood Warning in Saxony (as of 2008). Updates in this ordinance include ... new and modernised gauge stations, avoidance of false alarms, and improvement of the notification service. Beforehand, the LHWZ carried out extensive research and also considered the experiences of several communities. Furthermore, some of the threshold values for declaring the individual alarm stages were adjusted. Finally, the information delivery pathways were adjusted to the new administrative situation after the district reform in August 2008.

¹⁶ The original aim was a common Environment Code which could not be agreed.

Spatial Planning Law

Flood protection is also an issue in the overall spatial planning, which consists of the spatial planning acts (Raumordnungsgesetz und Landesplanungsgesetze) and the communal development planning (Bauleitplanung). While the spatial planning (plans for an entire Land and their subordinate regional plans) is regulated in the Spatial Planning Act and the relevant acts at state level, the communal development planning is based on the Building Code.

The concerns of flood protection are integrated into spatial planning in the form of priority and reserve areas. The protection of specific areas is based primarily on the HQ100 floodplains and on areas that are flooded when the water reaches a design flood level of > HQ100 or in case of defence failures. Another legal instrument that only exists in Saxony is the designation of flood originating areas that are designed to help prevent floods by interfering in the areas in which they are generated.

6.2.3 Flood risk management in Saxony: Actors, tasks & responsibilities

The competencies of flood and water policy in Germany lie mostly with the individual German Federal States (Länder, see above) whereas the central government is entitled to frame the legislation. As a consequence, and given the different geographical circumstances, different levels of flood protection, different approaches to flood risk reduction and to flood hazard/risk mapping exist in each of the federal states.

In Saxony the Saxon State Ministry of the Environment and Agriculture is the supreme water authority. Subordinate official authorities supporting the state ministry in its work are the State Office for the Environment, Agriculture and Geology (Landesamt für Umwelt, Landwirtschaft und Geologie – LfULG) and its (subordinated,) government-owned enterprise, the State Dam Administration of the Free State of Saxony (Landestalsperrenverwaltung – LTV). These act as the upper water authorities (and provide a “flood information service”, also available for civil person via internet or phone). The lower water authority in the case study area is the State directorate Leipzig (Landesdirektion Leipzig – LDL) that is responsible for the administrative district of Leipzig (Landkreis Leipzig – LKL based in Grimma, bordered by the Landkreis Nordsachsen in the North with the City of Eilenburg).

The most relevant actors concerned with flood maps are:

- Government of the Free State of Saxony (Ministries)
- The State Office for the Environment, Agriculture and Geology
- The Saxon Flood Centre
- The State Dam Administration of the Free State of Saxony
- The State Directorate Leipzig
- The District of Leipzig Land
- The local/community level – City of Wurzen and the Municipality of Bennewitz

The State Office for the Environment, Agriculture and Geology

The State Office for the Environment, Agriculture and Geology (in German Landesamt für Umwelt, Landwirtschaft und Geologie – LfULG) is a direct subordinate agency of the Saxon State Ministry of the Environment and Agriculture. It is divided into 10 divisions that deal e.g. with monitoring, documentation and reporting of the environment, implementation of environmental legislation, policy advice, support of agricultural and environmental measures, protection and development of the cultural landscape and rural areas, geologic and pedologic surveys, applied research, trainings, quality control, etc.

From the Division 4 – Water, Soil and Resources – two departments are relevant for surface, ground and flood waters. The Department 44 – Surface and ground water – deals with the implementation of the Water Framework Directive, water quality, ground water management, supervision, measurements and laboratory analyses. The most relevant is the Department 45 – Saxon Flood Centre (Landeshochwasserzentrum – LHWZ) and hydrology. It is responsible for flood information, measurement nets, development of methods and strategies for flood protection measures in Saxony as well as the coordination and control of State programmes, quantitative hydrology, water resource planning, implementation of the Floods Directive, river training, etc.

The Saxon Flood Centre

The flood information & alert service in the Free State of Saxony is headed by the Saxon Flood Centre (Landeshochwasserzentrum – LHWZ) based in the Saxon State Agency for Environment and Geology. The Saxon Flood Centre is responsible for flood information and early warning for all main rivers in Saxony. It provides relevant flood information directly to each authority with flood defence responsibilities as well as to any third parties (private persons) with particular risk of flooding.

The following information products are automatically delivered to the recipients when defined alarm stages (flood level thresholds) are reached:

- Flood levels,
- Flood warnings / all-clear messages and
- Flood flash messages via SMS.

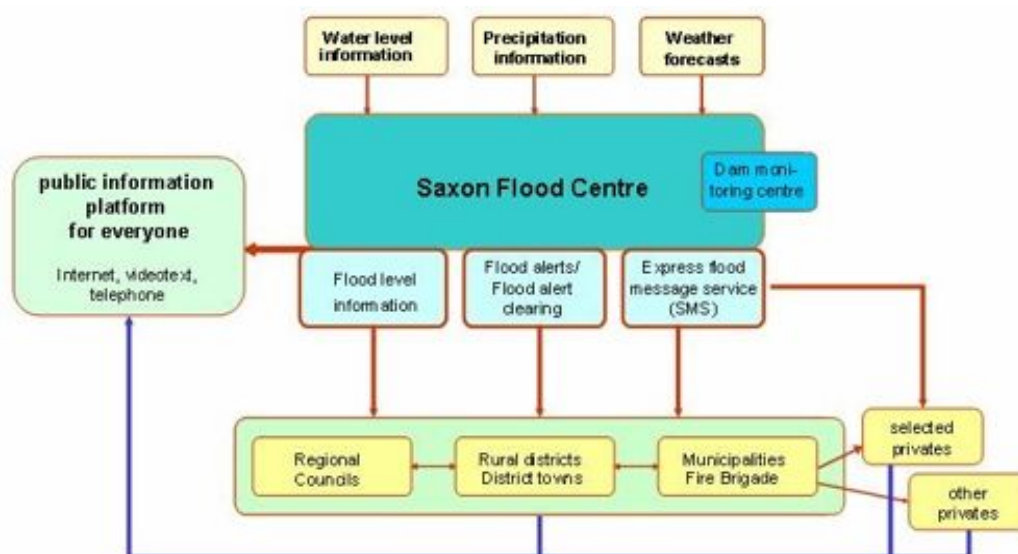
The following input data are being received regularly:

- Up-to-date readings of more than 100 flood level gauges
- Precipitation and thaw forecasts of the German Meteorological Service (DWD)
- Flows and water levels of reservoirs provided by the State Dam Monitoring Centre
- Relevant hydrological and meteorological data for the Upper Elbe River and its tributaries in the Czech Republic are provided by the Czech Hydro-Meteorological Institute.

The whole flood information system contains:

- An automatic flood level and precipitation data recall unit
- An information management system (database)
- Forecasting models for the Upper Elbe, Schwarze Elster, Mulde, Weiße Elster, Spree and Lausitzer Neiße Rivers

The organisation of the flood information and alarm service is shown in Figure 6.4.



Source: LfULG (<http://www.umwelt.sachsen.de/umwelt/wasser/en/index.html>)

Figure 6.4: The reporting and information chain for flood related messages in Saxony

The State Dam Administration of the Free State of Saxony

The State Dam Administration of the Free State of Saxony (Staatsbetrieb Landestalsperrenverwaltung – LTV) is in charge of nearly all dams owned by the Free State of Saxony and thus for the provision of water for the population, industry and agriculture. Of the same importance is the training, maintenance and flood protection along all major (1st order) rivers that lie in responsibility of the state. These tasks are fixed in the Saxon Water Act.

Immediately after the flood in August 2002, the LTV began to fix the damages on river banks, dams and other structures to be maintained. In parallel, the 47 HWSKs were established that are currently being implemented (see above). The LTV also gives advice to involved authorities.

Five „Betriebe“ across Saxony are responsible for the implementation of the LTV tasks, who in turn are in charge of „Fluss- und Staumeistereien“ on the local level. The latter supervise various water-related infrastructures, 1st order water courses and flood protection structures. The responsible Betrieb for the Vereinigte Mulde is the „Betrieb Elbaue / Mulde / Untere Weiße Elster“, based in Rötha south of Leipzig. The respective Flussmeisterei is the one in Grimma/Trebsen.

The State Directorate Leipzig

The State Directorate Leipzig is a regional authority in Saxony. Its main tasks in the environmental sector are expert advice and control on operational flood protection, control of the water brigades, accompanying the development of flood protection concepts for 2nd order water courses (in the responsibility of the communities), plan approval procedure, fire brigades, emergency management, etc.

Table 6.4: Categorisation of stakeholders according to scale and role

Scale	Legal bases	Executive					Lobby groups, public, media
		Government	Administration				
			State administration		Communal autonomous administration		
			direct	indirect	Entities	(Cooperations)	
EU	FD, WFD, SEA-D	DG Environment	EEA				
Federal level	Water Act, Flood Protection Act, Spatial Planning Act	BMU BMI	UBA Federal Armed Forces (Bundeswehr – BW), Technical Relief Agency (THW)				German farmers association
Länder level	Saxon Water Act, State Planning Act	SMUL SMI	LfULG (LHWZ) (State Directorate Leipzig), subcontracted planning offices	LTV -			State farmers association
Regional level	Ordinances		State Directorate Leipzig (BW / THW)	Branch Elbaue / Mulde		Regional Planning Association Western Saxony, Aktionsraum Regional Management Western Saxony, Landscape Care Association Muldenland	Regional farmers association, Nature protection associations
District level	Ordinances, etc.		(BW / THW)	Fluss-meisterei Grimma	District Landkreis Leipzig	(Special-purpose association)	?
Local level	?				Wurzen, Bennewitz	(fire brigades)	?
(borough)					Boroughs		?

Orange: policy makers

Yellow: producers

Blue: users

Green: both producers/advisors and users

Means of support (implementation process, guidelines, etc.)

LAWA (flood hazard guidelines of the German Working Group of the Federal States on the Water Issues)

EXCIMAP (handbook on good practices for flood mapping in Europe)

6.3 Current flood mapping practices (map types and their defined target groups)

The existing types of hazard maps, damage potential maps and/or risk maps can be divided into two groups – the official and publically available maps for almost all 1st order water bodies on the one hand and maps and software produced within the frame of pilot studies or research projects. A question that needs to be answered is whether there are specialised hazard and risk maps for defined groups of readers, e.g. citizens, disaster managers and why they might be produced for these different target groups.

6.3.1 Saxony-wide map types

A number of Saxony-wide maps related to flooding are more or less publically available in different formats, summarising major results of the Flood Protection Concepts. These are:

- Within in Flood Protection Concepts (HWSKs)
- Flooded areas for one or more selected historic floods
- Flooded areas in case of a (minimum) 100-year flood (Intensity map HQ100)
- Flood hazard maps for residential areas (Hazard map)
- Within the Atlas of Flood Hazards in Saxony (Flood hazard indication map Saxony) derived from the maps in the Flood Protection Concepts

Flood inundation map

Damage potential maps

- Legally binding flood-prone areas (according to the Saxon Water Act)
- Priority and reserved areas for flood protection (according to the Regional Planning Act)

Except for the last one they are also – or mainly – available on the web pages of the State Office for the Environment, Agriculture and Geology (LfULG, “information platform flood protection: <http://www.umwelt.sachsen.de/umwelt/wasser/2339.htm>). In addition, also detailed local reports on hydrologic characteristics, proposed measures and their state of realisation can be downloaded there. At present almost all information on river sections covered by the flood protection concepts are included.

As explained by staff members of the Saxon Flood Centre, these maps were originally not (primarily) intended for operational disaster management.

Flooded areas for one or more selected historic floods (mostly 2002)

As a result of the documentation of all flooded areas in Saxony in August 2002 (mainly along the water bodies of the catchments of the Weiße Elster, Vereinigte Mulde, Zwickauer Mulde, Freiburger Mulde, Elbe and Schwarze Elster Rivers – 220 watercourses in total). The length of affected water bodies summed up to 2,800 kilometres, the flooded area to 40,000 ha of which 20% were residential and traffic areas.

This survey was carried out using satellite images, aerial photographs, ground verification and GIS-tools and served as a basis for the development of the Flood Protection Concepts. The different data sets were created, specified and checked for plausibility and finally put together in the LfULG (last updated 11/2007).

The mapping scale for the digitalisation of the flooded areas for the peak water levels is usually 1:10,000 based on the Topographic Map 1:10,000 (TK 10). For plausibility checks and in some densely built-up areas larger scales were used (e.g. 1:5,000).

Map layers include: Inundated areas, district boundaries, municipal boundaries, background map 1:100.000, vegetation (only with topographic background map)

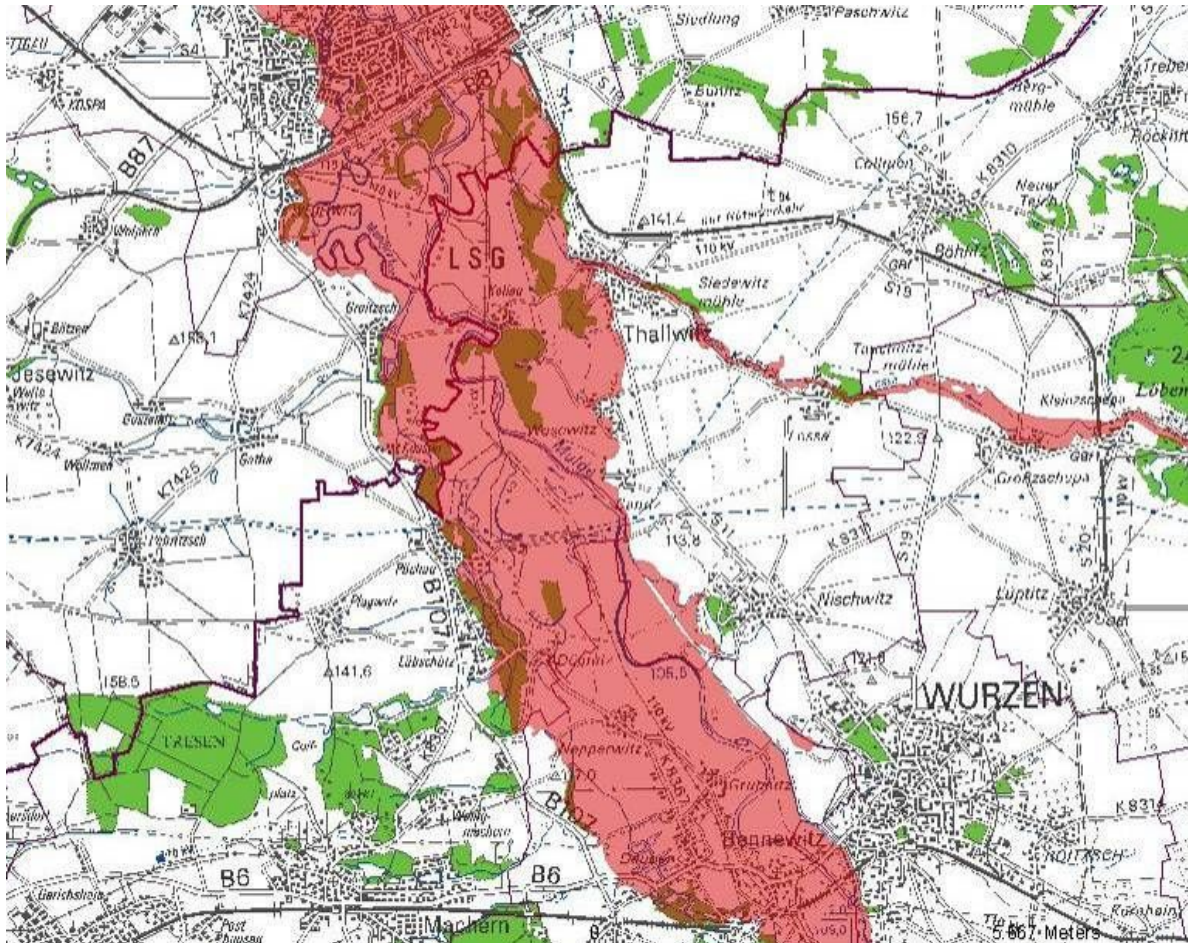


Figure 6.5: Example of the map showing the flooded areas in August 2002 for the area of Wurzen/Bennewitz

Source: LfULG (<http://www.umwelt.sachsen.de/umwelt/wasser/2339.htm>)

Flooded areas in case of a (minimum) 100-year flood (Intensity map HQ100)

For the planning of flood protection measures the flood event with a statistical return period of 100 years (HQ100) is particularly important. The protection level of most settlements, infrastructures and industrial areas is fixed to such an event.

The map shows the potentially flooded areas for a HQ100-event along 1st order water courses and the Elbe (see Section 6.2.3 for further explanation). The water depths are indicated by colour grading. This map is included in the Saxon Flood Protection Concepts as the "Intensity map for the current state".

Water levels and flood extents were modelled using 1d and 2d hydraulic models. The mapping scale is 1:10,000.

Map layers include: River axis, district boundaries, background map 1:100.000, vegetation (only with topographic background map), water depths HQ100, flood extent HQextreme

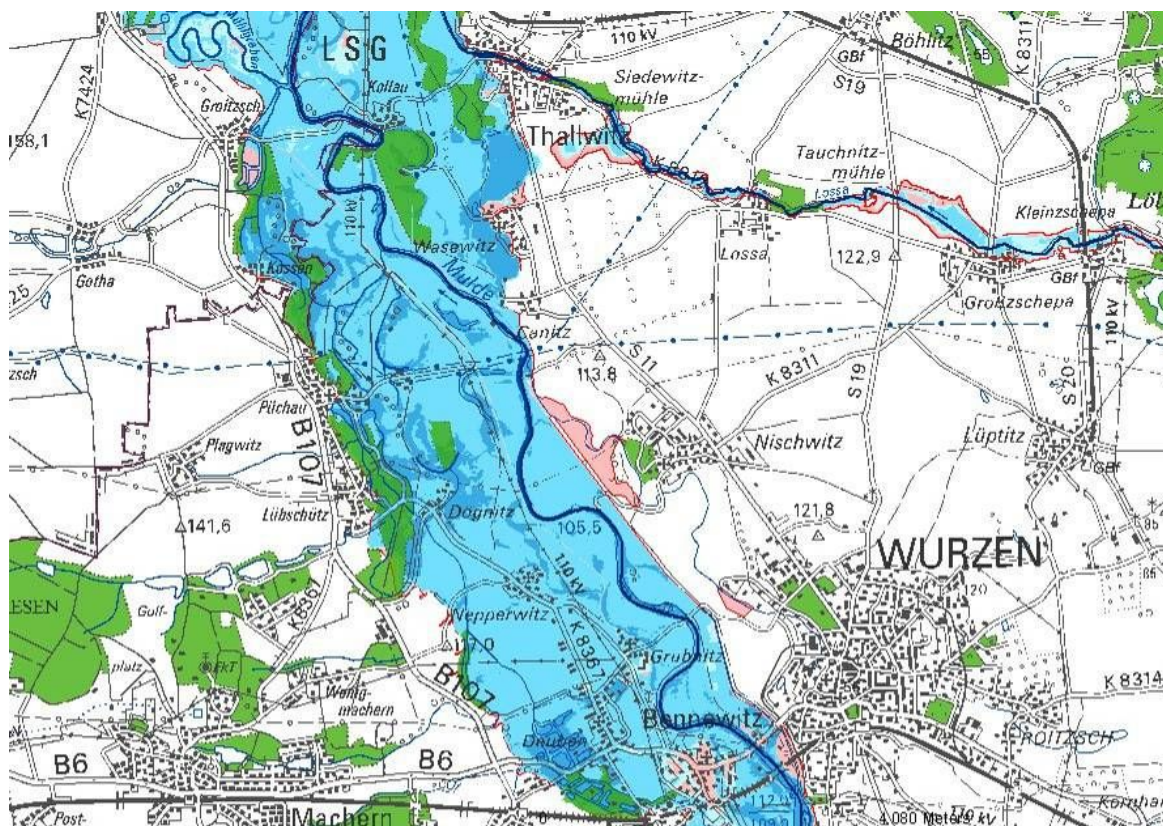


Figure 6.6: Example of the Intensity map HQ100 for the area of Wurzen/Bennewitz

Source: LfULG (<http://www.umwelt.sachsen.de/umwelt/wasser/2339.htm>)

Flood hazard maps for residential areas (Hazard map)

For 1st order water courses and the Elbe within the boundaries of continuously built-up areas, more detailed maps have been produced using a mapping scale of 1:5,000. The return periods shown in these maps may vary according to the local circumstances and requirements - HQ5/10/20/25/50/100/200/300 as well as an HQ-extreme. The hazard is determined by the occurring water depth, where applicable by the flow velocity and by the return period. Often also backwater effects due to debris blocking occur. The specific local situation is further elaborated in a report for the respective municipality or city. The high degree of detail allows for the use of these maps in (urban) land-use/development planning and operational disaster management.

Map layers include: Boundaries of the mapped areas, chainage, river axis, district boundaries, background map 1:50,000, vegetation (only with topographic background map), flooded areas for HQ5/10/20/25, HQ50, HQ100, HQ200/300 and HQextreme. The target groups for these kind of maps include municipalities, administrative districts, people at risk, companies/industries, the media, etc., aiming at improving public awareness, emergency management and urban planning.

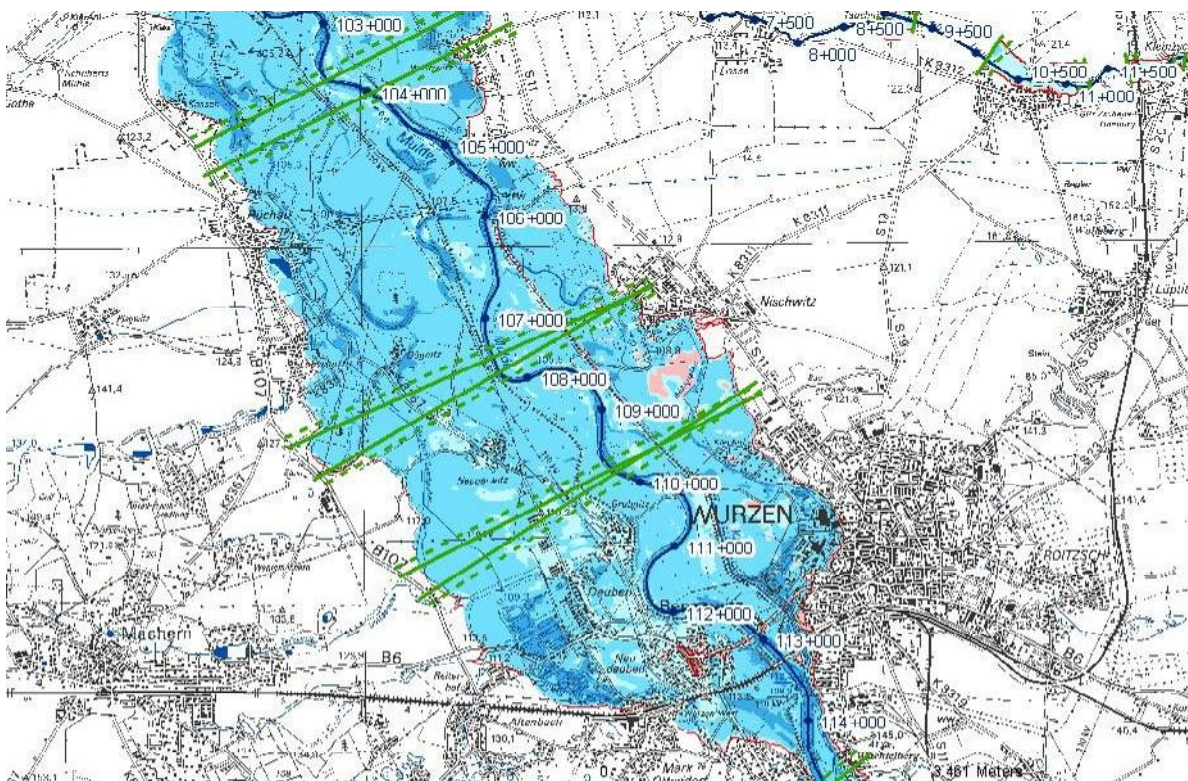


Figure 6.7: Example of the flood hazard maps for residential areas for the area of Wurzen/Bennewitz.

Source: LfULG (<http://www.umwelt.sachsen.de/umwelt/wasser/2339.htm>)

Flood inundation map (Atlas of Flood Hazards in Saxony)

The Atlas of Flood Hazards in Saxony – also called Hazard Indication Map Saxony – was produced as a map basis for spatial planning (agencies) and superordinate disaster management agencies and shows hazard in case of an extreme flood event (return period > 100 years). The possible failure of defences (e.g. dike breaches) is also considered. The flood hazard and the damage potential as well as endangered and dangerous objects in flood-prone areas along 1st order water courses and the Elbe River are shown in two separate maps. They were derived from the more detailed maps of the afore mentioned Flood Protection Concepts but with a mapping scale is 1:100,000.

The flood inundation map indicates – apart from the flooded areas – also the intensity by means of water depths and specific discharges for an HQ100-event and an extreme event. In the case of the Vereinigte Mulde River, the extreme event is defined as the HQ300 one.

Map layers include: background map 1:100,000, vegetation (only with topographic background map), flooded areas for HQ20, HQ100 and HQextreme, boundaries of the flooded areas, water depths for HQextreme, some critical infrastructure.

The target audience includes (long-term) regional planning authorities and emergency management agencies as well as the planning of protection measures.

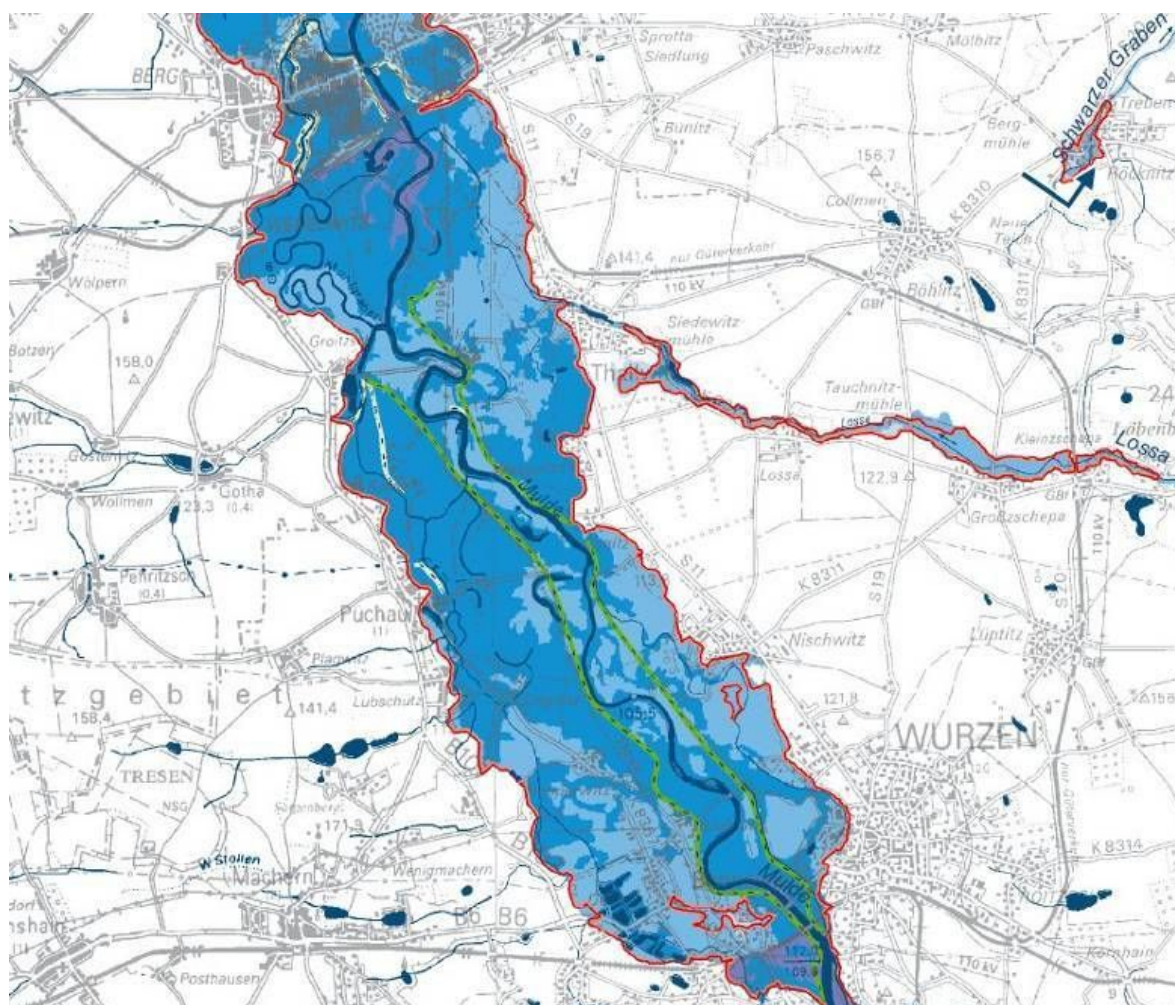


Figure 6.8: Example of the flood inundation map as part of the Atlas of Flood Hazards in Saxony for the area of Wurzen/Bennechwitz.

Source: LfULG (<http://www.umwelt.sachsen.de/umwelt/wasser/2339.htm>)

Damage potential maps (Atlas of Flood Hazards in Saxony)

The second map of the Atlas of Flood Hazards in Saxony is the damage potential map that in its extent always directly corresponds to the flood inundation map. It shows the expected damage in EUR/m² in case of an extreme flood event within the boundaries of the inundated area that corresponds to such an event. It needs to be pointed out that this map shows only the damage potential – and selected critical objects at risk or that may cause additional dangers - for a single extreme event, not the risk derived from a number of events (risk curve) that would be expressed e.g. as expected annual damage.

Map layers include: background map 1:100,000, vegetation (only with topographic background map), flooded areas for HQ20, HQ100 and HQextreme, boundaries of the flooded areas, damage potential for HQextreme, some critical infrastructure.

The target audience includes (long-term) regional planning authorities and emergency management agencies as well as the planning of protection measures.

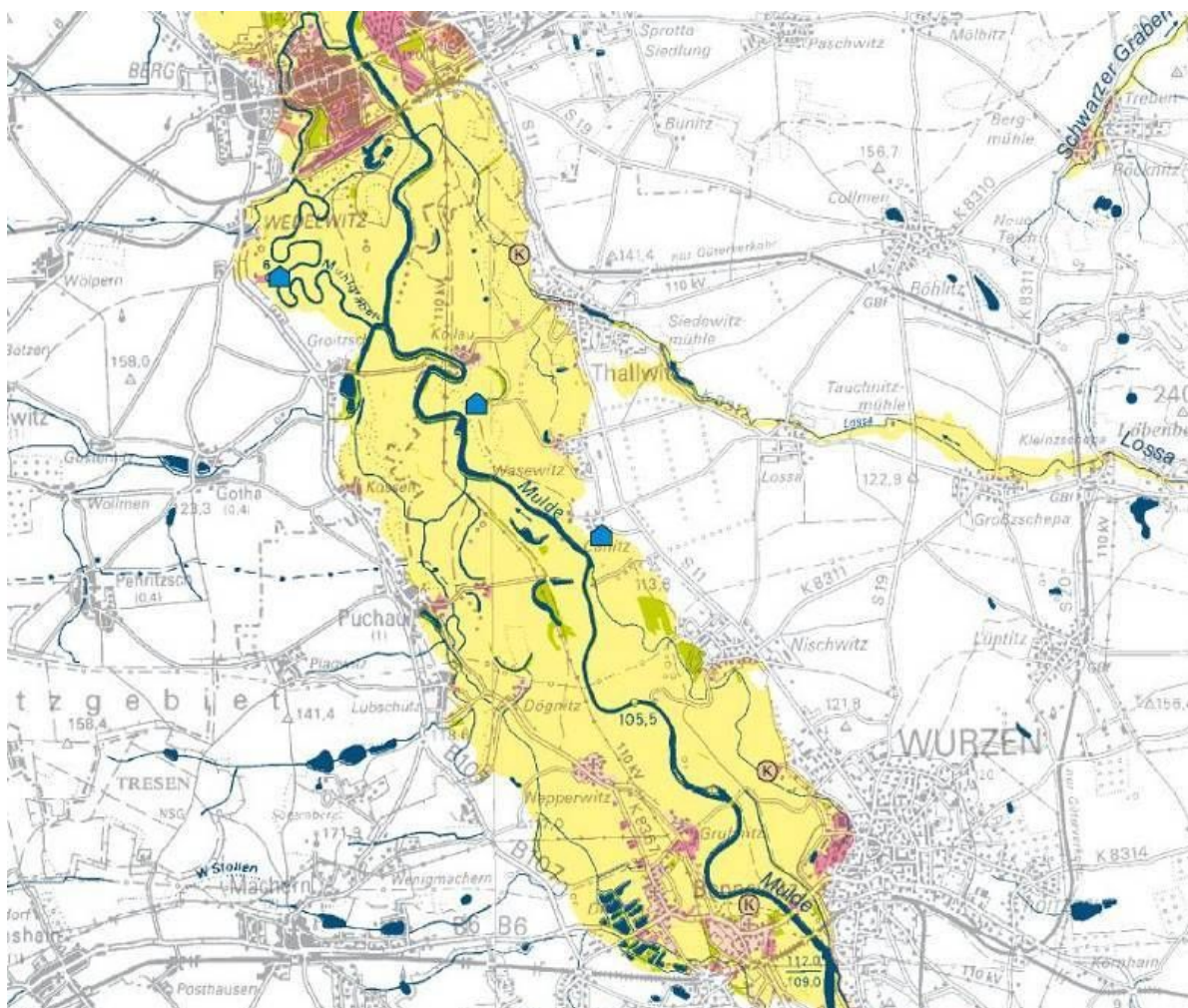


Figure 6.9: Example of the damage potential map as part of the Atlas of Flood Hazards in Saxony for the area of Wurzen/Bennewitz.

Source: LfULG (<http://www.umwelt.sachsen.de/umwelt/wasser/2339.htm>)

Legally binding flood-prone areas (according to the Saxon Water Act)

These areas are determined qua legal ordinance by the water authority in charge of the respective area. In a legally binding flood-prone area (Saxon Water Act – SächsWG) certain constraints apply that are supposed to avoid the increase of the flood hazard (e.g. due to building activities). All areas that are exposed to flooding at least once in 100 years automatically fall into this category. The maps must be made available in paper format in the (water) authorities. The mapping scale is 1:25,000.

Map layers include: keys of the individual flood-prone areas, reservoirs and flood polders, the inundated area, district boundaries, background map 1:100.000, vegetation (only with topographic background map).

These maps are the legal basis for (urban) land-use planning (Bauleitplanung) and other activities.

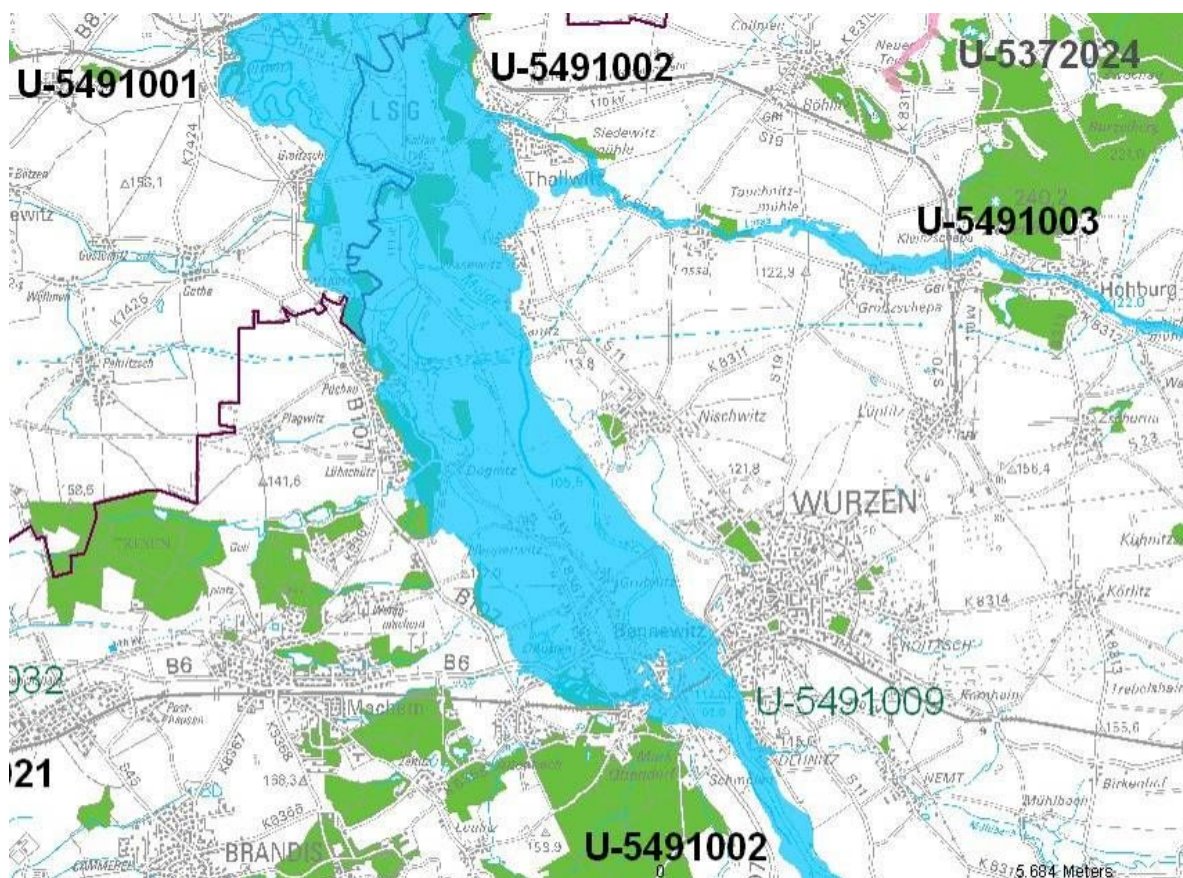


Figure 6.10: Example of the map showing Legally binding flood-prone areas (according to the Saxon Water Act) for the area of Wurzen/Bennewitz.

Source: LfULG (<http://www.umwelt.sachsen.de/umwelt/wasser/2339.htm>)

Priority and reserved areas for flood protection (according to the Regional Planning Act)

The so-called priority areas for flood protection are areas that are exposed to flooding (on average) once in 100 years or even more frequently. Also, former floodplain areas that are to be restored fall in this category. No new dikes (except for flood polders), residential and industrial development or blocking infrastructure is allowed, cropland should be replaced by grassland. If infrastructural assets need to be placed there, compensation areas are required. Priority areas correspond widely to the legally binding flood-prone areas.

Reserved areas for flood protection are those areas that are inundated in case of an extreme flood event or in case of defence failure, e.g. a dike breach. All populated areas exposed to < HQ100 also belong to this category. No new developments should be allocated there, and abandoned structures should not be replaced or restored. These “reserved areas” are usually based on the Atlas of Flood Hazards in Saxony.

Both area categories are shown in one map that is part of the Regional Plan Western Saxony (Figure 6.11).

The target audience includes (long-term) regional planning authorities and emergency management agencies as well as the planning of protection measures.

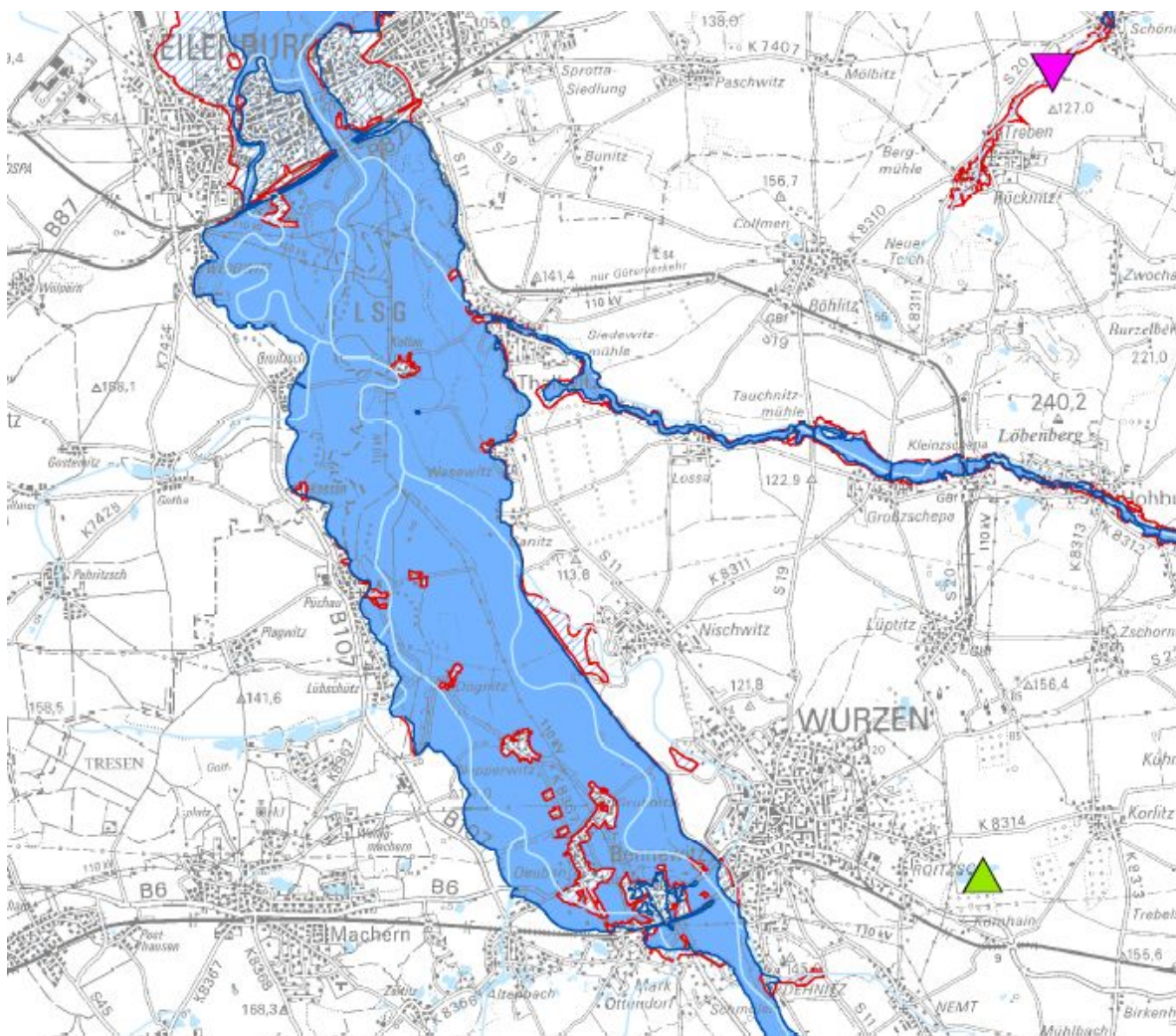


Figure 6.11: Example of priority and reserved areas for flood protection (according to the Regional Planning Act) for the area of Wurzen/Bennewitz.

Source: Regionalplan Sachsen (published by the Regional Planning Association Western Saxony, <http://www.rpv-vestsachsen.de>)

6.3.2 Maps in pilot sites, research projects, etc.

So far, true “risk maps” are only available within the frame of experimental studies, pilot sites and governmental or independent research projects (rather on a regional and local level). These are mainly conducted by the LfULG in cooperation with other national and international agencies and/or by research institutes and universities.

Maps from projects and pilot studies mainly conducted by the Saxon administration

A major step forward in flood risk mapping in Saxony was achieved by the INTERREG IIB project ELLA – ELBE-LABE Preventive flood management measures by spatial planning for the Elbe river basin. Under the lead of the Saxon State Ministry of the Interior 23 authorities from Germany, Czech Republic, Poland, Austria and Hungary cooperated to develop a joint action programme for spatial planning in the Elbe River basin. The approaches were implemented in nine pilot projects. The proposed actions are accompanied

by diagrams and maps (Hazard information maps/Elbe Atlas) indicating where the proposed measures are to be taken.

In order to carry out municipal flood protection more effectively, the pilot study “Preparation of municipal flood information maps” was carried out for the cities of Glauchau, Meißen, Radebeul and Torgau. Here, the municipal flood information maps and hazard zone maps were based on the existing hazard maps of the water management authorities. In future, these will serve as an additional basis in the organisation of flood defences, the planning of correspondingly adapted buildings and the approval of types of land use in potential flooding areas.

In the municipal flood information map, at a scale of 1:5,000, the flooding areas for different flood events are shown. The presentation of additional information from the fields of emergency services, technical infrastructure, the economy and cultural and social institutions, which were determined and mapped in cooperation with the local authorities, are shown by symbols and outlined images. The locations of fire brigade, police, emergency accommodation, medical installations or nurseries and schools are important places during a flood and should be protected. Information about possible evacuation routes should be given here as well. In cases of flooding, attention should also be given to industrial sites and technical services such as electricity, water and waste water.

In contrast to the municipal flood information map, the municipal hazard zone map, also with a scale of 1:5,000, is only based on flooding information. It explicitly shows an existing flooding danger and contains no additional municipal information. The danger level is shown using different hazard zones which are determined by superimposing the intensity and the frequency of a flood event (hazard level diagram). In consultation with the municipal administration, action recommendations are made for the different hazard zones principally with regard to spatial planning and for flood defence support.



Figure 6.12: Examples of a municipal flood information map (left) and a municipal hazard zone map (right) for an area in the City of Glauchau.

Source: LfULG (http://www.umwelt.sachsen.de/de/wu/umwelt/lfug/lfug-internet/documents/Flyer_KIK.pdf)

As part of the ELLA project, hazard maps were drawn up for various sections of the river, reflecting different tasks and contents. In pilot projects, these maps were then integrated into the spatial planning. The following maps were produced:

- Hazard information maps (Elbe Atlas)
- Potential Damage maps (Elbe Atlas)
- Regional flood hazard maps (Stendal pilot project)
- Communal flood information maps / hazard zone maps (e.g. Glauchau, Meissen, etc.)

The Elbe Atlas contains the hazard information and the potential damage maps for a large section of the Elbe River and many of its tributaries on a scale of 1:100,000. These maps are an important contribution to the implementation of the EU Directive on the assessment and management of floods.

In the future, the focus of spatial planning and communal planning will be the complete integration of the danger and hazard information into the spatial and the land use plans, with consequent control of the use of zones that are at risk of flooding. In the decision-making process, the flood hazard data must be properly weighed.

For planning purposes, three hazard zones were identified:

1. Floods with a low probability (extreme floods HQextreme)

In order to increase the awareness of the public, the areas affected only by extreme floods (HQextreme) should be identified for all main rivers, irrespective of the actual location, i.e. also in mountain regions. The HQextreme should correspond to an extremely rare event (minimum HQ300 or 1.5 x HQ100). In the Czech Republic, the highest ever recorded water level is used as HQextreme.

2. Floods with a medium probability (100-year flood HQ100 with / without protective installations)

HQ100 areas are normally mapped taking into account the existing protective structures. In order to create awareness of the effect of protective structures, the areas at risk of flooding in the event of a HQ100 if there were no protective structures should also be indicated. For water management planning and building development planning, the identification of areas based on HQ100 with protective structures is already mandatory. In the Czech Republic, there is currently no statutory obligation to identify and map these areas.

3. Floods with a high probability (20-year to 5-year flood HQ20 / HQ10 / HQ5)

Even frequently occurring floods such as HQ20 to HQ5 events still have a considerable potential for damage (see Elbe flood in spring 2006). We recommend identifying the areas concerned of flooding in settlements in Germany along the Elbe river and its class I and class II tributaries (or on "significant" and "small" rivers in the Czech Republic respectively), as they are important for communities for appropriate land use decisions. For HQ20 and similar flood events, areas that are affected by flooding under specific conditions are to be identified at particularly critical locations (e.g. in the event of blockage of a drain channel).

Omissions and methodological differences in the hazard and damage potential maps that were identified during the first compilation phase of the Elbe Atlas (2004-2006) are to be eliminated successively. The extension of the atlas area to the Elbe estuary and additional tributaries is recommended. The danger data, maps and information are published in the form of an atlas and as database records on an interactive web platform that is accessible to the public as well as the planning authorities. Any gaps still existing are to be closed in the future.

For the INTERREG IVB project LABEL, running from 09/2008-02/2012, 20 project partners from Germany, the Czech Republic, Austria and Hungary joined together to address the ever present challenges related to flooding in the Elbe River catchment. Thus, the transnational cooperation between upstream and downstream areas will be strengthened and common methodologies and strategies will be developed.

One of several pilot projects is the exemplary development of a flood risk management plan (as required by the EU Floods Directive) for the Weiße Elster River, a tributary of the Saale River that in turn is a major tributary to the Elbe River. Its course starts off in the Czech Republic and crosses several times the borders of the German federal states (Länder) of Saxony, Thuringia and Saxony-Anhalt.

So far, no comprehensive results are available as the project has only started at the end of 2008.



Figure 6.13: Part of a flood hazard map for the City of Plauen (Saxony, Germany) on the upper Weiße Elster River according to the Saxon conception within LABEL (left) and the same river in Plauen (right).

Source: LABEL project (http://www.label-eu.eu/uploads/media/EN_LABELJournal_1_02.pdf)

In addition, the Schwarze Elster River, a right tributary to the Elbe River in Saxony-Anhalt originating in Saxony, has been chosen as another pilot site to develop a flood risk management plan, including risk maps. This study has recently been launched and is entirely conducted by the LfULG (personal communication).

Other research projects

At the Helmholtz Centre for Environmental Research – UFZ, multicriteria risk maps were produced for the Mulde area within the frame of the EU-funded research project FLOODsite¹⁷ (Meyer et al. 2009, cf. Figure 6.14). Therefore, a GIS-data base of economic, social and environmental risk criteria was created, using a meso-scale approach for the ex-ante evaluation of economic damages, but also social and environmental consequences, like people affected, affected social hot-spots, affected biotopes. In contrast to the official damage potential map (cf. Fig. 6.9) damages were not only calculated for one specific event but for a range of flood events with different recurrence interval. Based on this the annual average damage or consequence was calculated for each risk criteria applying the definition of risk = probability * damage expressed by the following equation

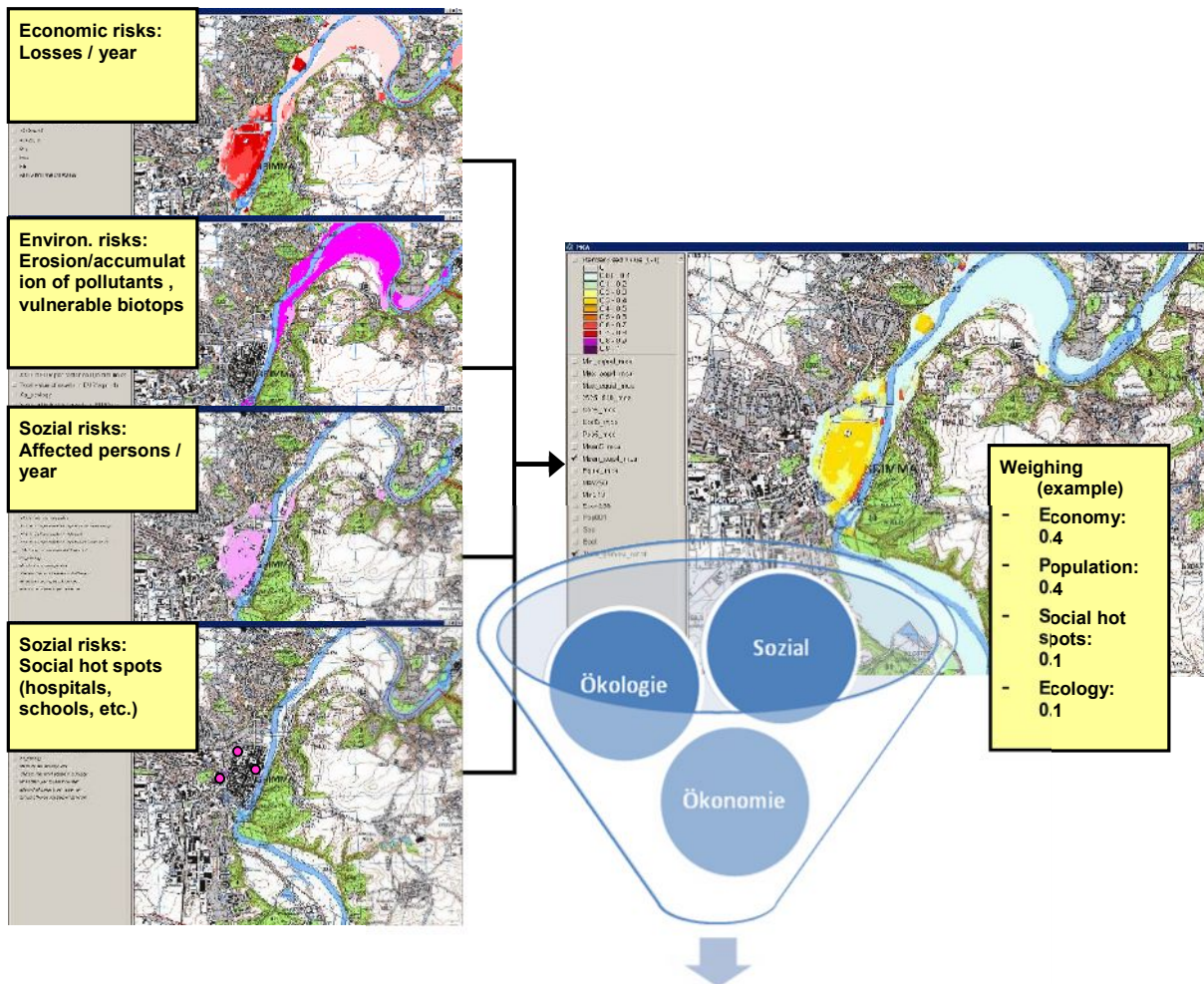
$$\bar{D} = \sum_{i=1}^k D[i] * \Delta P_i \quad (2)$$

$$D[i] = \frac{D(P_{i-1}) + D(P_i)}{2} \quad (3)$$

$\bar{D}$ is the annual average damage with $D[i]$ = mean damage of two known points of the curve and $\Delta P_i = |P_i - P_{i-1}|$ = probability of the interval between those points.

By means of multicriteria approaches these single risk maps can be aggregated to a single integrated risk (cf. Fig. 6.14). This requires a participative approach, allowing decision makers to express their relative preferences for the different risk criteria by assigning weights to them.

¹⁷ FLOODsite: Integrated Flood Risk Analysis and Management Methodologies (<http://www.floodsite.net>)



Source: Meyer, Haase & Scheuer (2009)

Figure 6.14: Integrated assessment of economic, ecological and social risks (FLOODsite)

Also GFZ in Potsdam carried out different flood hazard and damage modelling approaches in the Mulde region (especially city of Eilenburg) and compared the results of the different models (Apel et al. 2009).

6.3.3 Software using and/or producing flood maps

Furthermore, at least two software applications used by public authorities can make use of existing (digital) flood-related maps or may even include or produce them. The programme system INGE which is primarily designed for the local level and the decision support system DISMA which is rather designed for the district and regional level.

INGE¹⁸ Tool: Interactive hazard maps for municipal flood protection

In the framework of the ELLA project, the programme system "INGE" was developed. INGE is an information software (GIS) for the visualisation of the municipal alarm plans and for the determination of threatened objects in dependence of actual or expected water levels (Figure 6.15). This software can be

¹⁸Interaktive GEfahrenkarte für den kommunalen Hochwasserschutz

purchased¹⁹ and used by public agencies (mostly cities and municipalities) that are involved in flood protection. Due to the very general and open data concept numerous interests can be presented by different kinds of data.

The tools of INGE allow content-related combinations, which will facilitate and accelerate the execution of the tasks of emergency protection as well in case of flood disasters as during the phases of planning, post-processing, and training. Different types of data (such as alphanumeric data, digital photographs, documents, GIS- and CAD-files, etc.) may be flexibly integrated.

INGE uses information contained in the HWSKs and in the hazard indication maps and – where applicable – also the more innovative maps produced within ELLA (see Section 6.3.2 Maps in pilot sites, research projects, etc.).

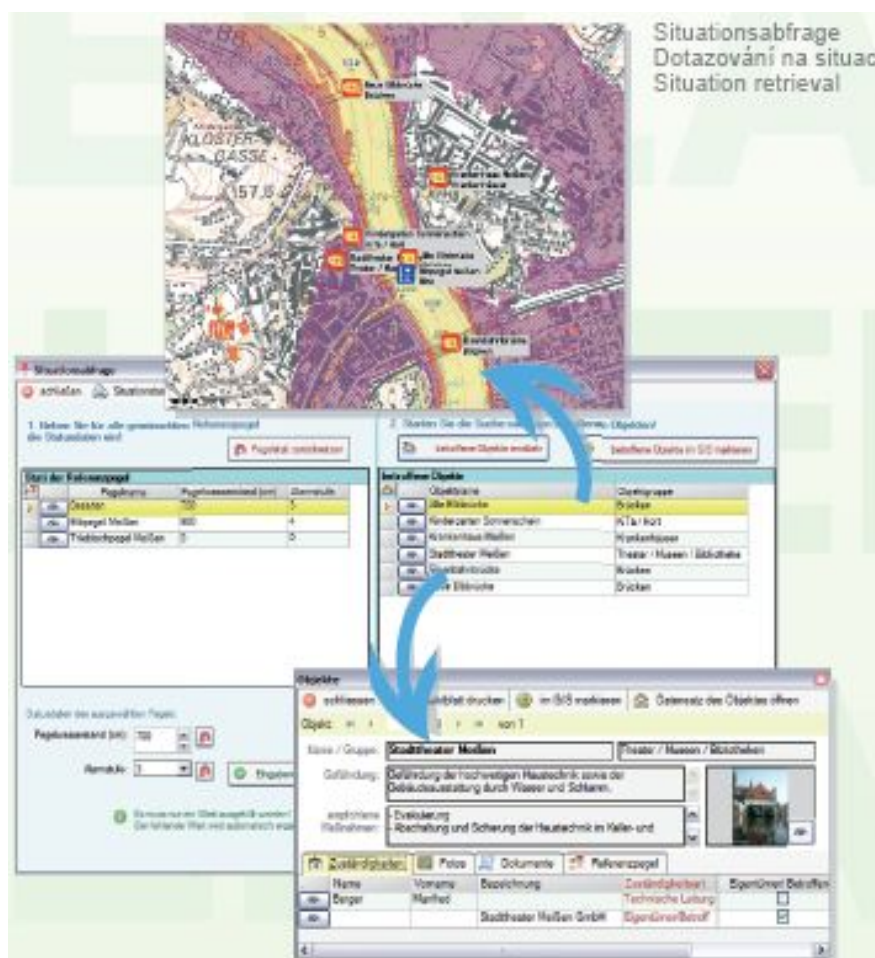


Figure 6.15: A screen shot from the INGE information software

Source: LfULG (http://www.umwelt.sachsen.de/de/wu/umwelt/lfug/lfug-internet/documents/Flyer_INGE.pdf)

DISMA – DISaster-MAnagement-System

The DISMA toolbox was developed by the TÜV²⁰ Berlin/Brandenburg by order of the Federal Office of Civil Protection and Disaster Assistance (BBK). It is a decision support system for the design of disaster

¹⁹ At present for 120 €

²⁰ Stands for Technischer Überwachungs-Verein (Technical Surveyance Association)

management plans and external emergency plans. Originally, it had its focus on calculating the spread of pollutants in different agents. It does not contain or deliver maps by itself and it is not flood hazard-specific. However, flood maps can be integrated into DISMA, adding valuable information when creating plans as mentioned above. It is mainly used by agencies on the regional level (e.g. districts and larger cities, regional fire brigades, etc.).

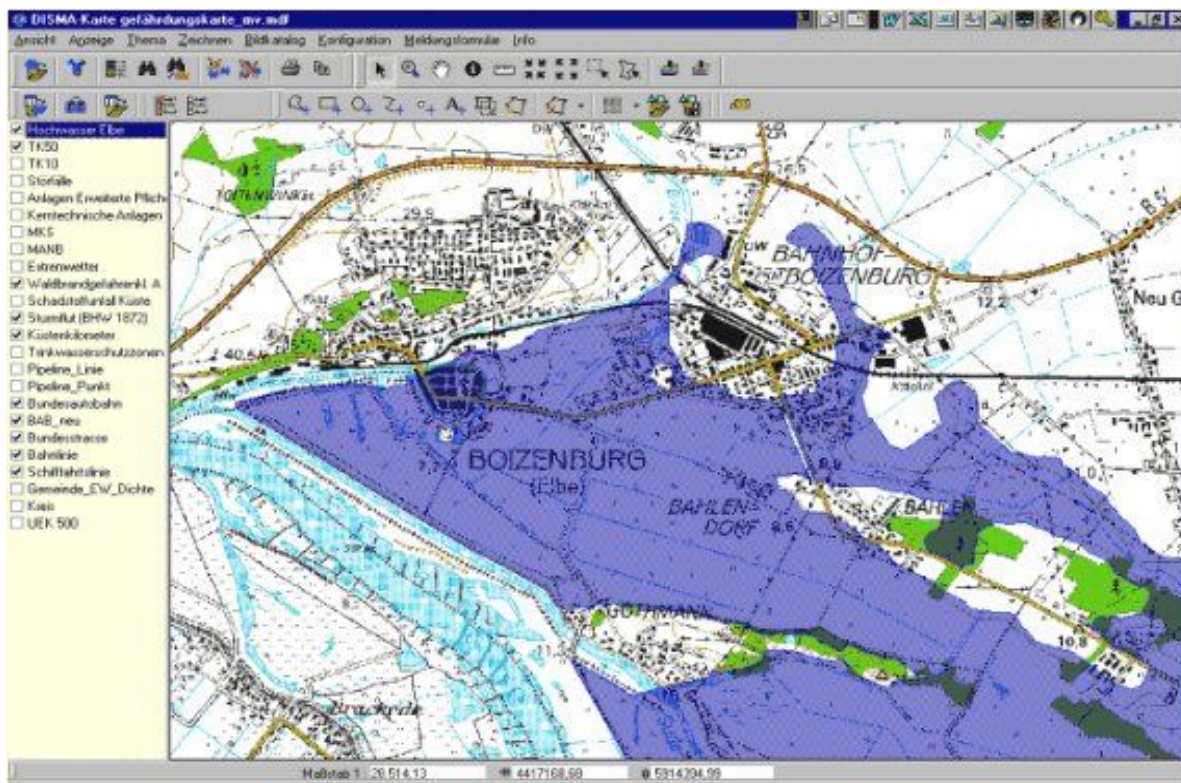


Figure 6.16: A screen shot from the DISMA decision support system

Source: State Office for Central Tasks and Technology of the Police, Fire Protection and Civil Protection – LPBK in Mecklenburg-Vorpommern (<http://www.katastrophenschutz-mv.de/pages/disma.htm>)

6.3.4 Availability of maps and further publicly available information

In contrast to some other German Länder, in Saxony almost all types of flood maps are publicly accessible in one way or the other. The easiest way to access them is via the web pages of the Saxon Flood Centre based in the Saxon State Agency for Environment and Geology. Here, the following information is provided:

- Information platform flood protection (operated by the Saxon Flood Centre at LfULG, Informationsplattform Hochwasserschutz):
<http://www.umwelt.sachsen.de/umwelt/wasser/2318.htm>
- Flood warning system:
http://www.umwelt.sachsen.de/de/wu/umwelt/lfug/lfug-internet/wasser_13482.html
- Flood education trail Dresden: <http://www.hochwasserlehrpfad-dresden.de/hw/index.html>

The Atlas of Flood Hazard Saxony and the ELLA Elbe-Atlas can be ordered (free of charge) from the LfULG on CD-ROM. All flood protection concepts, including the maps, can be accessed in paper format at

the respective local and regional authorities upon request. Furthermore, information on legally binding flood-prone areas and on priority and reserved areas for flood protection can be retrieved from the municipal land-use plans (Flächennutzungspläne) and regional plans. These are available partly on the internet (single maps in PDF format) or analogue format at the respective authorities or – in case of the regional plans – also for sale.

It is obligatory to give access to all the official flood maps. Other maps, such as those produced in pilot studies and research projects, are usually not publically available.

6.4 Flood hazard and flood vulnerability

6.4.1 Data sources

Hydrologic data in the official maps is partly based on mapped extents of historic flood events and to a larger extent on hydraulic modelling results. These were produced under the responsibility of the LfULG (and in particular the Saxon Flood Centre) by different engineering planning offices. Also the map produced by the UFZ use the hydrologic data.

As for economic, infrastructure and social data, the official statistics was the main supplier of information. With respect to land values, also urban planning agencies were involved. For hazard indication maps the Digital Landscape Model of the ATKIS cartographic information system (ATKIS-DLM25) was used. Sites with hospitals were taken from the Social Atlas of the Free State of Saxony, published by the Saxon State Ministry for Social Affairs in 2003. Relative depth/damage functions were taken from other studies at the Rhine River.

To determine ecological damages and to collect data on them is as difficult as to define such damages. Only in the UFZ-maps and in the prioritisation of measures are ecological aspects included. They originate either from the ATKIS or a biotope type map.

6.4.2 Flood hazard

6.4.2.1 Definition of relevant probabilities

As it can be seen in Section 6.3 (Current flood mapping practices (map types and their defined target groups), the probabilities of mapped flood events vary between the maps, but also within one group of maps. Official flood hazard maps are produced for events with return periods of 5, 10, 20 or 25, 50, 100 and 200 or 300 years as well as for so-called “extreme” events (sometimes corresponding to the HQ200/300 event).

The maps for the Vereinigte Mulde River produced by the UFZ (FLOODsite and RISK MAP) use the 10, 15, 50, 100, 200 and 500 year return periods.

So far, climate change – that may alter the discharge corresponding to a certain HQ – has not explicitly considered in the existing flood maps. However, it is expected that the freeboard will be able to cover these uncertainties.

6.4.2.2 Water levels

The water levels (or their grading) shown in the maps also vary according to the river and the type of map. For the hazard maps of the Atlas of Flood Hazards Saxony, the inundation depths are shown in steps of <0.5, 0.5-2 and >2m for 1st order rivers.

Water levels and of flooded areas were also calculated without considering existing flood protection measures such as reservoirs, dikes or flood polders. The illustrated depths/intensities and extents are the envelope of all possible inundation scenarios – this means that not all indicated areas may be flooded during the same event of a certain return period.

6.4.2.3 Intensity criteria

The general hazard maps are called “Intensity maps HQ100” and display three intensity levels (high, medium, low), depending on the water depth (). In mountainous areas, these levels depend on the discharge/flow velocity (not applicable near Wurzen/Bennewitz). For non-public use there are five intensity levels.

These intensity criteria are also included in the coarser hazard map of the Atlas of Flood Hazards Saxony. However, the hazard indication map displays water levels/depths only for the HQ(extreme) and in four levels: 0-0.5 , 0.5-2.0, 2.0-4.0 and >4.0 m.

Table 6.5: Derivation of intensity criteria

Intensity level	Thresholds of the intensity levels	Hazard characteristics
High	$h > 2,0 \text{ m}$ or $q = v * hw > 2,0 \text{ m}^2/\text{s}$	People and animals also inside of buildings highly at risk, major damages on buildings, sudden collapse of buildings possible
Average / medium	$2,0 > hw > 0,5 \text{ m}$ or $2,0 \text{ m}^2/\text{s} > q = v * hw > 0,5 \text{ m}^2/\text{s}$	People and animals outside of building highly at risk, inside of buildings little at risk, damages on buildings
Low	$hw < 0,5 \text{ m}$ or $q = v * hw < 0,5 \text{ m}^2/\text{s}$	People and animals outside of buildings little at risk, some damages on buildings (mainly in cellars/basements)
h = water depth v = flow velocity q = specific discharge (discharge per metre width)		

Source: LfULG

6.4.3 Flood vulnerability

6.4.3.1 Economic vulnerability

Determination of damage potentials

The damage potential map in the hazard indication maps shows the possible damages on assets (buildings, furniture, harvest losses, etc.) in areas potentially affected by a HQextreme. The information is given according to the land-use type and the intensity of the damage. The ATKIS object types were aggregated into eight land-use classes which were then linked to economic statistical data. The result was an asset value for each land-use entity in EUR/m² that represents the upper reference in case total

destruction occurred. However, in Saxony it is rather unlikely that buildings or other assets are totally destroyed by a flood. To get a more realistic picture, i.e. to find the share of an asset value that is the actual damage, damage functions are used. These deliver the damage as a percentage of the asset value depending on the intensity.

The following classification of damages if made in the official damage potential maps:

- Industrial areas: high - > 10 Euro / m²; low - < 10 Euro / m²
- Settlements: high - > 50 Euro / m²; medium – 10-50 Euro / m²; low - < 10 Euro / m²

Also the UFZ-study applies a quite similar meso-scale approach for the evaluation of economic damages (Meyer et al. 2009). Apel et al. (2009) test different meso- and micro-scale approaches for the city of Eilenburg.

6.4.3.2 Special risks (Critical infrastructure)

In order to indicate especially vulnerable sites, points with a special risk were determined and visualised. This applies especially to assets that have a very high damage potential themselves but that also may cause a certain type of damager. For some of these infrastructures, lower thresholds were defined below which they are not shown (e.g. power plants 50 Megawatt, water plants < 100.000 m³ annual yield. Industrial sites were selected according to their trans-regional significance and whether hazardous substances are used. Also hospitals are included in this category.

6.4.3.3 Social vulnerability

As mentioned before, only hospitals are included in the hazard indication maps. Other maps in pilot studies or software have also included the number of affected persons, schools, pharmacies, etc. (INGE, Meyer et al. 2009)

6.4.3.4 Ecologic vulnerability

The special risks which are mentioned above also contain hazardous substances which could cause further ecological damages. Meyer et al. (2009) also include vulnerable biotopes and erosion/accumulation potential of polluted material as environmental risk criteria.

6.5 Risk analysis

6.5.1 Specific definition of risk and methodology for its assessment

In general, risk is always understood as the annual average damage ($P \cdot D$). However, none of the official maps shows risk in such a way, as damages are only shown for one return period (the HQextreme) In contrast (as mentioned already in Section 6.3.2) the UFZ risk maps apply this risk formula, i.e. annual average damages are calculated for each risk criteria and raster cell.

6.5.2 Components of risk assessed

See Section 6.4.3 above. In the official prioritisation scheme, apart from economic damages, also the following “special vulnerabilities” are included:

- Danger to human lives
- Essential infrastructure facilities (e.g. water plants, hospitals, power plants),
- Important infrastructure facilities (e.g. railways, national traffic ways, train stations, ...),
- Extraordinary cultural heritage or monuments
- hazardous substances

The UFZ risk maps include the following risk criteria:

- economic: annual average damage
- Social: people affected (annually) & social hotspots (probability of vulnerable community locations)
- Ecologic: vulnerable biotopes, erosion and accumulation potential of pollutants & probability of vulnerable biotopes of being affected

6.5.3 Aggregation method

The prioritisation of measures (100-point assessment scheme) by the LTV can be seen as an aggregation method of various “risk indicators”:

- 1a. Cumulative expected damages (25)
- 1b. Benefit-cost ratio (25)
- 1c. Effects on Water Management (25)
 - Retention capacity (10)
 - Discharge conditions (10)
 - Water ecology (5)
- 1d. „Vulnerability“ (25)
 - Special vulnerability (people, infrastructure, heritage sites) 10
 - Potential secondary losses (e.g. hazardous substances) 10
 - Special protection needs (lacking possibility of defence) 5

The multicriteria risk mapping approach by UFZ (Meyer et al 2009) apply the two following aggregation methods (or multicriteria decision rules):

- additive weighting: each risk criteria is firstly standardised to value as from 0-1 and secondly weighted. Thirdly all criteria are summed up.
- disjunctive approach: Firstly threshold values are defined for each risk criteria. If a threshold value is exceeded in at least one criterion an area (raster cell) is assigned as a high risk area.

6.6 Map design

This section contains information on how the contents of the maps are visualised in terms of scale (detail), colour, graphic background and additional map data. Table 6.6 in the end of this section summarises again all main features of the aforementioned map types.

6.6.1 Map scales

In the first place, the scale of the maps under discussion refers to the mapping scale, e.g. the scale in which the maps were originally produced. Some maps may have been upscaled for publication, e.g. when their aim was rather to give an overview or when some of the details were too delicate.

Since many of the maps are available and used digitally, e.g. in GIS or DSS applications, they of course have no fixed map scale. However, they are also based on the mapping scale mentioned above or they may only be visible within certain zoom margins.

Maps displaying legally binding flood-prone areas (Überschwemmungsgebiete) usually have a mapping scale of 1:25.000. Flood intensity maps use a scale of 1:10.000, but for areas along the Elbe River also scales of 1:25.000 or even 1:50.000 were applied. For hazard maps in settlements that have a more limited accessibility, scales for mapping and display are 1:5.000 and 1:10.000, depending on the area. The Saxony-wide hazard indication maps and damage potential maps were produced for a scale of 1:100.000. Furthermore, some of the risk maps under development and those for test sites use scales of 1:5000 and 'higher.

6.6.2 Colour schemes

Generally speaking, the currently available flood maps in Saxony use mainly grades of blue but also purple and green for the display of the information on the flood hazard (flood extent, flood depth, flood intensity in terms of flow velocity). Information on potential damages in residential areas is usually presented in grades of red/orange, other damaged/vulnerable areas are presented in brown, purple, yellow or green.

In more detail:

- Hazard maps/intensity maps: Different blues/purples for intensity of the inundation (extent of the potentially flooded areas) and water depths
- Inundation maps (from the hazard indication maps): Different greens for floods $\leq$ HQ(100), different blues/purples for the HQ(extreme) of which the outline is a red line.
- Damage potential maps (from the hazard indication maps): Colours for intensity of damage (4 different land use classes, 1-3 intensities, see above), reds/orange for settlements, brown/purple for industrial areas, yellow for agricultural areas, green for other land uses.

6.6.3 Graphic map background and additional map data

For all mentioned flood maps, the initial/basal background are topographic maps 1:100,000 (Legally binding flood-prone areas, intensity maps, inundation maps and damage potential maps of the hazard indication maps) and 1:50,000 (Some intensity maps, hazard maps in settlements). Due to their scale, they most often do not show individual buildings. Often, very coarse vegetation layers are included (or can be added).

6.7 Results from interviews and workshops

6.7.1 The stakeholder involvement process in the case study

The participation process in the case study was organised around the following steps. (Figure 6.17):

1. As a first step, the case study area was delimited, a stakeholder inventory was made and potential interview partners were identified. Simultaneously, a review of legal documents addressing participation and of existing maps, tools and guidelines was carried out (Task 1.1).
2. Then, exploratory interviews with selected stakeholders were carried out. To ensure the comparability between different interviews and to make sure that all relevant topics were covered we developed a semi-structured interview guide. The focus was on current practices of flood mapping in the case study and the central challenges and issues to be focused on more in-depth during the workshops (Task 1.2).
3. During the first stakeholder workshop, previously prepared (blank) topographic maps as well as hypothetical GIS map layers were discussed and forged into draft maps and sketches. The aim was to go deeper into the limitations of existing risk maps with regard to their content (potential new risk criteria, e.g. social and environmental risk criteria as an input for the multicriteria risk mapping in Task 2.2) and their visualisation as input for Task 2.3 and into the communication and participation processes.
4. With these inputs and the previously gained results of RISK CATCH, a first series of maps was produced. The workshop was evaluated with the help of a questionnaire.
5. These maps were used for the EGS tests in Tours with altogether 41 test persons from the different case studies. From our case study 8 interested stakeholders were taken to Tours. Participants needed to fill out an extensive questionnaire (see detailed EGS report on <http://risk-map.org/outcomes>).
6. Between the EGS tests and the second stakeholder workshop, additional interviews were conducted with very specific questions, supposed to deliver more local knowledge for the FloodCalc tool and specifications for map contents and design.
7. Again, the maps were enhanced with these new insights by means of the FloodCalc tool and used as a basis for discussion during the second stakeholder workshop. This workshop aimed at collecting final comments on the maps and the mapping process.
8. During the last phase, the final maps as well as ... were created. Continuous exchange with ...

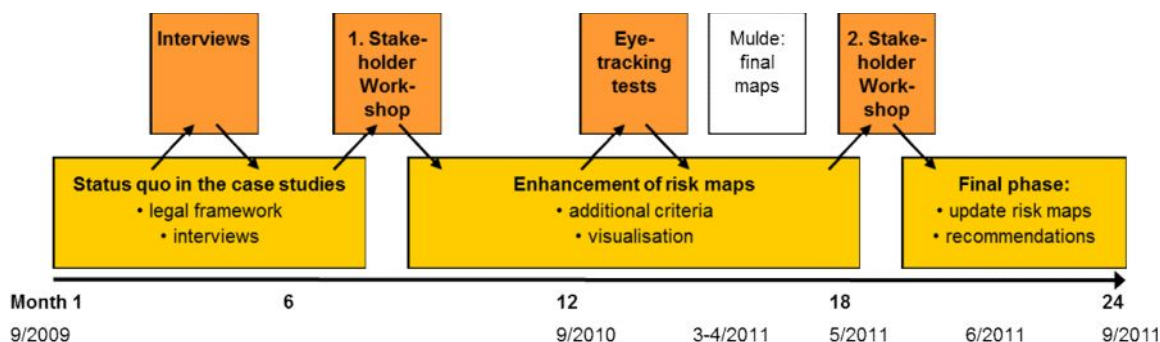


Figure 6.17: Research and participation process in the case study

6.7.1.1 Interviewed stakeholders and workshop participants

During the first months of the project, nine rather explorative interviews were conducted with institutions identified or thought to be concerned with the production, update, control and use of flood maps:

- LfULG, Referat 45 ... – 21.08.2009 (first interview)
- District Landratsamt Landkreis Leipzig (Grimma) – 19.01.2010
- Regional Farmers Association (Regionalbauernverband) Delitzsch-Torgau – 21.01.2010
- City of Wurzen – 26.01.2010
- Landratsamt Landkreis Nordsachsen (Eilenburg) – 16.02.2010
- State Directorate Leipzig, Referat 41 – 24.03.2010
- Municipality of Bennewitz – 14.04.2010
- LfULG, Referat 45 – 30.04.2010 (second interview)
- LTV, Betrieb Elbaue / Mulde / Untere Weiße Elster – 03.05.2010

The first stakeholder workshop in the Mulde region took place on 31 May 2010 at the UFZ in Leipzig. According to the focus of the case study – namely the horizontal and vertical cooperation between producers and users of flood maps in public bodies in Saxony – a number of stakeholders were invited. There were 12 external participants from:

- the City of Wurzen (2)
- the Municipality of Bennewitz (2)
- the District of Leipziger Land (3)
- the State Directorate Leipzig (2) and
- the Saxon State Authority for the Environment, Agriculture and Geology (LfULG) (3).

They had been identified following a stakeholder analysis and the interview series mentioned before. Actors that were interviewed and invited but were unable to attend included representatives from the District Nordsachsen, the State Dam Association, the Regional Planning Association and the Regional Farmers Association. From the project (UFZ) there were 4 persons, plus 1 moderator.

6.7.1.2 Workshop design and activities

The workshop was roughly structured according to the main themes “map contents” and “visualisation” with the underlying theme of the process of risk mapping (communication, participation) that came up during the preparatory work.

The first part was dedicated to the map contents. Participants should have the chance to express their opinions about what should ideally be included in flood hazard and flood risk maps. For this, three groups with 3-4 participants from different organisations and levels (state, regional, local) were confronted with a blank (topographic) map of the Wurzen/Bennewitz area and 2 existing flood maps on movable walls (Figure 6.18). The tasks were e.g. to fill in the areas affected during the last big flood in 2002 from the experience of the participants, plus the areas that may potentially be affected. Furthermore, participants were asked to insert information that would be useful in order to be better prepared for the next flood and its consequences. It was explicitly addressed that not everything can be represented in a map, but participants were encouraged to also name other important issues that cannot be presented in a map. The discussion aimed at finding commonalities and differences between the groups, focusing on overall wishes, limitations of flood maps and other relevant issues.

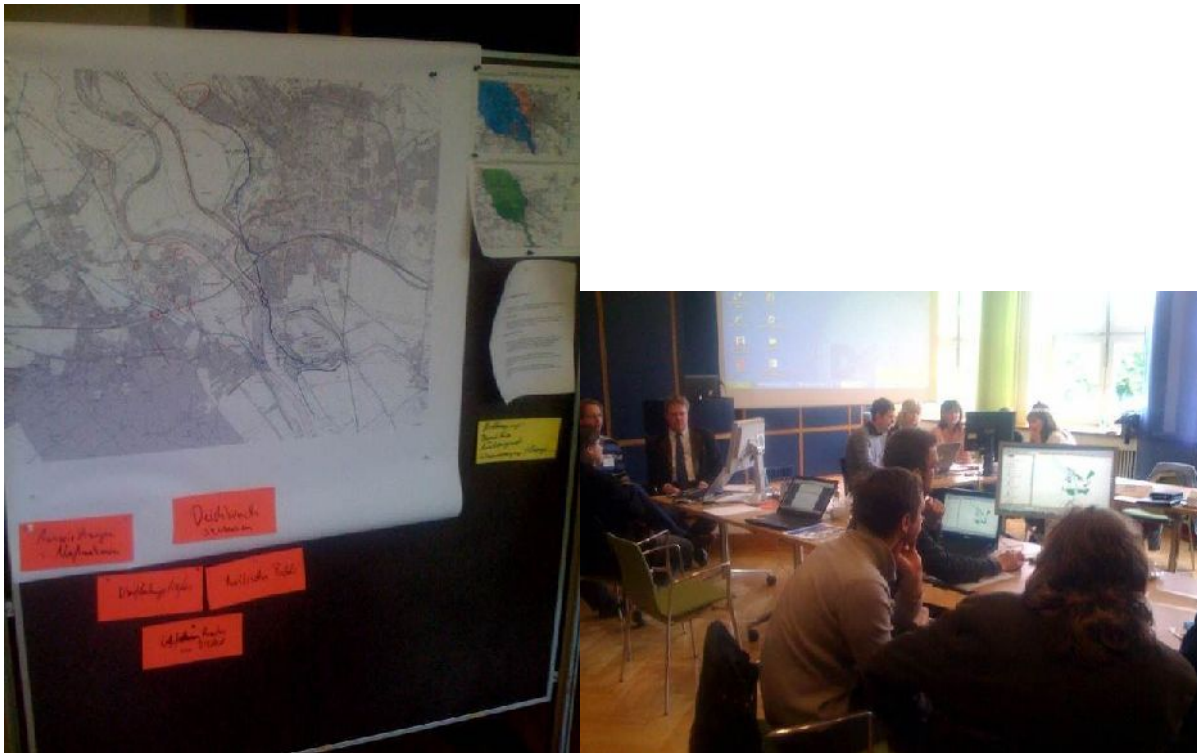


Figure 6.18: 1st workshop: blank maps (left) and group work with GIS layers (right)

During the second part of the workshop the focus was on predominantly on visualisation but also included questions about preferred contents of flood maps. The aim was to let the participants indicate how the previously identified information could be visualised in an ideal way. Different information layers were tested in different variants in order to identify components to be varied for the EGS tests in Tours. This included both the visual display of maps (e.g. how many classifications of inundation depths) as well as different risk criteria such as economic risks (annual average damage), social risks (people affected (annually) & social hotspots (probability of vulnerable community locations)), ecological risks (vulnerable biotopes, erosion and accumulation potential of pollutants & probability of vulnerable biotopes of being affected) as well as aggregated risk (waited summation of ecological, economic and social risks) (cf. also chapter 6.5.)

For this exercise participants were again divided into three groups, but this time according to their administrative role, i.e. the lower communal level (City of Wurzen and Municipality of Bennewitz), the higher communal level as well as the regional level (District Leipziger Land and State Directorate Leipzig) and the State level (LfULG). A previously created ArcView workspace was provided that included an idealised, fictional map layers that could be combined according to different preferences and exported as a map print (Figure 6.19).

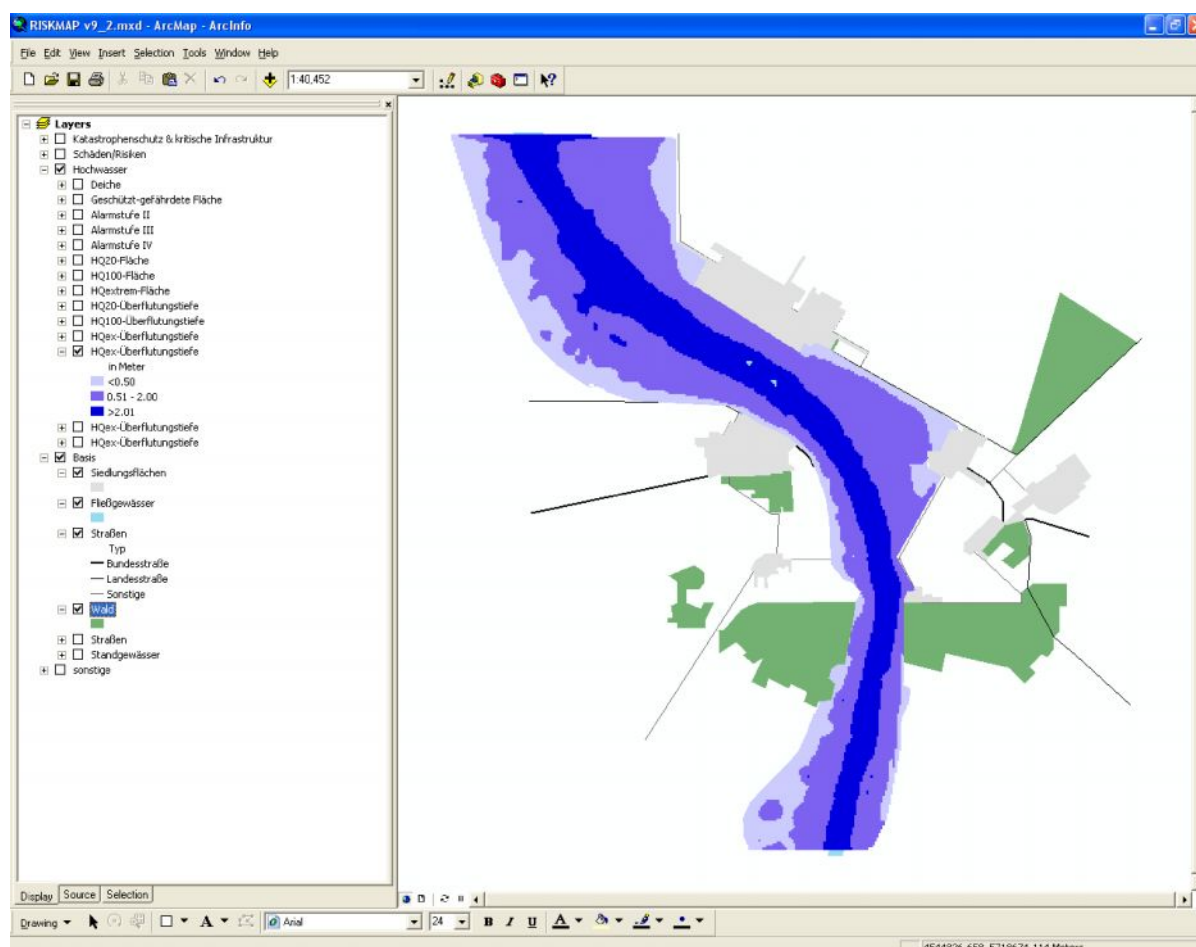


Figure 6.19: fictional map with GIS layers

This “puzzle” exercise was accompanied by a guidance document/questionnaire. As a result, 2-3 maps were produced per group. Eventually, commonalities and differences and overall preferences were identified in the plenary, and the resulting maps were discussed

6.7.1.3 Findings of the first interviews

The issues that arise from the interviews can be grouped into three themes: (1) Visualisation, (2) content and (3) the map development process and their usage. Furthermore, limits of current official flood maps were identified, along with critics on the communication process during the map (flood protection concept) generation and the delivery of the final products to the end users. Wishes and alternatives were collected in the greatest detail possible.

Limits of current official flood maps

Existing maps are considered by some of the interviewed persons as erroneous. This means that in most cases modelled spatial extents of a given flood return period are not congruent with people’s personal observations and experience. Therefore, some municipalities are not working with existing flood maps as they are considered as being too **inaccurate** for using them in their daily work. Some areas are, for instance, defined as endangered in flood maps whereas from a local perspective they are not at risk of being flooded and vice versa. This problem seems to be particularly pressing when smaller tributaries enter the main river channel and experience a backlog and hence rising water levels. Such small-scale events that are nevertheless challenging for local municipalities are often not very well represented in the

official flood maps. Yet, particularly for emergency cases such detailed and accurate information on flood maps are considered relevant as an inaccurate map might lead to wrong decision making in emergency cases (e.g. sending an ambulance car to a street although it is blocked by high water levels).

A general challenge is the **timely validity** of maps as in many locations new technical protection devices were constructed in the aftermath of the 2002 flood and some maps thus do not reflect the current situation. Therefore citizens are sometimes asking why certain areas of a municipality are still marked as being at risk although they are seemingly protected by a dike. The official position to this argument is quite straightforward: Only when all currently planned and constructed measures are implemented along the Mulde River, will the flood maps be updated. Another challenge relates to the high dynamic of the river: After every flood, and this also includes smaller floods that do not affect the urban area, the river bed slightly changes. Therefore, one person argued: *“Regardless of who makes the map, during an operation it would not be up to date”*.

Different official maps seem to contain not all the same and sometimes even **contradicting information**: *“Hazard Indication Maps (Gefahrenhinweiskarten) are in my opinion not congruent with our Hazard Maps (Gefahrenkarten) from the Flood Protection Concepts as they seem to contain considerably more and larger flood-prone areas (Überschwemmungsgebiete) than our Hazard Maps”*. Similarly, the printed analogue maps do not seem to be the same as the digital versions (e.g. the different water depths are displayed with three colours in the digital maps and with four in the printed maps).

Communication

Although it was often stressed that maps are considered as an important means to raise awareness, the empirical observation by many of the interviewed person clearly shows the limits of such an approach: On the one hand the **maps are quite often not very well displayed**; on the other hand it seems that many **citizens tend to ignore them** as they assume that with the newly constructed dikes the situation is secured and the communities are no longer at risk from being flooded. This seems to be understandable if one looks at the official communication from the higher authorities and especially from the media emphasizing that with the reconstruction of enforcement of dikes the areas along the Mulde River will be flood secure again.

Flood maps were handed over by responsible authorities to municipalities during an **official event**. Based on personal empirical observations and experiences, some municipalities repeatedly gave suggestions for improving the existing maps. However, it was claimed by some that such suggestions were not or not properly considered by the responsible authority. This is considered as a rather unsatisfactory situation and some started to produce their **own alternative map products**: As a result of considering the official flood maps as erroneous one municipality started drawing their own maps by using existing topographical maps. Based on the extent of the 2002 flood they extrapolated a worst-case scenario and marked its possible spatial extension. In a next step, high risk areas were identified that need to be dealt with in case of an emergency with the highest priority such as residential areas with a high proportion of elderly or handicapped people, critical infrastructure or industrial sites.

In defence of this accusation, the higher authorities reported that during the modelling phase there was an intensive contact with the respective regional river maintenance office (LTV, Betrieb Elbaue / Mulde / Untere Weiße Elster / Flussmeisterei) and even with some mayors who check whether the results of the modelling exercise reflect the local experiences. It was underlined that the current situation is satisfactory.

However, there is a strong desire for a more meaningful exchange between producers and users of maps as particularly those working on the local level are a source of experiences and observations, which they consider as relevant and helpful for improving the content of flood maps: *“Although I am not able to proof my observations numerically like an hydrologists, I simply saw it. Perhaps this would be a possibility to check some of the calculations based on our own observations with regard to their plausibility. I think it is helpful for neither side if we are not collaborating more intensively in the long run”*.

The feedback from the municipalities to the LfULG on whether to present information rather numerically or verbally is weak. There is not much knowledge how information is dealt with. The LfULG tries to collect as much data as possible. Some participatory activities coincided with the administrative reform of the Saxon districts in 2008, when responsibilities were unclear and most authorities had other priorities. This implies that the good timing of involvement is very important.

The importance of **personal experience** was supported by other interviewed persons who underlined that personal experience is always relevant for confirming or possibly modifying the maps based on hydrological models as the latter are not as accurate as personal observations. Although, on the regional level, it was confirmed that numerical calculations are in some cases not particularly accurate, at the same time it was underlined that quite rarely a person or institution is complaining about the maps: *"Experience is incredibly important, but it happens seldom that someone passes by and tells us: 'Your maps, they are a mess, that is not working'".*

It was furthermore mentioned that the existing flood maps are often used, but mostly for emergency management, although they were initially aimed at strategic planners (which would explain some of the unsatisfactory comments from emergency managers). Solutions of current integration problems of different GIS tools were asked for.

Alternatives and wishes

Particularly for those working on the regional level and/or who have to deal with requests by the public, a **more differentiated display of water levels below a return period of 25/100** such as 05/100 or 10/100 were demanded. This appears relevant as quite often already at these lower/less catastrophic flood stages certain unprotected parts of the area need to be controlled and observed.

At the local level, the most relevant information seem to be important phone numbers, the number of people living in certain areas, such as streets or houses of persons who would need special assistance. Currently this information is written down and stored physically in a folder. It would relieve the work of the municipality if this information could also be stored in **digital maps and data bases**. Similarly, on the district level such a data base is currently being developed. Additionally, there is a **need for more exchange of information and data** among and between the different actors on the local and regional level, as actors are developing data bases alongside each other without sharing this information with other actors working on the development of similar data bases.

For example, it would be beneficial to have more information on **critical infrastructure** such as the electricity grid. In case of an emergency there is hardly any information available among the responsible authorities. Similarly, current maps do not contain information about sewage plants. Furthermore, it was suggested that there was also a need to include information about **possible evacuation routes** that are still accessible in case of an emergency and are not affected by rising water levels.

A topic that came up quite often was the **connection of return periods with water / alarm stages** or, more specifically, with specific water gauges along the river / upstream:

Torgau-Oschatz Elbe: *"to a certain gauge ... I know, that this is not always possible because the flow velocities and the water quantities are different, but in this way one has a little reference point, I don't know, like on the Elbe River a 100 year flood corresponds to a water level at gauge XY of 9.20 metres or something like that, it depends ... so that one has a little bit of a link and that with the help of the maps one can maybe find out more ... the relief, well I only use the topographic height information that is in the maps, and sometimes there are not many measuring points in them ... being a layperson one has to juggle a lot in order to calculate something somewhere. Of course I do have a blank spot on the map and I say that here at this point ... lies, stands the water half a metre high or between half a metre and two metres, this one could a little ... well between half a metre and two metres, that's really extreme, well if I stand in half a metre of water or I don't know, one and a half metres, one could maybe a little ..."*

Interviewer: *"You mean that for example at neuralgic points there should be an additional concrete water depth?"*

Torgau-Oschatz Elbe: *“For example, yes. Or to really this medium, to really subdivide this medium depth class ... because then it would ...”*

On a more general level it was emphasised that the different needs and requirements of different user groups should be taken into account and hence different maps should be produced.

6.7.1.4 Workshop findings

During the workshop, many points already mentioned during the interviews came up again. Most of the points, however, were further specified during the workshop and a more contextualised picture developed.

Contents

The content part was mostly concerned with the preferences of stakeholder regarding different risk criteria (economic, ecological, social and aggregated). Generally, **economic and aggregated risks** were of interest only for strategic planners on a higher level. For most participants from the regional and local level mainly dealing with emergency management these contents were of less interest. The focus was rather on **social risks**: particularly, hotspots and some ecological risks such as oil tanks. It was moreover a consensus that at least two main user groups, namely emergency management (civil protection crisis managers) and strategic planners should be differentiated as addressees of flood maps. For civil protection crisis managers hotspots, critical infrastructures, access ways, evacuation points and routes, dike responsibilities, energy lines, etc., were considered important. Strategic planners and professionals from higher levels seem to be more interested in the flood extent, the frequency of flooding and damage potentials or even aggregated risk Figures.

There were also more specific points discussed. In terms of the contents there was a general satisfaction observable with regard to existing economic damage potential maps. However, topicality problems and updating efforts, difficulties to include climate change and the need of finer gradation for high return probabilities in the maps were concluded, as well as a discrepancy between models and observations:

- Flood extent and the spreading of flood waters (direction and flow velocities) were seen as more important than water depths.
- Importance of social hotspots was highlighted, that is objects that need to be protected during specific events and this particularly by participants from the local and regional level. Keeping this knowledge up to date is however quite resource demanding as a lot of local knowledge is required.
- The economic damages / risks were especially on the local level and for emergency management not very relevant. In regards to strategic planning it might be enough to present the information verbally in three classes, or for a specific typical event.
- As for ecological risks, only points where hazardous substances are stored were seen as relevant (petrol stations, oil tanks, certain industries, etc.). Municipalities mentioned contaminated sites as a possible map content, but members of the LfULG group argued that these are not a relevant source of pollution during floods (not even in 2002).
- The aggregated overall risk (MCA) was only valued as an indicative information for spatial planning on State level, but not for emergency planning or other municipal or regional tasks.
- There was a general desire to indicate areas protected by dikes that could be flooded during an extreme event or in case of a dike breach. A useful but not very workable factor would be the age and condition of such a dike. Another additional content could be the positioning of dike patrols and responsibilities.
- Most suggestions for added content were given with regards to emergency management and civil protection (police and fire brigade stations, hospitals, evacuation routes, gathering points, bridges, energy network, important businesses, responsibilities, traffic network, sewage plants, threshold values for water depths at critical points, uncertainties etc.)

- For some, risk information seems to be more interesting than damages for individual events, because if damages were indicated for a single event it would also be uncertain / erroneous, since every flood is different.

For the assessment of the efficiency of single measures in an emergency it would be interesting to have maps from which can be estimated that the maintenance and defence of a certain dike section is worthwhile with such high operating expenses. The flooded area, affected population and the potential damages in case of a dike breach should be indicated. Addresses of the elements at risk (social infrastructure), dike sections and even dike patrols are sometimes already included in great detail in the municipal action plans.

Table 6.6 summarises the main outcomes of the discussions, namely which importance was assigned to different themes in the maps by different stakeholders / levels. Some made a differentiation between the requirements of emergency management / planning and strategic planning.

Table 6.6: Results from the evaluation of the importance of different map components

Criterion	Not important 1	2	3	4	Very important 5
Flood hazard 4					G L B (EP/SP)
Economic risks	G B (EP)	L		B (SP)	
Social risks		G (Wurzen) B (SP)	B (EP)	G (Bennewitz) L	L
Ecology		B (SP)	L B (EP)	G (esp. oil tanks) L	
Infrastructure/critical infrastructure/ protection 4	civil			L B (SP)	G3 L B (EP)

G = Community level; L = District level; B = State and regional planning level
EP = Emergency planning; SP = Strategic planning

3) Not necessarily all data in one map, better a (GIS) data base with different layers

4) 2 groups mentioned that the link between hazard and critical infrastructure should be enhanced (e.g. usability during certain events – should be in every analogous map)

Visualisation, scale and format

There was a general satisfaction observable concerning the visualisation of existing flood maps. Suggestions for improvement included more flexible GIS tools and more handy formats of analogous maps. Strategic planners in higher authorities use much more often digital data and are therefore much more flexible. On the contrary, emergency managers often need analogous maps in case of an actual event (power supply may be interrupted, equipment may be wet, maps on boards used for troop briefings, etc.). Some participants mentioned even a kind of an “analogous GIS”, i.e. a folder with several map layers on overhead transparencies.

In principle 3 **water depth classes** should be sufficient, as in modelled data a larger number of classes could imply a certainty that is actually not there. Also, since areas that are more than 2 m under water will not be accessed at all anymore, it is not necessary to differentiate depths > 2 m. However, sometimes it is useful and actually recommended by the LAWA guidelines to have 5 or more classes (e.g. in wide and flat floodplains). In case of steep hydraulic gradients, high flow velocities or dense building structures, fewer classes or just one class (rather the flow velocities) is recommended. Flooded surfaces should always be shown in a semi-transparent colour, as the background also matters a lot.

Scale was seen as important issue. Analogue maps should be available as overview maps (1:10,000 – mentioned by the local level) and additionally as detailed maps for the single municipalities (1:2,000 to a maximum of 1:5,000). This is in line with the LAWA recommendations that suggest a scale of 1:2,500 up to 1:10,000 with an optional zooming out to 1:25,000. Scales < 1:25,000 make generalisations necessary. However, representatives of the LfULG argued that 1:2,000 is very detailed and in practice hardly feasible. It would very much depend on the content whether such a map would make sense.

It was furthermore discussed whether information on flood intensity, damage or risk should be given in a **numerical and / or verbal** way. Numerical information is always important for the communication with the public and to prioritise measures and objects. Verbal information may be just as informative while at the same time better capturing uncertainty or abstract indicator values.

6.7.2 Alternative mapping: Exploring mapping preferences with experimental graphic semiology

6.7.2.1 Maps for the EGS tests in Tours, France

According to the results of the first workshop and based on recommendations on visualisation of maps derived from the RISKATCH project (Fuchs et al. 2008), a set of four maps was created by means of the FloodCalc, tool (see section 3.2). This set of map should be tested by means of the experimental graphic semiology method (EGS, see section 3.3 for a detailed description of the approach).

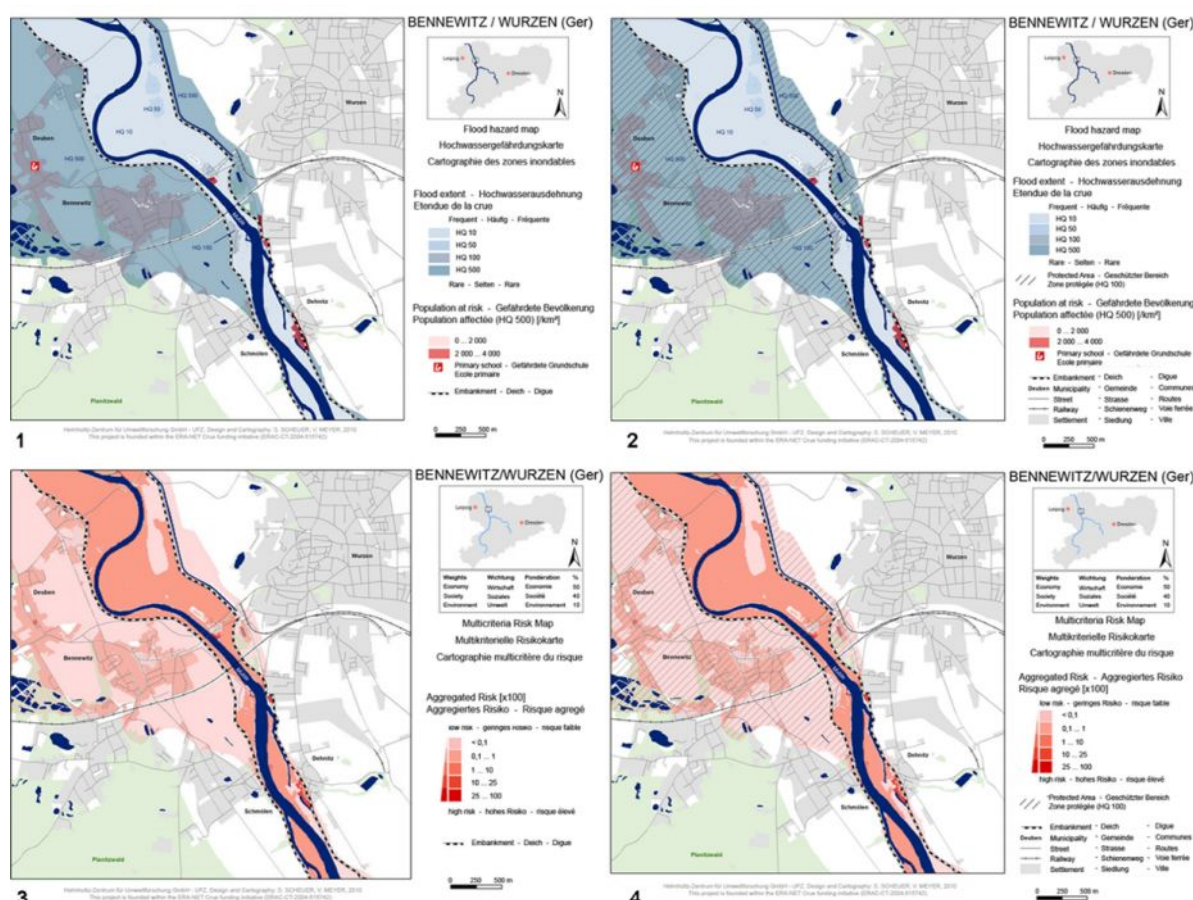


Figure 6.20: Set of maps for the case study Bennewitz/Wurzen tested by means of experimental graphic semiology.

The four maps show the same detail of the case study area but differ mainly in three aspects with regard to content or map design, respectively:

1. **Content:**

- Two maps (Map 1 & 2) are mainly hazard maps, showing the flood extent for flood events with different return periods. Additionally, information on the affected population and social hot spots (in this case a school) for an extreme event is displayed in these maps
- The other two maps (Map 3 & 4) are multicriteria risk maps showing an aggregation of economic, social and environmental risk criteria.

Rationale: In the first workshop many participants, especially the ones dealing with emergency management, expressed that flood extent, affected population and social hot spots are the most important contents for them. But it was also mentioned that maps showing all potential risks would be interesting especially for strategic planning.

2. **Visualisation of protected areas:** All four maps furthermore show the dike line in the area which was mentioned to be important by many participants during the first workshop.

- Two maps (Maps 2 & 4) furthermore visualise the area protected by these dikes (i.e. the area potentially affected in case of dike breaches) by means of a texture.
- The other two maps (Maps 1 & 3) do not highlight this protected area, i.e. they only show the dike line.

Rationale: It was also mentioned in the first workshop by many participants that the areas protected by flood defences should be visualised somehow. Therefore, we wanted to test these two variants.

3. **Complexity of the legend:** The third aspect which was varied in the test maps was the legend:
 - a. Two of the maps (Maps 2 & 4) have a complete legend, i.e. like it is normally recommended in cartography textbooks, every graphic element shown in the maps is also explained in the legend.
 - b. In the other two maps (Maps 1 & 3) the legend is kept minimal, i.e. the most important information is displayed in the legend, while typical background elements, like streets, railways etc. are not explained in the legend

Rationale: Especially when not having much time to study a map, complete or complex legends might attract too much attention of map readers and distract them from the most important contents. It should be tested if this is the case in this example.

Together with test maps from the other case studies these maps were tested by means of EGS including eye-tracking test in Tours on 29 October 2010. The group of test persons in Tours was composed of citizens affected by flood risk in the case studies and concerned with flood issues and by representatives of administrative bodies responsible for institutional management of flood risks within the respective case studies. The overall results of these tests are described in Section 9.3, or in more detail in the EGS report on <http://risk-map.org/outcomes>.

For our case study maps the EGS tests in Tours delivered the following results:

- All four test maps show quite similar results in terms of the average number of eye fixations during the test (which was close to the mean of all test maps). This could be interpreted in a way that all four maps do not differ so much in terms of graphical elements of special attractiveness. If some of the map contents should raise more attention to the map reader, they could be highlighted more (graphically, by colour or text).
- It became apparent throughout the EGS that the main areas of interest during for the map reader were in all maps the centre of the maps as well as the central, coloured elements of the legend (see Figure 6.21 and Figure 6.22). For allowing for a quicker eye-movement between these elements, the enlarged section of the map could be adjusted in a way that the central area (bridges over the Mulde) is closer to the legend.
- The combined hazard & population map (Map 1) was evaluated by test persons to be very good in terms of the level of complexity and information density (scores of around 50 on a scale from 0 (too simple, too sparse) to 100 (too complicated, too dense)). The multicriteria map (Map 4) also received good results, although evaluated to be a little bit too complex and too dense (scores of about 60 (complexity) and 57 (density)).²¹
- The combined hazard & population map (Map 1) was evaluated to be more aesthetic, more innovative and more useful than the multicriteria map (Map 4). However, both maps received good to satisfactory results in all three criteria.
- In general, a combination of hazard and consequence information displayed in *one* map was preferred by most of the test persons. Furthermore, most of the test persons were in favour of showing the different consequences of flooding (social, economic and environmental) together in *one* map. This means although for our case study the combined hazard & population map had better scores than the individual representation of the hazard and the potentially affected population, there seems to be still some need for a way of displaying multiple risks in *one* map.
- With regard to the visualisation of the protected area no clear result emerged from the EGS tests. Some comments mentioned that the texture is good but others also remarked that it is too much in

²¹ While in the eye-tracking test all four maps were tested, the following questionnaire considered only the maps 1 and 4 (For the questionnaire the overall number of test maps had to be reduced to 10 otherwise the questionnaire would have taken too much time.)

the foreground of the map. For the improved maps we therefore kept the texture for the protected area but used a little bit more decent colours. Furthermore the visualisation of the dike line was criticised by some test persons (the black and white dashed line remembered was too close to the often used signature for railway lines). Accordingly this has been changed in the second series of maps to a light green.

- Also with regard to the level of the complexity of the legend no clear trend emerged from the EGS tests. In the improved maps we therefore used the complete legend, shifting the most important elements of the legend to the top and centre and the background information to the bottom.
- A general outcome of the EGS tests was that symbols and text in the maps was well perceived by the test persons, i.e. it attracted their visual attention.

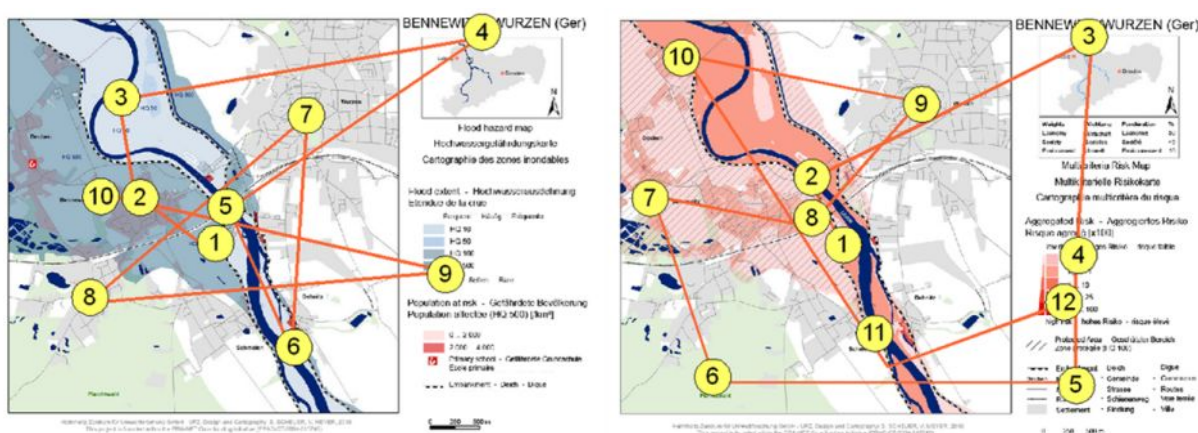


Figure 6.21: Examples for the eye movement of two test persons. Yellow circle show points with longer fixations, the number indicate the chronology of these fixations.

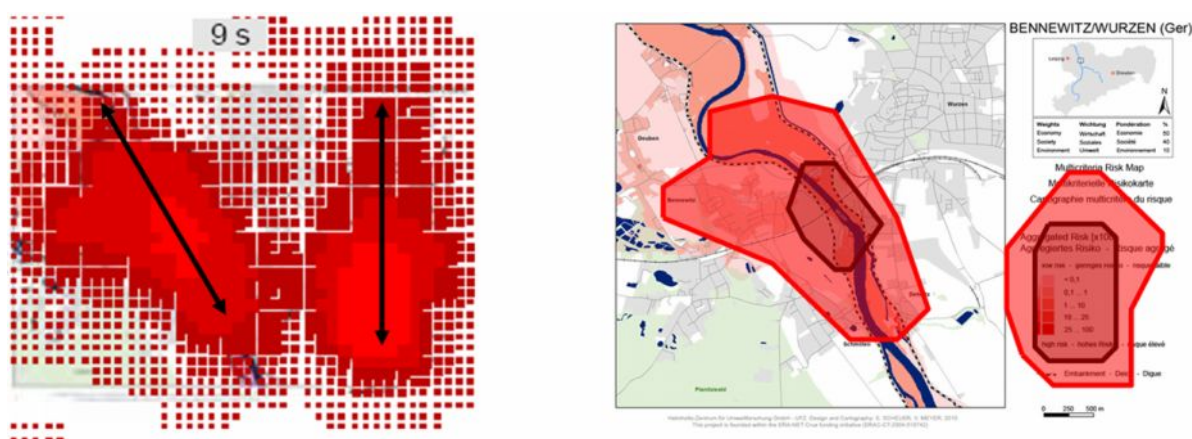


Figure 6.22: Main areas of interest in map 3. The left Figure shows the temporal concentration of all test persons within the first 9 seconds of the test. Bright red colours indicate the areas where the gaze of test persons spent the most time, i.e. which attracted the eyes of test persons most. Based on these the main areas of interest are highlighted in the right Figure (black: core zone, red: extended zone)

6.7.2.2 Maps for the second workshop

Based on these results from the EGS test in Tours, but also on results from the first workshop and the interviews conducted in the case study, a second set of maps was prepared. This second set of maps was again presented to the stakeholder during the second workshop (see Figure 6.23). The following maps have been included:

1. **Map with flood extent, affected population & emergency management information A:** As the maps with flood extent and affected population received good evaluations during the EGS test these contents were also the basis for this map. Compared to the maps tested in Tours the blue colour range was applied the other way round (dark blue now being the extent of the most frequent event), based on comments during the EGS tests. Based on the needs of the stakeholders which were expressed during the first workshop and interviews additional information was added: 1) critical infrastructure like bridges, weirs, poles etc. which are at risk of flooding and 2) information required for emergency management like meeting points, gathering points, material grounds and evacuation routes (and their level of being affected themselves by the flood). Both are visualized by means of a symbology or signature which was built based on existing symbols in emergency management and/or which should be more or less self-explanatory.
2. **Map with flood extent, affected population & emergency management information B:** Same as Map 1, but another symbology is used which was based on the municipal hazard indication maps developed by the LfULG (see figure 6.12). Symbols are mostly smaller and sometimes maybe not self-explanatory at first sight.
3. **Map with flood depth information, affected population & emergency management information A:** Same as Map 1, but instead of flood extent for different events inundation depths (but only for the most extreme event) are shown in the map in five classes. The rationale is that it was not quite clear among participants during the first workshop which of the two hazard information is preferred or seen as more important.
4. **Map with flood depth information, affected population & emergency management information B:** Same as Map 3, but inundation depth information is displayed only in 3 classes. The rationale for including this map is that it was also a controversial point during the first workshop if it was better to show inundation depth by a more detailed (pro: higher level of detail) or simplified legend (pro: higher level of detail is often arbitrary, mainly not necessary for emergency management decisions and furthermore could reduce the understandability of the map). Therefore this point should be at least briefly discussed during the second workshop, based on these two maps.
5. **Multicriteria risk map:** This is mainly the multicriteria map tested in Tour with smaller adjustments according to the overall recommendations from the colleagues of Université de Tours. The main difference is that “risk hot spots” (school and kindergarten as well as areas with high number of potentially affected persons) have been highlighted by means of rectangles and explanatory text.
6. **Map with economic risks:** Similar to map 5 but only economic risks are displayed here in terms of annual average damages and the highlighted risk hot spots refer to economic risks. This map was included for the second workshop as it should be discussed a little bit more whether it would be better to aggregate different consequence information (like in the multicriteria map) or whether it would be more useful to have maps with only one type of consequence in each map.

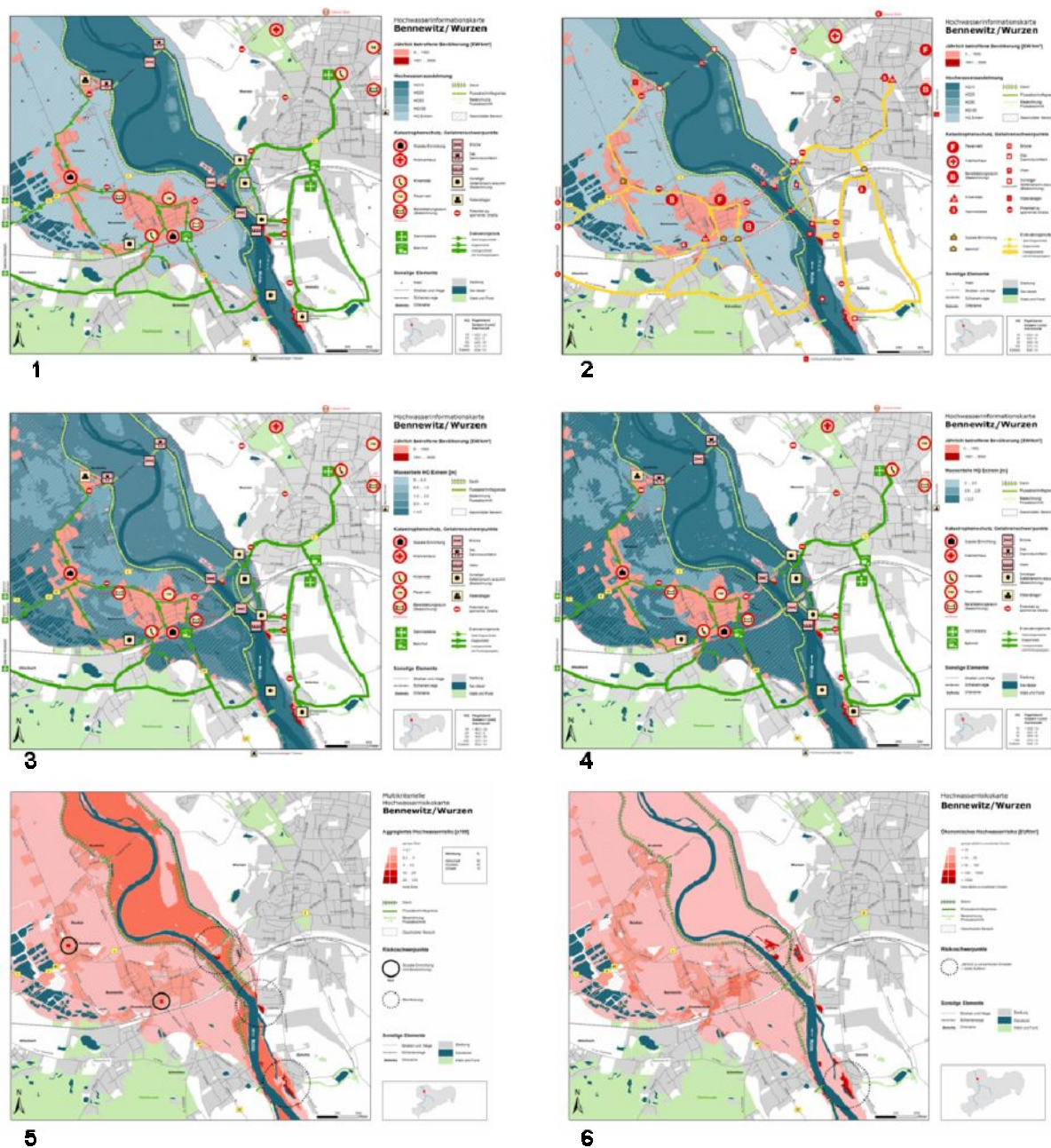


Figure 6.23: Set of improved maps discussed with stakeholders in the 2nd workshop

6.7.3 Additional interviews and second workshop

6.7.3.1 Stakeholder and participants

After the EGS tests in Tours, the participants of the first workshop and of the testing were again interviewed in order to validate the results and to ask for the provision of very concrete data (alarm plans, GIS layers, symbols/semiotics, etc.). They included the following interviews:

- District Northern Saxony (Landkreis Nordsachsen, seat in Eilenburg), 23.02.2011

- City of Wurzen 13.12.2010
- Municipality of Bennewitz 23.02.2011
- State Directorate Leipzig (Landesdirektion Leipzig), 13.12.2010
- District Leipzig (Landkreis Leipzig, seat Grimma), 13.12.2010
- Saxon State Authority for the Environment, Agriculture and Geology (LfULG), 28.02.2011

In most cases it was achieved that the participants for the second workshop were the same as for the first workshop. The only institution not present for the second workshop was the LfULG as well as the Municipality of Bennewitz. However, all test persons from Tour were able to attend the workshop, including a representative of the District Northern Saxony who did not attend the first workshop. The project members as well as the facilitator remained the same as for the first workshop.

6.7.3.2 Workshop design and activities

The aim of the second workshop on 10 May 2011 was to present a set of enhanced maps (see Figure 6.23) to the stakeholders in order to collect feedback for the creation of the final maps. These should serve as a positive example how to produce flood maps that are in line with the requirements of the Floods Directive and that are both created in a participatory process and useful for further participatory activities, such as risk communication and spatial planning.

Since approximately one year had passed between the two workshops, the objectives of RISK MAP as well as the results of the first workshop were briefly summarised. It was then explained what took place in the project in between the two workshops, namely the eye-tracking tests in Tours, the incorporation of comments and EGS findings in the exemplary flood maps and the structuring of local expert knowledge in a knowledge database (see Section XY).

Following this lecture-style part, in the second part of the workshops the enhanced maps (Figure 6.23 above) were presented on movable walls to the participants. After an extensive discussion a first oral evaluation was carried out that was subsequently specified in a questionnaire. Finally, an overall discussion and evaluation of the maps took place again in front of the large format map prints.

6.7.3.3 Findings from the additional interviews and the second workshop

Contents

In the following section comments for each map are summarised.

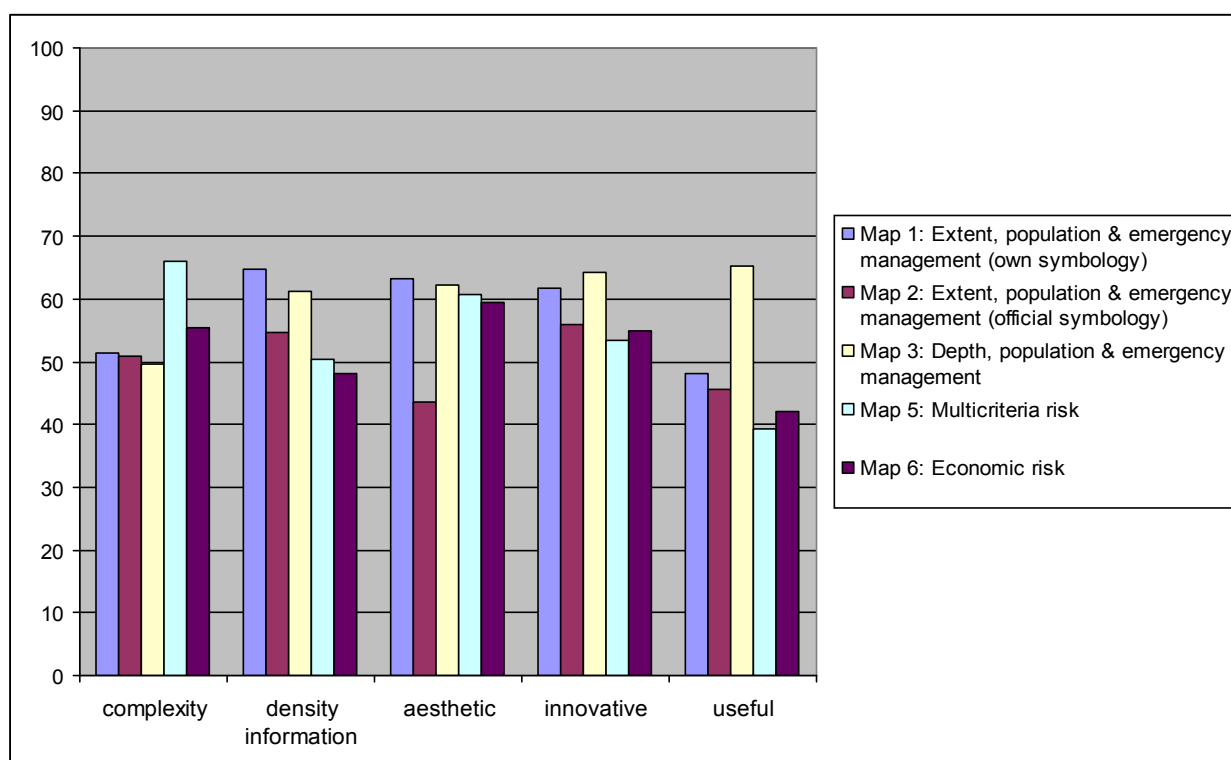


Figure 6.24: Evaluation of the new maps by stakeholders (n=6) during the 2nd workshop. For “complexity” and “information density” 50 is the best score. For the other three criteria 100 would be the best score. Map 4 was not included in this survey

The maps that scored best were maps 3 & 4 because they conveyed the best amount and degree of information. However, also here it was criticized that the maps suggest that there is a protected area even during an extreme flood. In Map 4 there was no link between the water depth indicated in the map and the water level at the area’s gauge. It is still not really possible to read the alarm stages and the corresponding water levels at the gauge from the map.

The maps that scored lowest were maps 5 & 6. Since the participants all came from water authorities, the economic risk was not a priority for them (but may be so for strategic planners). Since now map (damage) is related to a concrete (historic or hypothetical) event, it is hard to derive decisions from them.

It was seen as confusing and difficult to interpret what an average annual **affected population** would stand for, especially because many people associate/confuse a return period with a specific event. Thus, it was not seen as valuable or pragmatic information in such a map. Instead, it should be left out or only included in maps for strategic planners or only the population potentially affected during a single event should be indicated. For the emergency management/civil protection it is important to know what is really happening, how many people need to be evacuated and so on. For this, one would need to know how many persons are living and/or staying in the area that may be affected even by only an extreme and rare flood. It would be good to have different maps, among them those indicating/focusing on evacuations. However, it was uttered by some that there is still a problem concerning the exact numbers of inhabitants living in a single address as the official data is not always trusted by the stakeholders. As far as the population living in the affected area is concerned, it would be useful to indicate where the highest number or certain types of residents live.

For the emergency management, further crucial questions were: Where are roads and paths blocked? Where are possible passages or “secret” ways that are only known to older locals? Evacuation could be

carried out e.g. by bus at the official public transport bus stops. Gathering points should always be above the edge of the first river terrace in the direction of Altenbach.

Moreover, as stated several times already during the interviews, there is a wish to see a link between return periods and alarm stages. This would make it easier to understand what a certain alarm stage implies in space.

If a map was to be presented in a **public show case**, participants mentioned that for such a map the evacuation routes, emergency shelters and alarm stages with their link to the reference gauge would be important information. Also, for this purpose, it would make sense to distinguish between a map for creating risk awareness and a map to be used during an actual event.

If **sluices** are indicated in the map/**dike line**, it would be useful to add the critical water level at the gauge upstream above of which they would need to be closed (although nowadays many sluices close automatically).

Visualisation

Green was seen as the ideal colour for evacuation routes. However, it would be important to indicate which routes can be used when. It was advised to further work with different thicknesses of the lines.

Critical comments were made with regards to the **symbols used** in areas that are only affected during an extreme flood event, or a very low recurrence probability. The map was seen as confusing because it suggested that some infrastructures would be still available even during such an extreme flood. It was suggested to **present different return periods in different maps**, or to at least indicate which infrastructure may be used until which flood extent corresponding to a certain return period. It is necessary to have this information for all assets – so far they are partly still missing in the maps or the accompanying documents.

In case of a digital version of the maps it would be useful to base the symbols used on unambiguous symbols that are already used in civil protection, such as the ones in the DISMA software (so far, these were not all included yet in all maps). Self-explaining symbols (e.g. a telephone receiver) were preferred over letters (in case of the telephone a capital T). The user could then place them in the map according to the needs in a specific situation. In principle it would be good to place the symbols in areas that are not affected and indicate their actual location with arrows.

It was mentioned that the size of the symbols could be according to the importance (e.g. a less important factor like a road closure could be held small and an important information like a gathering point could be expressed by a larger symbol). Secondary information could be presented in small symbols so that they don't cover other information. As for the civil protection infrastructure and as mentioned before, it was irritating that its information symbols still seemed to be usable even in case of an extreme flood. Although some facilities such as schools and kindergartens that need to be evacuated should remain as symbols in the map, other symbols such as gathering points, shelters, telephone booths etc. should be taken out.

Another critical remark concerned the polygonal presentation of the population – it could be confused with higher lying lands. Instead, it was again stated to maybe have a separate map for an extreme high return period or to use hachures for the areas protected by dikes during less extreme floods but that would be affected during extreme floods and/or dike breaches. This was elaborated further, namely as a suggestion to have again **separate maps** for a typical flood event of a certain return period (range). If too much information is pressed into one map, that information would blur and give rise to more questions than answers. But since most dikes are designed for a 100 year flood event, it may be sufficient to have such maps only for return periods >100 years or for potential defence failures. A too detailed map or plan may be dangerous in terms of creating a certainty that is not grounded.

It was also discussed in how many **classes** the water depth should be presented. It was a general agreement that 3 classes are sufficient, because in water depths >2 metres only a helicopter can be used – for vehicles it is too deep and therefore unpredictable and for boats the flow velocity may be too high.

Communication / process

An important point made was in order to clearly state the **date** when the map was produced. This is especially important for the legally binding flood-prone areas. Many of them may be outdated because the 100 year return period areas have changed since the realisation of many measures from the Saxon flood protection concepts. Another issue related to the timeliness of the maps was that the water levels corresponding to an alarm stage change (e.g. on the Elbe in June 2008 – it was changed based on a question poll by the Saxon Flood Centre among municipalities).

New issues

From the additional interviews, several new topics arose of which only some could be included in the maps:

- Smaller water courses
- Gauges
- Groundwater
- Energy infrastructure and potential emission sources of pollutants
- Timeliness

One aspect was that in the meantime, namely in August/September 2010 there had been locally very high groundwater levels and inundations from **smaller streams and rivers** (120 mm in 3 days, In Torgau: Schwarzer Graben, some retention through the Großer Teich, in Eilenburg: Sprödauer Bach in a new bed, Leine: carried a HQ100(!), Kossen: dike breach). This posed a “new” challenge / problem as after 2002 all the efforts had concentrated on the 1st order water courses. Water authorities were confronted with accusations for not maintaining the water bodies, giving nature protection too much priority (river cleaning can only be carried out in winter).

Some municipalities do not have any maps or plans for such cases, although they could have applied to be granted financial support from the district to create so-called “Wasserwehr(satzungen)”. The district carried out a survey among the municipalities to what extent they are or would be affected by any kind of flooding. Most municipalities replied that they struggle most with “wild run-off” and with non-existing regulation of water courses (no harmonised management of fish ponds, not enough maintenance). Problems especially arise on the local level: For example the need to remove meliorations (canalisations, piping) carried out during GDR times. Therefore, more maintenance is required. Insufficient financial resources were almost always mentioned. Although **municipal flood protection concepts for second order water courses** can be subsidised up to 75% of the overall costs (so that the municipalities would only have to pay 25% of the overall costs), costs are still too high and municipalities do not cooperate or they think that single structural measures are much more effective. Thus, only very few municipalities have created them. An idea that came up was to use the extent of alluvial clay (Auelehmverbreitung) as an indicator for potentially flood-prone areas. This would be an interesting map content, too.

Many smaller water courses have no or only few gauges so that the information chain to and from the Saxon Flood Centre does not work. Thus, municipalities and lower water authorities often called for **more gauges**. However, from the viewpoint of the LfULG this would not help much since ...

Especially on the district level the possibility was mentioned to additionally create and / or combine **groundwater** maps (Vernässungskarte / Grundwasserflurabstände) flood maps. High groundwater levels occur more frequently following heavy and sustained rainfall but also due to the decreasing withdrawal of drinking water and the abandoning of open open-cast mines that required artificial lowering of the groundwater level.

Power poles that could be undercut by flood waters and other critical energy infrastructure were mentioned. Additionally, the issue of hazardous substances that should be considered arose again (these fall under the responsibility of the State Directorate, where potential emission sources are known are issued).

6.7.4 Evaluation of the participatory process by the participants

Apparently, the results we obtained and which were presented in this section largely depend on the input, views, and needs of the stakeholder who participated in our workshops, our interviews and in the EGS test in Tours: Different stakeholder – different results. However, there are some overall conclusions which can be drawn regarding how the participants evaluated the participatory process

The stakeholder came to the conclusion during the final workshop that this participatory process was regarded as very valuable as they were offered an arena to utter their expectations and needs and to also exchange and share information and experiences among and between each other. The workshops brought together stakeholders from quite different levels to collaborate and this enabled some confrontation of the opinions of the other levels and their work. The workshops, particularly working in small groups, allowed the different stakeholders to discuss some issues and to gain an alternative perspective (to their own established ones). The workshops were thus deemed very successful in that the participants were cooperative and learned from each other.

In this respect, the workshop may be seen as a starting point for enhancing communication and understanding between the levels, as participants developed new contacts and established a dialogue. If this process could be repeated and built upon it could establish stronger working relations between the different groups. However, there was also a clear expectation formulated as the overall success of the process also depends on the final outcomes and – more importantly – on the implementation of some of the results in the everyday practice of flood mapping. In this sense, participants also made the final evaluation dependent on the impact of the project on their respective level of work and responsibility, which means in most cases, that there is a strong hope that these maps and findings will be passed on to the responsible institutions on higher levels, mainly to the LfULG.

Another point which needs to be addressed was that such processes are often not possible or hardly possible as participants are occupied with their daily work. They regarded this exercise therefore as quite “comfortable” situation. Particularly that the workshops participants were able to see the results of their input and our work during the second workshop was considered as very relevant for them as it proofed that their input was actually taken serious.

One could have been under the impression that everyone is minding his or her own business because of limited personal resources, and that therefore important tasks remain undone. Implicitly this could mean that there is an authority missing that takes care of the exchange from the “bottom” upwards to the “top” and the other way around, both in terms of data and preferences.

All participants of the first workshop – in total 12 from all 4 administrative levels – were concerned with flooding within their professional tasks. The higher their administrative level was the more specialised were their knowledge and tasks in terms of flooding. These tasks and responsibilities of the participants varied from specialist counselling (e.g. when implementing the floods Directive), planning, flood warning and information provision to safeguarding public works above and underground, evacuation as well as civil protection.

All of the participants use flood maps in their daily professional tasks. 3 of them stated to be very experienced with the use of flood maps, 8 to be experienced and just one person said to be neither experienced nor inexperienced. Concerning the different types of flood maps in Saxony the map for legally

binding flood-prone areas and the intensity map HQ 100 are the most frequently used maps by the participants. Whereas the map for legally binding flood-prone areas was named 10 times and the intensity map HQ 100 eight times (both out of 12) to be the most frequently used map, the hazard map for built-up areas and the hazard indication map were only mentioned 5 and 3 times, respectively. The majority of the participants uses the map for the legally binding flood-prone areas and the intensity map weekly or monthly. In contrast, the hazard map for built-up areas and the hazard indication map are only used once a month or even more rarely. However, the differences should rather be attributed to the different tasks of the participants than to the quality and usefulness of the maps.

Almost all of the participants named flood protection / planning as the purpose for using flood maps. Spatial planning and emergency planning was additionally named by 50% of the participants. 58% of the participants are furthermore involved in the production of flood maps. In this context, provision of data and checking and validating the maps are the most frequently mentioned working steps the participants are involved in.

Concerning the first workshop all participants felt that their opinion was appreciated and taken up during the workshop. In terms of the ability to communicate the ideas and opinions the participants stated that 6 of them felt always to be able to do so; 5 stated most of the time and just one person said sometimes.

The ideas and comments of the participants which had enriched the discussion the most were the presentation / visualisation of events, other contents, experiences when producing flood maps, the timeliness issues, necessity of emergency planning as well as the quality of old and new dikes and the representation of the residual risks and uncertainties.

In total 2/3 of the participants was thoroughly or very satisfied with the results of the workshop, 1/3 was just satisfied.

Although no formal evaluation of the second workshop was carried out, feedback was still collected. The participants were quite keen to see the map results and if and how their expertise, wishes and comments were considered. It was seen as a certain privilege to have tailored flood maps for one's own area.

6.8 Case study-specific recommendations

The stakeholders involved in the Saxon case study came mainly from authorities responsible for emergency management, but also from the State authority responsible for the creation of official flood maps. No truly strategic (spatial / urban) planners or individual members of the broad public were involved. Therefore, the following recommendations reflect mainly the needs and expectations of the representatives from emergency management. However, not every individual wish was taken as a recommendation.

First, some **general and overarching statements** can be made:

- The needs with regard to flood maps are different for emergency managers and strategic planners. A second overall evaluation was conclusion is that different user groups have different needs. Opinions, background knowledge and demands from the different levels were sometimes very different or even contradicting; which would be another argument for user-specific flood maps.
- Frequent updating of maps or at least information on the reference date of the maps seems to be useful

Participation

- It can be stated that the existing flood maps in Saxony are already of a very high quality, sometimes exceeding the requirements by the Flood Directive. They are well known and received and used by many authorities and other interested parties.
- However, there is a clear need for improved collaboration and exchange both horizontally between authorities / different departments and vertically between politicians, authorities / professional actors and the public. This can be specified by the following points:
 - It seems to be particularly important to collect expectations, needs and requirements but also different views and opinions as well as any kind of additional information explicitly “before” a participation process (workshop).
 - A “neutral” facilitator has proven to be highly valuable in many participatory processes.
 - Repeatedly, insufficient data exchange between institutions and unevenly distributed tools (GIS, other software and interactive products) was mentioned. This should be continuously improved.
 - It is furthermore crucial to provide feedback mechanisms on existing or newly produced flood maps (i.e. validation issues, additional information, updates, etc.) as well as on the outcome of a project. For example, the second RISK MAP stakeholder workshop in the Mulde Case Study was seen as very important.
 - From the beginning of any participation process it is necessary to consider the resources invested in this process – participation must be linked to some kind of added value, which needs to be clarified before the process starts.

Contents:

- As mentioned before, there is not one ideal flood map that meets the demands of every user group on every level. Instead, needs and wishes can be classed in a kind of matrix structured along the dimensions of administrative level (community, district, state directorate, state) and roughly of the two groups of emergency managers and strategic planners. In case other interested parties such as the organised and general public or other professional players were involved, this matrix would become even more complicated.

Table 6.7: Recommendations for contents

	Emergency management	Strategic planning
State level State Directorate		also maps on economic risk, other consequences, multicriteria maps
District	detailed and updated hazard information (e.g. 5 years return period and for each event single map), especially inundation depth, critical infrastructure, emergency management information, such as evacuation routes, meeting points etc.	not well represented in our case study
Community	link to alarm stages and gauging stations areas protected by defences	

Visualisation:

- In terms of visual aspects, a clear colour grading of just one colour is advised. Blue would be the colour reserved for the hazard. For the hazard, 3 classes of water depth may suffice, from which one should indicate >2 m as this is approximately the limit for vehicles. Darkest hues should indicate the most profound waters or the most frequently flooded areas. Lighter hues should indicate shallower waters and less frequently flooded areas. For the risk or damage information,

reddish colours are advised. Again, darkest hues should stand for highest risks or damage potentials.

- It is recommended to have a high contrast of the hazard and risk information as well as of any symbols to the background. This background ideally consists of a topographic map in grey scales.
- The most important information should be located in the middle of the map, not too far from the legend.
- The legend should ideally be placed on the right side of the map. It should follow a hierarchical structure, showing important information in the upper and central parts and secondary information in the lower parts.
- The use of self-explanatory and common (i.e. already used by e.g. emergency management) symbols e.g. for critical infrastructure and civil protection information is highly recommended.
- Green was seen as an appropriate colour for evacuation routes. Information should also be given on the direction in which evacuation should take place and in which cases these routes can be used at all.
- The potential of placing important information in text format within the map should not be underestimated. For example, if the number of persons to be evacuated is expressed (just) by a symbol, the reader would need to refer back to the legend to see what this symbol and its size corresponds to. If an unambiguous symbol is combined with a number, the information can much faster be taken up.

Open questions

- It will always remain a challenge to find a trade-off between readability and information density in a map and consequently, how many maps should be at hand for a certain area.

What would be a product for the participants?

- After a participation process, involved stakeholders expect a certain outcome, e.g. that their input was actually considered (even if not followed reasons why they were not taken up should be given). Even better would be the establishment of a certain procedure or network that ensures a stronger influence on the LfULG's activities.
- Another outcome would be an actual product, such as the developed tool (FloodCalc). However, this should be very easy to use and compatible with other software. The possibility to update it according to changes in the system and to continuously feed it with new data is essential for a successful implementation.
- A larger internet platform would only be useful if it was administered by one responsible institution. By experience, there are many obstacles, especially in regard to the responsibilities for such an interactive platform. The existing map services on the webpages of the Saxon Flood Centre are much appreciated, however, at the moment they are quite static and cannot be adjusted easily to the specific needs of the different user groups or as the situation changes.

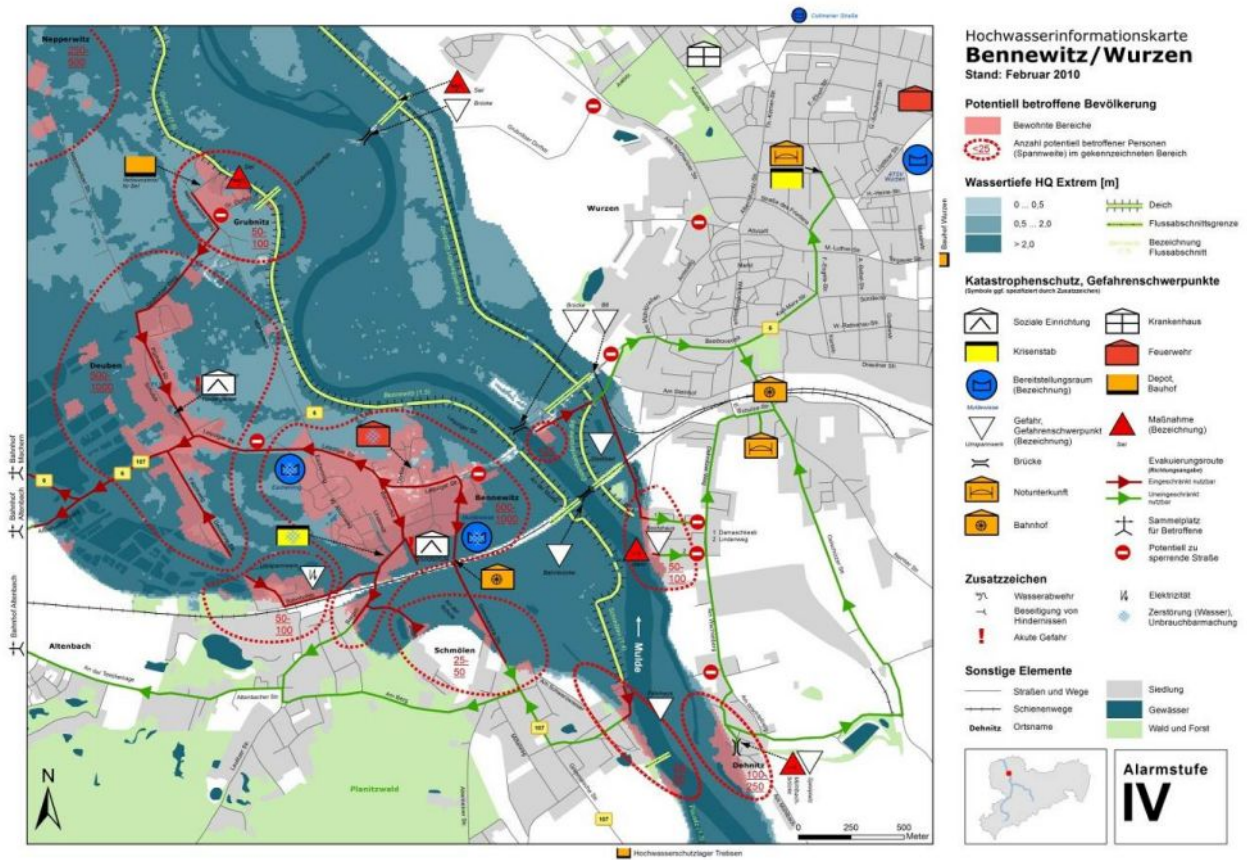


Figure 6.25: Map for emergency managers, updated after the 2nd workshop

7 Case study Bavaria

Johanna Seidel, Wolfgang Dörner

7.1 Case study Lower Rott River

The River Rott, especially the Lower Rott, has lend itself as an area for further considerations on flood risk management, including the new and improved production or improvement of existing flood hazard maps and flood risk maps.

The river rises and flows through the Tertiary Hills of Lower Bavaria and ends into the Inn near the city of Passau. The catchment area covers 1200 km². Right in the middle of the river a hydrological break, in form of a detention basin is located right in front of the town "Pfarrkirchen". From that and because of the various types of intensive agricultural use and anthropogenic altered river valley in the further course of the river Rott, different aspects arise that are representative for numerous issues and problems of flood risk management. The shallow sites of the Lower Rott related with rank loess and in addition well connected infrastructure to the highway has led to an intensification of agricultural use plus the settlement and expansions of residential areas, industry and commerce.

In these test sites, necessary data and recommendations for improved risk maps are already partly available. Furthermore, in-depth knowledge is available since these study sites had been subject to extensive research activities during national and international research activities.

7.1.1 Case study area

7.1.1.1 Physical geographic features

The catchment is situated in the tertiary hill landscape with a height between 340 and 550 m above sea level. The river has a length of about 110 km and the average gradient is 1,8 %.

The soils in the valley are of alluvial origin, on top of the hills they are of diluvia origin. The very dominant clay provides very good condition for agricultural land use. Figure 7.1 and Figure 7.2 give an overview of the catchment area and the area of interest – Pocking and Ruhstorf, placed in the lower part of the catchment area.

At the Rott in the head water of Pfarrkirchen a detention reservoir is located, intended to protect downstream agricultural and urban areas. Agriculture is the dominant form of land use. Because of the extreme hill slopes in the eastern part of the catchment in combination with fertile loessy soils and maize cultivation erosion and pollution is a major problem. A lot of urban areas like Eggenfelden, Pfarrkirchen and Pocking are located in the main river valley. Especially close to Pocking industrial areas are predominant in the wide and flat flood plain and are a major concern from a flood risk management perspective.

The following hydrological data²² refers to the city of Ruhstorf:

Table 7.1: discharge (Ruhstorf)

Discharge (average): Winter:	NQ 2,33 m ³ /s	MNQ 4,24 m ³ /s	MQ 11,6 m ³ /s	MHQ 112 m ³ /s	HQ 239 m ³ /s
Summer:	1,90	3,48	7,35	77,9	295
Year:	1,90	3,36	9,44	123	295

Table 7.2: water level (Ruhstorf)

Water level (average): Winter:	NW 42,0 cm	MNW 58,0 cm	MW 82,0 cm	MHW 237 cm	HW 296 cm
Summer:	37,0	51,0	66,0	201	279
Year:	37,0	50,0	73,0	249	296

²²Bavarian Environment Agency:
<http://www.nid.bayern.de/abfluss/stationen/statistik/index.php?pgnr=18808004&gknr=2&wert=abfluss&thema=niedrigwasser&status=>

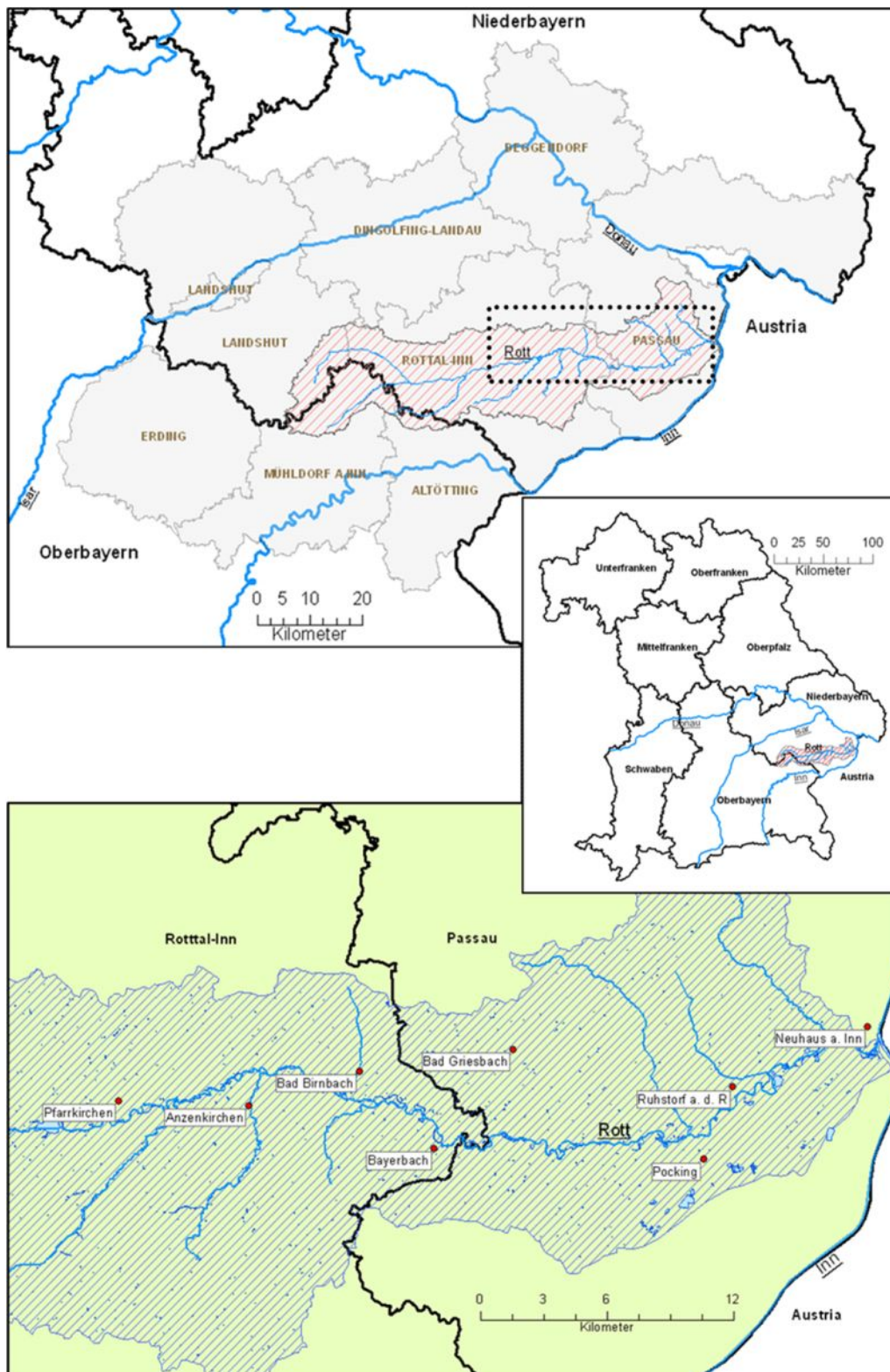


Figure 7.1: 01 – Catchment area of the river Rott and the project area; 02 – River Rott and its catchment area in Bavaria; 03 – Case study area and the main area of interest: Pocking and Ruhstorf a. d. R.



Figure 7.2: Pocking and Ruhstorf – Area of interest and content of flood hazard and flood risk maps

7.1.1.2 Human geographic features

Because of the agricultural land use as the dominating factor, rural settlements, settlements with scattered buildings and intensive agricultural use are determining characteristics. Agricultural land use has a very long tradition in Bavaria. Bavarian agricultural policy aims to preserve production and competitive family farms throughout Bavaria. But there is a general decrease of agricultural jobs. Right now about 6% of all the employees are involved in agricultural production. On the opposite site there are an increasing number of employees working in the industry, which has an effect on land use. During the last two decades there was a remarkable increase in industrial and commercial use of land in potentially inundated areas. Figure 7.3 shows the industrial and commercial parks of Pocking, placed right next to the river Rott. Table 7.3 provides an overview of basis information of the catchment area of the river Rott (Dorner et al. 2006)

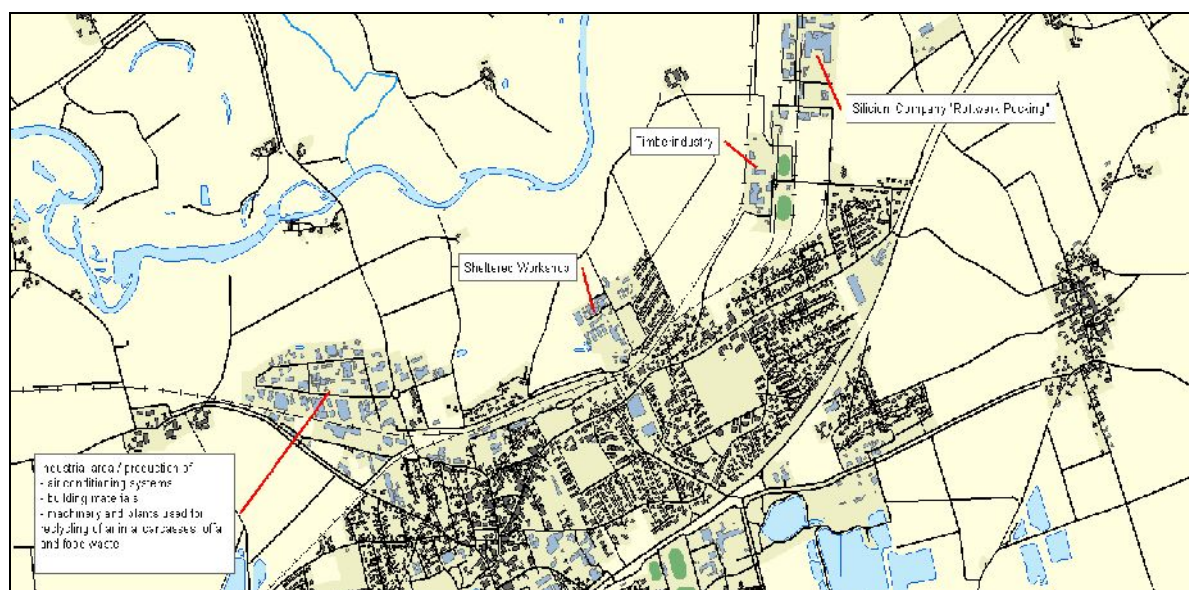


Figure 7.3: Industrial and Commercial parks of Pocking

In age the largest share of the population are 18 to 40 years 26%, 36,6% are between 40 and 65, 20,5% are over 65 years and 16,9% under the age of 18 years. About 48,000 workers are employed under social insurance contributions. Half of them work in the manufacturing sector²³. The most important sectors are: service industries, machinery and transport equipment, construction, electronics, optics, printing and food industries; the granite and the timber industries in the district have tradition. Figure 7.3 provides an overview about the industrial and commercial parks located in Pocking. .

The tourism is a very important sector. Every year nearly six million overnight stays are counted. Centers of the tourism are the "spa-triangle": Bad Griesbach, Bad Füssing and Bad Birnbach. Bad Griesbach and Bad Birnbach are both located in the case study area.

Table 7.3: basic information about the catchment of the river Rott

Basic Information		
Administrative	municipalities, partially shared with catchment area	53
	municipalities, complete in catchment area	9
	administrative districts, partially shared with catchment area	6
Water bodies	main water course	200 km
	rivulets	1400 km
	settlement	89 km ²
Use	forest	255 km ²
	field	724 km ²
	grassland	196 km ²

7.1.2 Previous flooding experienced

The River Rott, especially the Lower Rott (Untere Rott) is representative for settlement areas and industrially / commercially used areas in the lower reach. Since it is situated close to larger cities and has

²³<https://www.statistik.bayern.de/>

highway access, industrial zones and commercial areas developed during the last decades in the flat and open flood plain of the river Rott.

Table 7.4: Flood History and Protection Measures

Flood History and Protection Measurements	
1954	damaged buildings and damage to agricultural areas and roads
1956	damage to agricultural areas and roads
1968	damaged buildings and damage to agricultural areas and roads
1969	reinforcement of flood protection measures, motor boats, emergency vehicles, diving equipment and duty gear were purchased, mostly privately
1972	commissioning of the water reservoir "Rottauensee", designated for public use (recreation), production of electricity and - most important - flood protection
1991	damaged buildings and damage to agricultural areas, roads and bridges
1996	local flooding of buildings and agricultural areas
02/2005	damage to agricultural areas
2006	damage to agricultural areas and roads
2007	completion of a flood dike around Pocking
03/2009	snowmelt in connection with heavy rainfall, the capacity of Rott and other rivers had been exceeded several times, repeated overflowing and flooding of agricultural and forest areas
2011	damage to agricultural areas

Floods in the past led to the constructions of dams, two artificial lakes were dammed. New built industrial sites are not protected by these. The Table 7.4 shows the flood history of the river Rott of the last 50 years. The information is provided by the Bavarian Environment Agency²⁴. The Figures 7.4 and 7.5 provide exemplary overviews of the floods in the past.



Figure 7.4: Exemplary picture: 1954 flood Event in Pfarrkirchen



Figure 7.5: Exemplary picture of the 2011 flood event in the administrative district Rotttal-Inn

²⁴ <http://www.lfu.bayern.de/wasser/index.htm>

7.2 Bavarian case study – background information

7.2.1 Legislative context of flood risk mapping in Germany, Bavaria, and the development of the current flood map and online information service

All human impacts on the surface water and ground water are purposefully arranged and monitored. In the same way all water management but also special regularizations for structural flood control measures have to be coordinated and controlled. Table 7.5 provides an overview of the authorities and their roles in Bavaria²⁵. It is in the responsibility of the water management. It is based on the water laws. The water law itself is made up of legal norms of the European Community, the federal Government and the Federal State of Bavaria.

²⁵ Water authority Deggendorf: <http://www.wwa-deg.bayern.de/hochwasser/organisation/index.htm>

Table 7.5: water authorities in Bavaria and their specific roles

Authorities	Role
Bavarian State Ministry of the Environment and Public Health	overall strategy of flood protection
	development of regional planning guidelines
	management of financial resources for investment, maintenance and promotion
Government	control and coordination of flood protection measures at the level of counties
Regional planning association	designation of priority areas for flood drainage and retention
Bavarian Environment Agency	preparation of flood forecasts
	management of local ordinances on flood information and flood warning
	advising of the water authorities
	planning and achievement of flood protection measures for the state and districts for water bodies 1st and 2nd order
	implementation of flood information and flood warning
Water authorities	advising of the municipalities for actions on water bodies of 3rd order, promotion of measurements
	identification of flood plains
	official expert for flood issues
	performing on water law proceedings
County administration authority	establishment of flood information / messages
	passing of flood reports
	preparation and management of emergency and disaster operation
Cities and municipalities	construction of flood protection measures on waters of 3rd order
	setting up of reporting plans and action plans for municipalities
	providing of information to interested parties and citizens in case of a flood event
	danger prevention (fire fighters, disaster control, emergency services)

7.2.1.1 European Directive on the Assessment and Management of Flood Risks (The Flood Directive)

In central Europe, there's a close cooperation in the water policy sector. The Federal Government of Germany substitutes the interests of the water management in the European Union. The Government gets advised by the Regional / National Working Group on Water Issues (LAWA 2010).

In the year 2000 the Water Framework Directive of the European Union entered into force. It was a starting signal for an integrated water policy in Europe. It aims a coordinated water management, including water bodies in the catchment areas. The Directive contributes to the harmonization of water protection within the growing community and further improves the status of waters, while crossing states and country borders. The consistent implementation of a holistic view of water, especially from an environmental point

of view makes the Directive even more attractive. At the same time it also regulates specific facts. Both aspects especially show up in the

- rigorously planar approach, the watershed-based approach,
- river-type-specific approach,
- combined approach of analysis of pollutants (emission and immission) and
- single substance or groups of parameter-based approach.

In the year 2006 a three-phase plan to prevent and protect against flooding was suggested by the European Commission. One year later, in the year 2007, the European flood directive was passed by the European Parliament and European Council. The Directive aims to reduce the risk to human health, environment, cultural heritage and economic areas. Therefore all inland waterways and coastal areas should be examined for all possible flood risk (EUROPEAN PARLIAMENT AND EUROPEAN COUNCIL 2007). In addition, already existing flood risk maps should be improved or even new compiled. By 2011, all member states have to complete the preliminary analysis of river basins and associated coastal areas. For high risk areas, flood risk maps have to be finished by 2013. Flood risk management plans have to be (newly) developed till 2015. The Plan clearly focuses on prevention, protection and precaution. The flood risk maps and flood management plans must also be publicly available. In case of a flood event all necessary information about flood risks and possible safety measures has to be disclosed to the public. Not only the transfer of information is important, but also the improvement of the awareness of flood risks due to the participation of interested. (EUROPEAN PARLIAMENT AND EUROPEAN COUNCIL 2007)

7.2.1.2 Preventive Flood Control (Gesetz zur Verbesserung des vorbeugenden Hochwasserschutzes, 2005)

The Federal Ministry of the Environment, Nature Conservation and Nuclear Safety²⁶ (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit - BMU) was established in 1986. The federal ministry for Environment, Nature Conservation and Nuclear Safety is now in the responsibility of: climate change and renewable energy, resource efficiency, water management. This includes: Waste management, soil conservation, environmental health, pollution control, plant safety and transport and chemical safety, nature conservation and sustainable use of nature, safety of nuclear facilities, nuclear supply and waste management, radiation protection and international cooperation in the environmental policy. It inherits a range of flood defence responsibilities principally in the Federal Water Act.

The history goes back to 1957, where the Law on the Procedure of the Water Balance covered all natural water sources under national law, i.e. surface water, coastal water and groundwater for the first time.

The act to improve preventive flood control entered into force on May 3rd 2005. It adopts the federal guidelines for the improvement of flood protection. In particular, the countries are committed to determine water bodies and river segments on the basis of calculation of a statistically determined once in a hundred years flood. The states must identify inundation areas for all water bodies and river segments and adopt appropriate flood protection. The public has to be involved.

With the Act to Improve Preventive Flood Control the statutory regulations for flood protection in Germany were updated in many laws, including the Federal Water Act, the Building Code (Baugesetzbuch – BauGB), the Federal Spatial Planning Act (Raumordnungsgesetz – ROG), the Federal Act on Waterways (Wasserstraßengesetz – WaStrG) and the Weather Services Act (Gesetz des Deutschen Wetterdienstes – DWDG).

The new Federal Water Act (WHG – Wasserhaushaltsgesetz) entered into force on 1st of March 2010. The federal government created the conditions for a nationwide homogeneous implementation of water rights.

²⁶ <http://www.bmu.de/allgemein/aktuell/160.php>

Greater standardization and better systematic approaches helped clarifying and simplifying the practical use. The new Federal Water Act includes the practical implementation of the European Water Frame Directive in the ten river basin districts that are partly or wholly on German territory. The Federal Government is working closely with the federal states and works towards a similar enforcement of European and national legal requirements. Other key areas of the water policy are the preventive flood protection and the protection of ground water.

7.2.1.3 Bavarian Water Act (BayWG)

The Bavarian Water Act (Bayerisches Wassergesetz) defines the River Rott as a water body of first order. It is a water body of the Free State of Bavaria. The Free State is in the responsibility of construction, maintenance and finance of flood protection measures. Cities and communes participate in the costs, depending on the advantages of the measures. The information is provided by the Bavarian Water Management Authorities²⁷. Appearance of floods and flood protection are the key questions of the work of the water authorities. In case of a flood event, the water authorities run the flood forecast, the flood information & alert service and control the dams and flood protection basins. The water authority is an agency within the Bavarian State Ministry for Environment and health.

The Bavarian State Ministry for Environment and Health²⁸ is responsible for the evaluation of risk in accordance to § 73 par. 1 WHG and for the assignment and the preparation of hazard and risk maps in accordance to § 73 par. 3 sent. 2 WHG / § 74 WHG. Risk management plans have to be drawn by the State Ministry for Environment and Health in consultation with the State Ministries of Interior, Economic Affairs, Infrastructure, Transport and Technology and the Ministry of Food, Agriculture and Forestry (§ 75 WHG). Municipalities should take part in the documentation process. The state offices for Environment and water authorities have to provide technical and scientific legwork. The Bavarian district administrations can provide further input within their assigned tasks. The State Ministry for Environment and Health is also responsible for the enforcement of § 79 para 1 WHG. It includes the overall coordination and controlling of local and administrative authorities relating their duty to inform the public in accordance § 79 par 2 WHG. [SOURCE]

7.2.1.4 Ordinances on Flood Information and Flood Warning and on Flood Notification (Hochwassernachrichten- und Alarmdienstverordnung / Hochwassernachrichtendienst Bayern (HND))

The organisation of the flood information and alarm service is shown in Figure 7.6. The Bavarian Environment Agency (Landesamt für Umwelt - LFU) is head of the Bavarian flood information & alert service²⁹. The flood information centre at LFU forms a central information platform. There in-depth information and data of the water management agencies, the German Weather Service (Deutscher Wetter Dienst – DWD), the neighbouring countries and the Waterways and Shipping Administration are collected, analyzed and distributed to relevant agencies. Detailed flood situation reports can be provided through the media, via Internet and phone messages.

Flood hazard can be identified by evaluation of weather predictions on an early stage. When the water levels exceed the pre-set levels, the HND intensifies the monitoring at the gauges and notifies the responsible and relevant authorities. The water authorities then, working as the main reporting agencies, inform the district offices and also the cities and communes. They are in charge to inform the affected citizens.

27 <http://www.wwa-m.bayern.de/index.htm>

28 <http://www.stmug.bayern.de>

29 <http://www.hnd.bayern.de/>

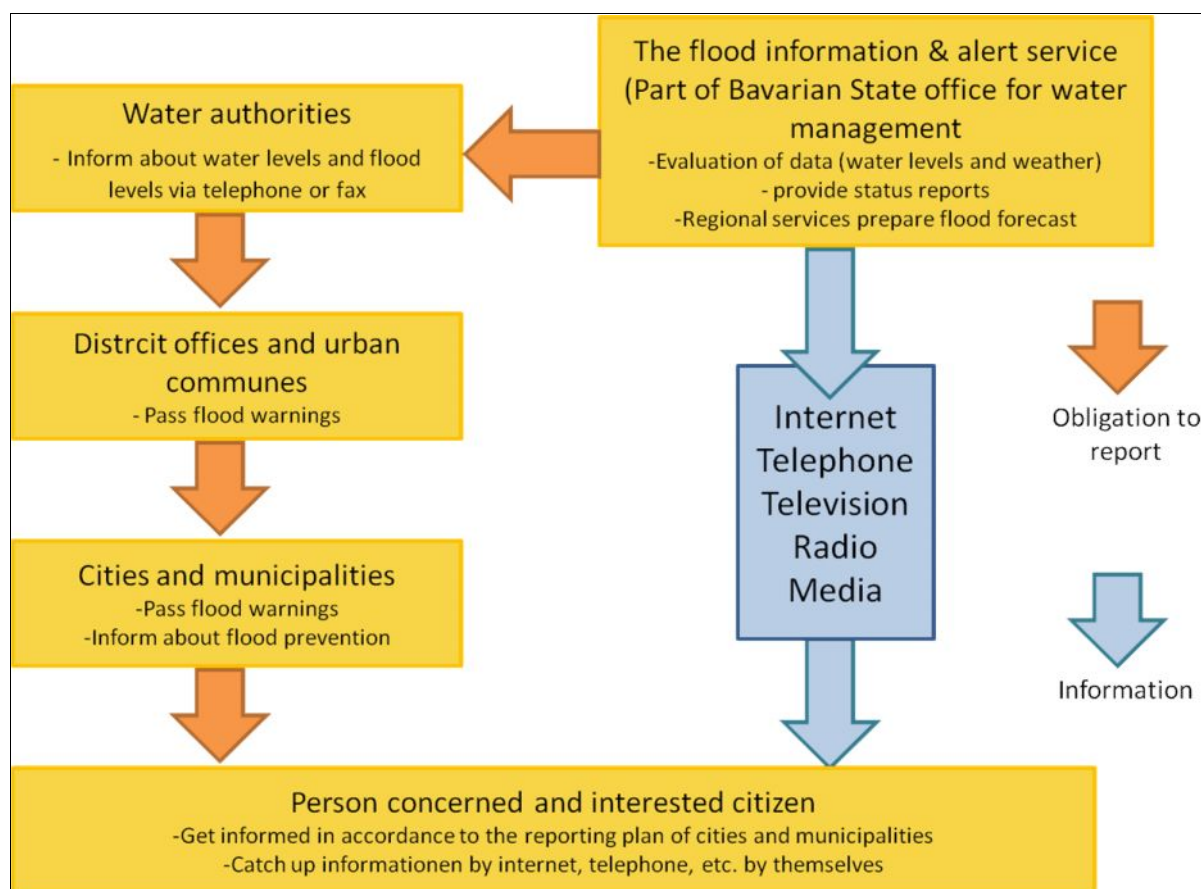


Figure 7.6: The organisation of the flood information and alarm service

7.2.1.5 Spatial Planning Law

Flood protection is also an issue in the overall land use planning. The Bavarian land use planning act (BayLplG)³⁰ instructs that the requirements of water management and the interests of ordered water balance have to be considered in the landscape. This includes particular the supply of water in sufficient quantity and quality for the population and the economy, the pollution control of groundwater and the surface water and flood protection. Overall Bavarian planning authority is the Ministry of Economic Affairs, Infrastructure, Transport and Technology (STMWIVT) as the top planning authority, the governments as higher state planning authorities and the district offices as lower state planning authorities. The concerns of flood protection are integrated into spatial planning in the form of priority and reserve areas. The protection of specific areas is based primarily on the HQ100 floodplains and on areas that are flooded when the water reaches a design flood level of > HQ100.

As already mentioned above, the statutory regulations for flood protection in Germany were updated in many laws, including the Building Code (Baugesetzbuch – BauGB and the Federal Spatial Planning Act (Raumordnungsgesetz – ROG), both under supervision of the federal Ministry of Transport, Building and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung – BMVBS)³¹:

Land use planning act (Raumordnungsgesetz):

³⁰ <http://www.landesentwicklung.bayern.de/rechtsgrundlagen/rechtsgrundlagen-bayern.html>

³¹ http://www.bmvbs.de/DE/Home/home_node.html

- The land use planning act (spatial planning) ensures the timely planning of protection and reclamation measures of wetlands, retention areas and flood prone.

Code of building law (Baugesetzbuch):

- The soil sealing has to be limited to the minimum. In development plans, information about retention and percolation of rainwater has to be noted.

7.2.2 Roles and responsibilities for mapping and users of the flood maps

7.2.2.1 Flood risk management: actors, tasks and responsibilities

Flood risk management plans address all different aspect of flood risk management. A special focus is of prevention on flood risk and flood protection. The plans include appropriate targets and measures to reduce potentially adverse consequences for human health, environment, cultural heritage and economic activities.

Management plans cover the whole river catchments. A common plan or package of coordinated plans can be developed by all countries or states which are part of a river catchment. The process of establishing flood risk management plan can be seen in Figure 7.7³². In Bavaria, management plans are created in coordination with surrounding states and provinces of the catchment areas of the river Danube and Elbe. Management plans are based on flood hazard and flood risk maps. The federal working group on water has agreed on the following fundamental objectives of flood risk management that should be part of management plans within the “Recommendations for the Establishment of Flood Risk Management Plans” (LAWA/b 2010):

- preparedness: avoiding new risks in flood risk areas (in advance of a flood) and reduction of existing risks in flood risk areas (in advance of a flood)
- handling: reduction of adverse consequences during a flood event
- aftercare: reduction of adverse consequences after a flood event

Informing the population and active involvement of interested stakeholders is an essential requirement of the flood risk management directive. Interested parties can be (LAWA/b 2010):

- Planning authorities
- Local communities, government
- Organizations
- Civil protection organizations such as disaster control and emergency services
- Accepted organizations of agriculture, forestry, environmental protection and economy.

These groups get informed about flood hazard and flood risk timely and participate in the assessment of objectives and measures in an appropriate way.

³² http://www.lfu.bayern.de/wasser/hw_risikomanagement_plaene/index.htm

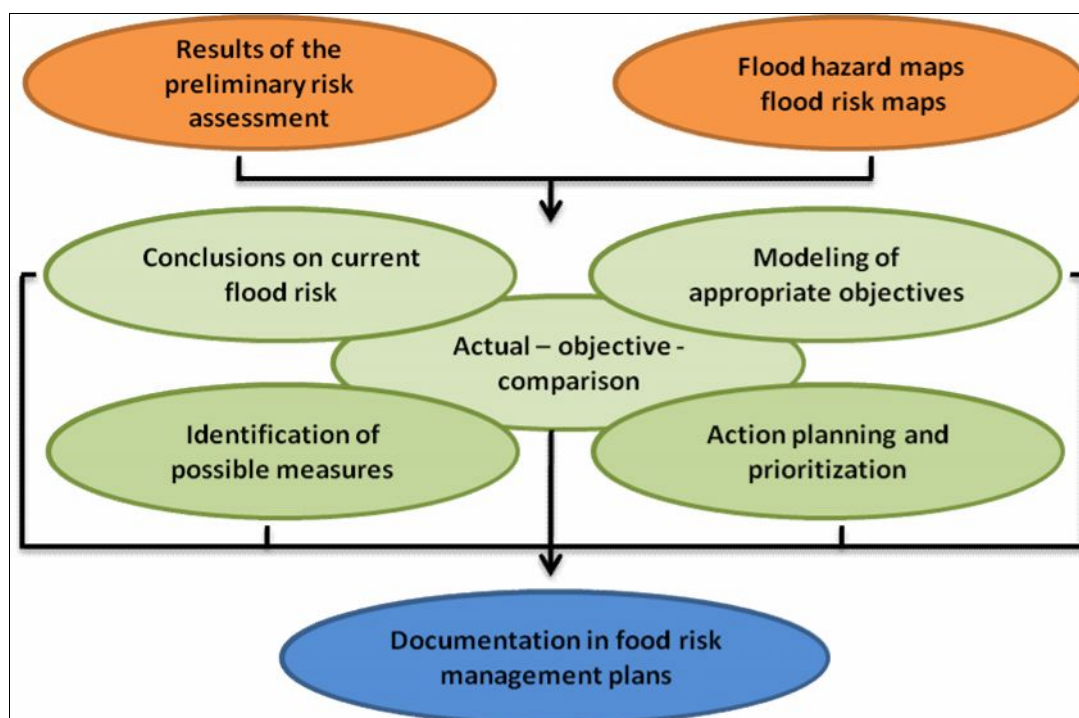


Figure 7.7: Establishment of flood risk management plans

The flood risk management plans have to take into account following aspects (LAWA/b) 2010):

- Special characteristics of the affected catchment
- Information on land use and water management
- Presentation of the extent of floods , the flood flow routes and areas providing potential water retention areas
- Spatial planning, land use nature conservation, shipping and the infrastructure of harbors
- Environmental objectives linked to the water framework directive
- Comparison of costs and benefits on different measures

7.2.2.2 Uses and users of the flood map

The flood hazard maps and flood risk maps have to satisfy all the needs and requirements of the different user groups. Therefore the requirements of the user groups are taken into account for choosing content and design of the maps.

The user groups of the flood hazard and flood risk maps are the same as the federal working group on water has defined (LAWA/a 2010):

- Water Management Administration
- Authorities of regional planning
- Persons responsible for disaster prevention and protection
- Population
- Building owners

- Residents
- Decision makers from industry and business

For the water authorities the maps serve as a basis for concepts of flood risk management and for establishing action-priorities and for the design of flood protection measurements.

Authorities of regional planning use flood hazard and flood risk maps for identifying areas which are binding on the municipal land-use planning (designation / identification of priority and reserved areas). In addition, flood risk maps can serve as a very important decision-making basis. They are used to reduce or even prevent damage risk in the building precaution-business.

Published flood hazard and flood risk maps can help to improve the knowledge among the population significantly. Building owners, residents or decision makers from industry and commerce receive information for the further planning of protection measurements.

7.2.2.3 Flood mapping and planning

The flood maps provide detailed information on flood hazard and flood risk. The information is only provided for water bodies with a potentially high flood risk. They form the basis for the development of flood risk management plans.

Flood hazard maps: Contain information of spatial extent of floods, the water depth, the flow velocity and different probabilities (low probability HQ_{extrem}, mid probability HQ₁₀₀ and low probability HQ₅-HQ₁₀)

Flood risk maps: illustrate possible adverse consequences of different flood scenarios. They point out the risk for human health, environment, cultural heritage and economic activities.

7.2.2.4 Public uses of the flood map

Paragraph 76 WHG defines the duty to supply information to the public. Flood hazard maps, flood risk maps and other flood-related information maps have to be presented and published in print form and in an interactive online map service.

7.3 Current flood mapping practices

7.3.1 Print

HAZARD

§74 Water Act (WHG) in connection to § 6 EU flood directive require the production of flood hazard and flood risk maps for all areas with a potentially significant flood risk. The maps have to provide detailed information on flood hazard and flood risk for water bodies with a potentially significant flood risk. Thus they are the basis for planning, design and development of flood risk management plans. The maps have to be completed by 22.10.2013. The maps, serving as a basis for the management plan, had to be finished by the end of 2010.

Therefore the flood hazard maps contain information about the spatial extent of the flood, the water depth and the flow velocity (where appropriate). Following flood scenarios are covered:

- Low probability (HQ_{extreme})
- Medium probability (HQ₁₀₀)
- High probability (HQ₅, HQ₁₀)

RISK

The flood hazard maps are the basis for flood risk maps. The HQextreme events serve as the basis for the assessment of the so-called residual risk. The residual risk is not covered through construction measurements, which are usually sized for HQ100 events. The municipalities and the citizen can use the maps for decision making to deal with the residual risk.

Flood risk maps display the possible consequences of the scenarios mentioned above. They highlight the risk for human health, environment, cultural heritage and economy. The information about flooded areas is blended with the information of about land use. The potentially affected land-use classes are highlighted.

Following aspects are considered:

- Number of affected population
- Type of economic activity in the affected area
- Installations and facilities listed in den Annex of the EC Flood Directive on prevention of pollution, which could cause widespread pollution in case of a flood
- Protected areas

Print maps are not publicly available. The implementation of Paragraph 76 WHG takes place through the provision of online maps.

7.3.2 Online

Online maps run on a JAVA based online platform, called IÜG Bayern (Informationsdienst Überschwemmungsgefährdete Gebiete – Information service on flood endangered areas), provided by the Bavarian Environment Agency. The IÜG is an interactive map service. The service gives the opportunity to gain an overview of the status of the investigation and determination of flood areas in Bavaria. The map service displays flood plains of frequent, medium and infrequent flood events and water-sensitive areas. If available also water depths, inundation areas and the wrap-around of observed floods can be shown.

In order to address different requirements of the information service, it is possible to choose between a standard and an expert version³³. The standard version provides specified combinations of maps of different themes, and supplies quick overviews to the user, see also Figure 7.8 . In contrast to the standard version, the user of the expert version, Figure 7.9, can choose from a large variety of layers and has the possibility to combine them to different maps. When switching between the two user interfaces the map will be retained.

33 Standard:: Bavarian Environment Agency (<http://www.geodaten.bayern.de/bayernviewer-flood/flood/index.cgi?user=standard&rw=4476080.0&hw=5355340.0&layers=tk50,&step=128.0>)

Expert: Bavarian Environment Agency(<http://www.geodaten.bayern.de/bayernviewer-flood/flood/index.cgi?user=expert&rw=4476140.0&hw=5355340.0&layers=tk50,uesgAll&step=128.0>)

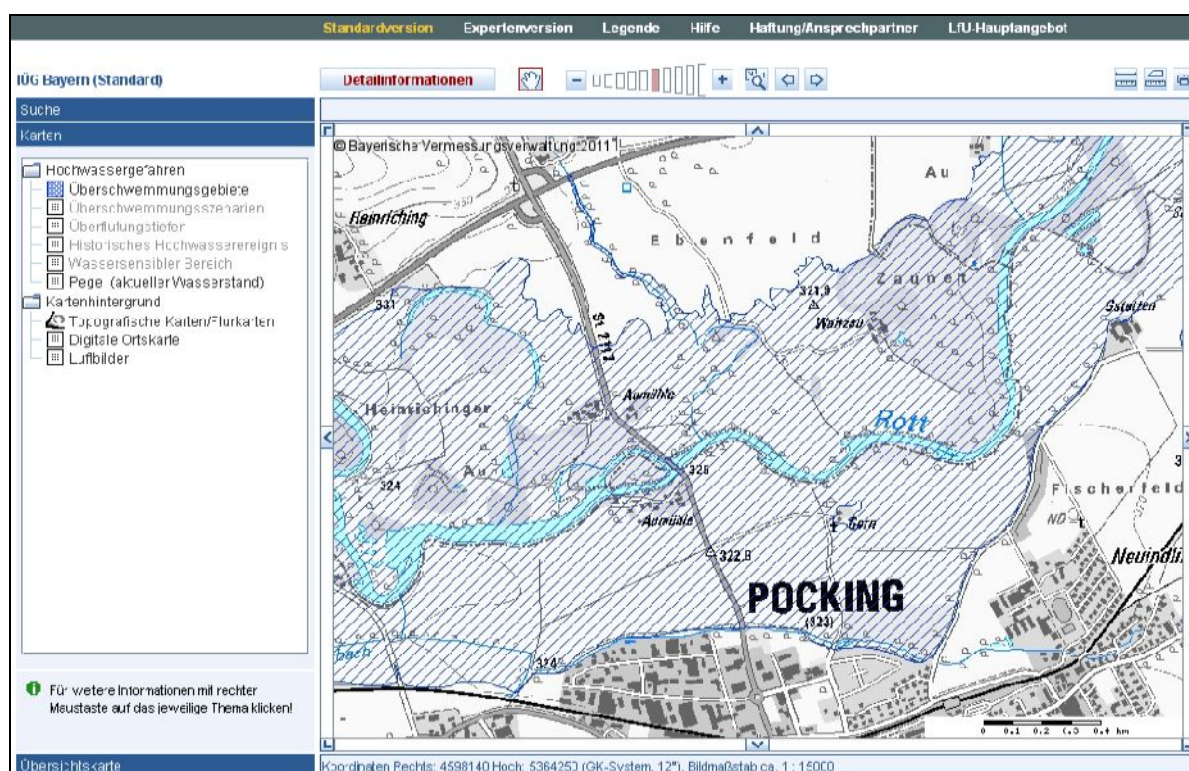


Figure 7.8: IÜG – Standard version, showing Pocking and provisionally secured flood areas

From the scale of 1:400 and higher, only the land register maps are shown in the background. Usually, flood plains are determined on a scale of 1:2,500. IÜG provides a representation of flood plains to 1:1,000. But the system states that the possibility of zooming does not increase the accuracy of the map content of a scale of 1:2,500. Properties can be seen while using the land register maps. Therefore the concernment on individual properties through floods can be read. Drawing inaccuracies in the area of +/-10m are possible. Extreme events are only shown on smaller scales. These areas can only be determined due to uncertainties in the input data with a precision of 1:25,000. Table 7.6 provides an overview of backgrounds used for different scales.

Table 7.6: Selectable scales and background maps for IÜG

Scale	Background
1:1,000 – 1:4,000	Digital land register maps (without plot number)
1:8,000 – 1:30,000	Topographic map 1:25,000
1:60,000	Topographic map 1:50,000
1:120,000	Topographic (Survey) map 1:200,000
1:240,000 – 1:500,000	Topographic (Survey) map 1:500,000

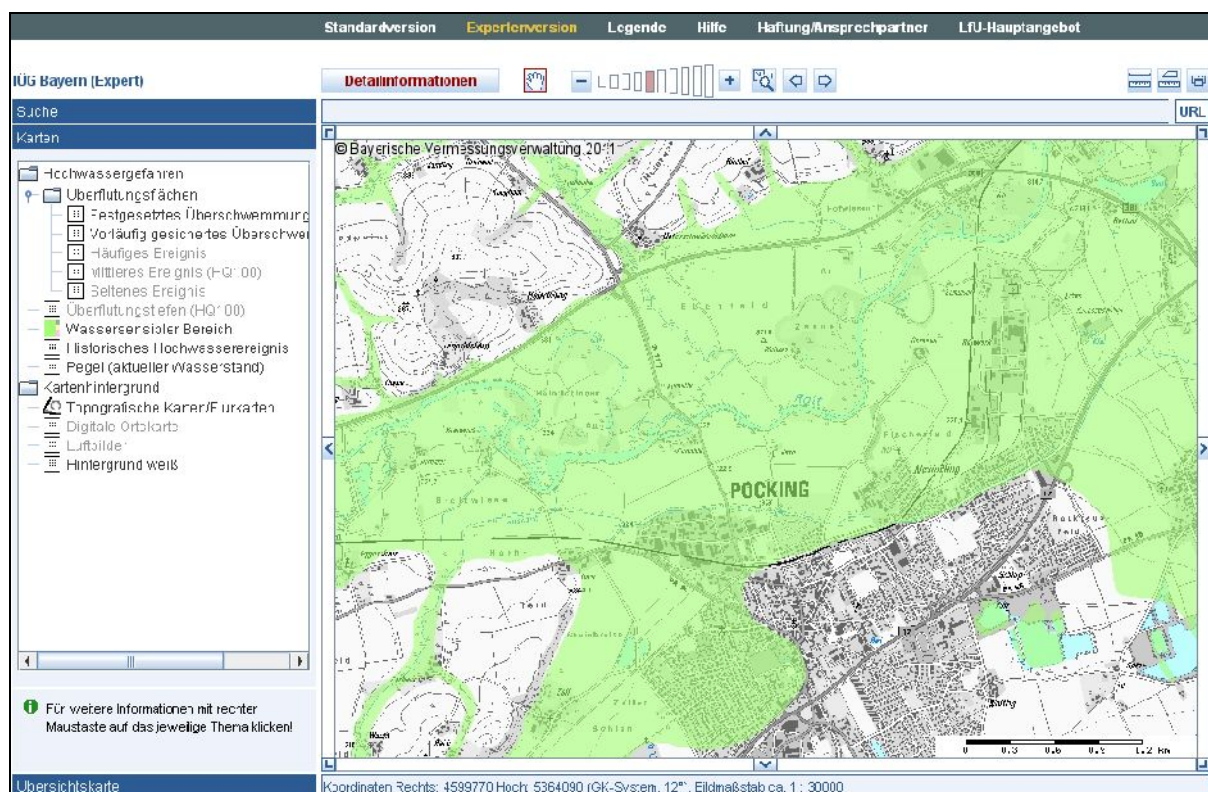


Figure 7.9: IÜG – Expert version, showing Pocking and water sensitive areas.

7.4 Flood hazard and flood vulnerability

7.4.1 Data sources

Data sets from recent events and existing modelling results were used for analysing the status quo. Models are based or calibrated using data from the German national weather service and measuring network of the Bavarian Environmental Agency and Offices. Spatial flood data is based on model results from hydraulic calculations. They are used to determine the flood exposure (the resulting inundation areas) and other parameters such as flow depth and verify the effect of protective measures. A comprehensive evaluation of the data was already done. Modelling techniques, such as hydrological, routing, etc. and historical events were already evaluated.

7.4.1.1 Definition of relevant probabilities

Flood hazard is defined as the combination of the probability of occurrence and the involved / resulting intensity of the event, the flow velocity, the flood rate and the duration of the impounding. Existing model results were derived from the hydrodynamic model HYDRO_AS-2D for design events and different probabilities (HQ10, HQ100 and HQ1000). The model is a 2-dimensional stream flow and water level calculation package which is based on the Finite Volume Method. The Surface Water Modelling System (SMS) was used to perform a 2-dimensional hydrodynamic flood routing.

The model is based on a Digital Terrain Model derived from laser scanning data and terrestrial surveys. Official flood hazard maps are produced for events with return periods of 5, 10, 20 or 25, 50, 100 and 200

or 1,000 years. The maps for the Bavarian Case Study – River Rott use the 10, 100 and 1,000 year return periods.

7.4.1.2 Discharges and critical flow velocities

Factors such as transport processes, flow velocities and shear stress were not taken into account.

7.4.1.3 Water levels and intensity criteria

Water levels and intensity criteria were also not considered.

7.4.2 Flood vulnerability

Risk is the product of an occurrence probability of a negative event and its financial impact. Technically, it is often defined as the product of the elements of risk and vulnerability. Vulnerability is made up by several aspects: life and health of population, impact of the property (movable and immovable property), threat to livelihood and economic fundamental as well as the production, supply and services for the public (Dorner/b et al. 2006).

Vulnerability is directly linked to the consequences of a natural hazard. Numerous issues and problems exist for assessing vulnerability. In contrast to the representation of flood hazard, the methods and data for determining vulnerability, quantifying and visualizing vulnerability are sometimes more difficult to handle. Compared to flood hazard, vulnerability underlies rapid changes which make forecasting hard and clearly shows the need for regular surveys and upgrades (Dorner/b et al. 2006).

The identification of damage potentials seems to be a decent instrument for quantifying vulnerability. Damage potential can be divided in monetary and financially difficult or even impossible to assess damage. A further subdivision can be the distinction between direct damages, caused by the action of flood events, and indirect damages. To avoid monumental data collections, it is also possible to set a vulnerability index for direct comparison between different regions and to refrain from direct financial evaluation. This could be done by using existing geographical and statistical data and the evaluation of national accounts. Floods mainly illustrate humanitarian and economic risks. The affected population and potential economic losses play important roles in the assessment of vulnerability. Environmental damages are not excluded from consideration but are not yet fully included in an economic sense (monetization).

Vulnerability does not always affect an entire region, but depends strongly on the distribution of the water network (density, size of water body, exposure of flood, infrastructure, etc.). It also depends on the distribution of different land uses in the place of interest. Data on different land use, population and wealth are available as they are part of the state and regional planning. They are even available as geographic and cartographic images in GIS. ATKIS data and digital field maps / cadastre maps represent very well the distribution of land uses such as agriculture, forestry, and commercial, residential and mixed buildings and infrastructure on the scale level of communities (Dorner/b et al. 2006).

7.4.2.1 Economic vulnerability

Economic vulnerability can either be defined as direct damages to infrastructure, buildings, installations and movables or indirect damages, such as interruptions in enterprises (forced closure or loss of profits). A possible way of setting economic values for certain areas or building is following: the type and size of the buildings can be recorded from digital datasets of the communality administration and validated by remote sensing techniques as well as field studies. These data can provide the basis for a monetary evaluation of the reconstruction values. These values can then be calculated using the volume of the buildings and average prices per cubic metre according to the type of building (Kranewitter 2002).

7.4.2.2 Special risks (critical infrastructure)

See above, economic vulnerability.

7.4.2.3 Social vulnerability

Social vulnerability included the population itself but also particular facilities, such as hospitals, kindergarten and workshops for handicapped. The number of persons at risk was derived by calculating statistical values to the population at the community level. The number of the affected population represents only an orientation value. In order to indicate especially vulnerable sites, points with a special risk were determined and visualised. Social vulnerability can also be shown not using an orientation value for a certain area but using buildings of special interest. In that special case, buildings of interests are workshops for handicapped, hospitals, schools, etc. The number of affected person, employees or disabled person is well known.

7.4.2.4 Ecologic vulnerability

Ecological vulnerability does play a significant role in case of chemical industry in the respective areas of interest. Ecological vulnerability can often be closely connected to economic vulnerability as losses of or damages to agricultural areas and woodland do not only play an import role in loses of recreation areas and losses of retreat areas for flora and fauna, but also a loss in value or even incalculable damages for nature and owners. The special risks which are mentioned on the maps contain hazardous substances, polluting substances and toxic substances which could cause further ecological damages.

7.5 Risk analysis

7.5.1 Specific definition of risk and methodology for its assessment

The Bavarian Environment Agency describes flood risk in the following way: Flood risk is the product of the probability of occurrence and the size / dimension of a flood event plus the exposure of subjects of protection³⁴.

The European DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the assessment and management of flood risks defines flood risk as follows: “flood risk” means 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”.

In the Bavarian case study, risk analyses were carried out on a large scale. The calculations resulted in quantitative risk for individual objects, and were therefore suitable for larger scales. The maps provided information on exposed building and different categories.

7.5.2 Components of risk assessed

The Indicators of the Directive are:

- Human health:
- Affected population

³⁴ http://www.lfu.bayern.de/wasser/hw_risiko/index.htm

- Residential buildings
- Infrastructure (social and health relevance)
- Centres, agglomeration areas
- Environment:
 - Conservation area
 - Hazardous material
- Cultural heritage:
 - Archaeological sites
 - monuments
 - architectural ensembles
- Economic activity
 - Industrial and commercial parks
 - Trade
 - Infrastructure
 - Centres and agglomeration areas

In the Bavarian case study the components of risk assessed were spatial information and punctual information. The spatial information contained affected areas either residential areas, industrial and commercial parks. The punctual information contained information about areas with hazardous material and social hot spots, for example hospitals and workshops for handicapped.

Not the annual damage was calculated by the exact location of several buildings in risk was provided. The components were classified into three categories.

- Social risk: social hotspots, residential areas, including the numbers of inhabitants
- Economic risk: industrial and commercial parks with specified descriptions of sectors
- Ecologic risk: biotopes and hazardous material

7.6 Map design

The entire set of maps was built up in a landscape format. The legend was placed on the right side. The maximum number of information included was two. Hazard information was given by the visualization of different HQ events. Risk information was provided by graded colours. In addition, information related to special risks (workshops for handicapped, fire department, etc.) was provided by pictograms. A scale bar was included in order to avoid misinterpretation of the scale when adjusting the size of the maps. For better orientation in the area of interest, the names of the river, the municipality and the major roads were given. Because of the international character of the RISK MAP project, all major information was indicated in three languages (English, German and French) in order to meet the requirements of the different stakeholders. The maps should be accessible to all individuals being tested. The orientation as well as copyright and source information was included, too

7.6.1 Map scales

In order to compile a broad variety of large-scale and object-based risk maps, two test sites in Bavaria were chosen: (1) Pocking and (2) Schwaibach. The initial map scale was set from 1:8.000 (Pocking) up to 1:1.700 (Schwaibach). Figure 7.10 shows the flood hazard and flood risk maps designed for the EGS-tests in Tours.

7.6.2 Colour schemes

Colour schemes were chosen related to the findings of the RISKATCH project in combination to European and national regulations for flood hazard and flood risk mapping (Fuchs et al. 2009, LAWA 2010, Sprachinger et al. 2009). The risk information was shown in different classes on individual maps:

- the colours yellow, orange and red were used for buildings with a classified annual damage
- gradient shades of blue were used for buildings impacted by different HQ events
- affected residential areas in red and affected industrial and commercial parks in yellow.

A second colour (grey) was used to show no-data information. A third colour (beige) was used to visualize areas covered by building in general. The information related to the process intensity of the HQ events was shown by a blue colour scheme (with respect to probability of occurrence in relation to vulnerability in decreasing order). Additional information was given by individual colour schemes (fire department: green). Standardized pictograms were used for the additional information like fire department, polluting substances, toxic substances, handicapped workshop and hazardous material.

7.6.3 Graphic map background

The graphic map backgrounds were land register plan (black and white) according to the previous findings of the RISKATCH project (Fuchs et al., 2009a; Fuchs et al., 2009b). Using large scale makes the land owner recognize his own parcel of land (Hagemeyer-Klose et al. 2009).

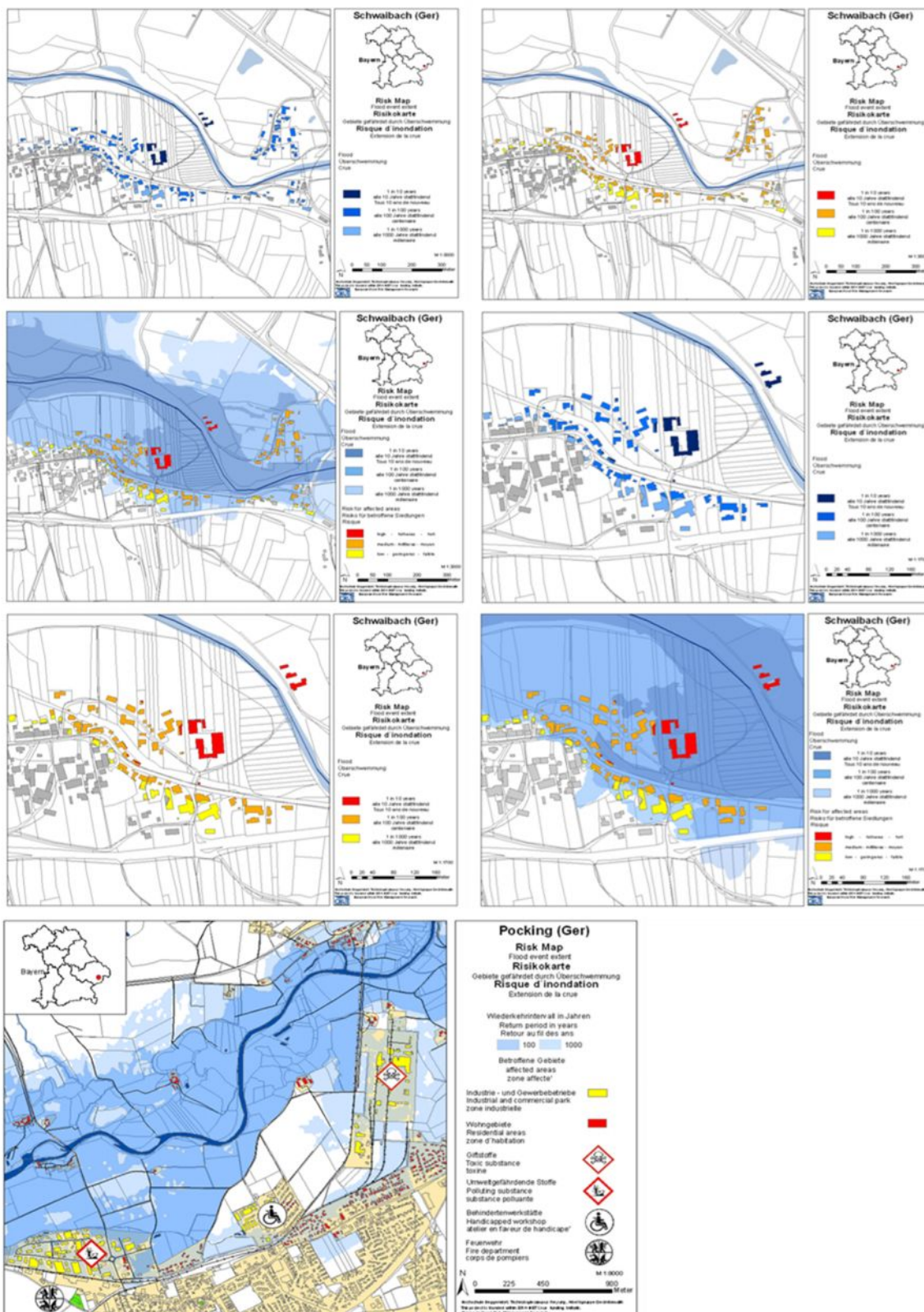


Figure 7.10: Flood hazard and flood risk maps, designed for the EGS tests in Tours, France

7.7 Interview findings

Different interviews had been carried out in den Bavarian case study. The Interviews were undertaken at different places, mainly on-site at the working place of the participants. The interview participants of the University of Applied Sciences Deggendorf were members of the disaster control and emergency service. Therefore 8 representatives of fire brigades and relief organization (Maltese) participated at the interviews, but also members of the federal armed forces.

The overall aim of the interview-series was to identify the specific needs and requirements of specific end-user groups in the project. The interview participants were asked the same questions like the participants of the workshops. The questionnaire was separated into 5 sections, going from

- general question about occupational background related to disaster management,
- questions about experiences with geographical information systems,
- questions about operational experiences in disaster protection and disaster management,
- questions about the maps in general but also special flood maps
- and visual and content aspects concerning flood hazard maps and flood risk maps.

Further information about the activities and the findings of the interviews can be taken out of chapter 9 – Workshops in Bavaria, as the results of the interviews and the workshops are the same.

7.8 Workshops in Bavaria

The first workshop had been carried out in den Bavarian case study. The workshop took place at the Technologie-Campus, a branch of the University of Applied Sciences, Deggendorf, on August the 28th 2010. The Interviews were undertaken at different places, mainly on-site at the working place of the participants.

The second workshop will take place on September 15th 2011, again at the Technologie-Campus Freyung. All stakeholders of the interviews and workshop of the first round are already invited.

7.8.1 Aims of the workshops

The overall aim of the workshop and the interview-series was to identify the specific needs and requirements of specific end-user groups in the project.

The aim of the second workshop is to confront the different user groups with the flood hazard maps and flood risk maps, improved and produced during the first phase of the project and testes via eye-tracking (EGS), and to foster discussions of possible adjustments of the current suggestion for implementation.

7.8.2 Participants

The stakeholders of the University of Applied Sciences Deggendorf were members of the disaster control and emergency service. Therefore representatives' of the District offices of the administrative districts Deggendorf (Danube valley) and Freyung-Grafenau (Bavarian Forrest), Maltese relief organizations (Danube valley), Fire brigades (Danube valley) and Federal Armed Forces, stationed in the Bavarian Forrest, participated at the workshop and interviews.

7.8.3 Workshop design

The workshops and interviews provided information about the intention and the objectives of the stakeholders, which underlined the actions of the user groups. The interviews and workshops were moderated discussions. The questions pointed at the use of maps and frequency of uses of flood hazard and flood risk maps and regional differences of maps. Preferences in content and visualisation of flood hazard and risk maps were asked as well. The stakeholders were separated into different user groups

7.8.4 Workshop activities

The first workshop was designed as a moderated discussion with participants from the local district office, section disaster management. Following questions were used to guide through the discussion:

- Questions about the operational experiences in disaster protection and disaster management (field of application, influence on decision-making)
- Questions about the use of maps in general and the (special) use of flood maps (experience in dealing, assessment of the usefulness of different flood maps, use or rather the purpose) – for these questions; Saxon flood maps were presented to the workshop participants as they provided a wide variety of different flood maps.

The next questions made up the main part of the workshop. The open discussion was divided into three blocks, all focusing on needs and preferences on visualization and content on flood hazard maps and flood risk maps. After providing an introduction in flood hazard, flood risk and mapping procedures and even flood hazard elements such as probability of occurrence, the different blocks started with brainstorming sessions, followed by the collection of different ideas for needs and requirements on visualization and content by the workshop leader. The blocks were delimited in content as followed:

- Which information on flood hazard do you want in flood hazard maps and how should it be presented?
- Concerning possible consequences of floods, which information do you want to be part of flood maps and how should it be presented?
- Which informant on disaster protection and disaster management do you want to have on flood maps and how should it be visualized?

7.8.5 Workshop findings

7.8.5.1 Flood experiences

Depending on the professions and the locations, the majority of the stakeholders were not experienced with floods. Especially employees of the district offices and military service in the Bavarian mountain, the Bavarian Forest were not familiar with floods so far. Only the stakeholders in the Danube valley gained experience in floods. The rivers located in the Bavarian Mountains and the local residents do not suffer from floods, but at the estuaries in the Danube Valley all the more.

7.8.5.2 Capturing flood experiences through mapping

During the interviews and workshops no specific question has dealt with that point. But the stakeholders were asked about the general usefulness of flood hazard maps and flood risk maps. The stakeholder had the chance to vote from 1 (not useful at all) to 5 (very useful). Everyone agreed that flood maps are useful to very useful. Only values of 4 and 5 were given.

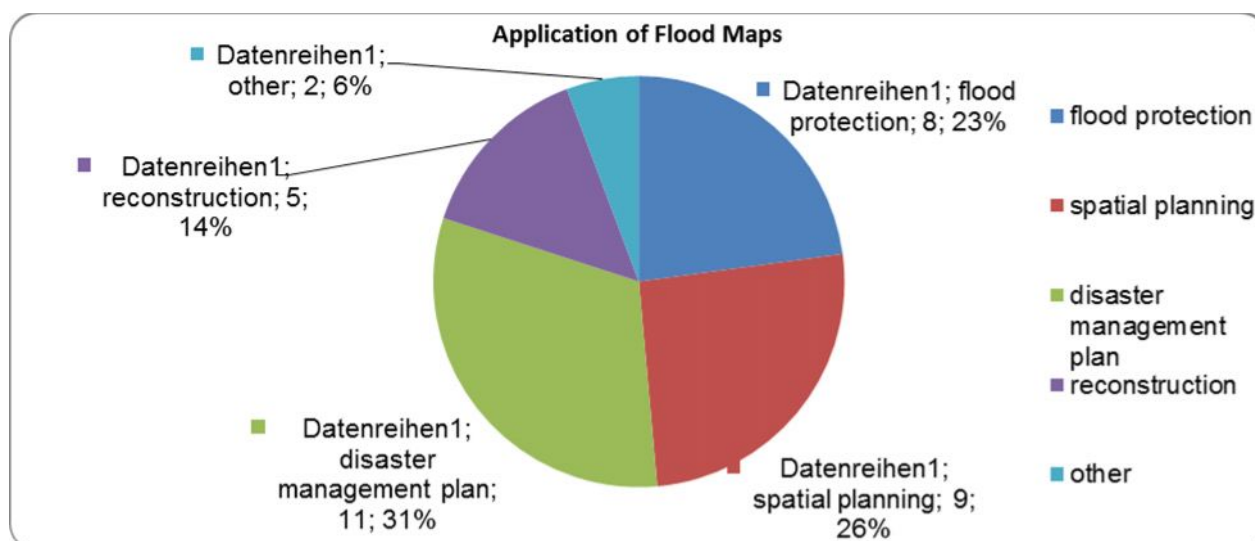


Figure 7.11: Application of flood maps

7.8.5.3 Use, experiences and opinions of the current flood maps

As already mentioned before, the use of and, incidental, professional experiences with flood maps of the stakeholders were rather rare. The stakeholders were therefore asked about possible application of flood maps. The majority of the stakeholders felt disaster management plans and spatial planning to be the most important application field of flood maps, see Figure 7.11. Flood protection was also mentioned several times. Other applications such as citizens / house owner, ambulance transport/supporting staff, but also shipping were mentioned

Confronted with other disaster aspects, the use of flood maps on a professional way is rather rare. A small majority of the stakeholders' uses flood maps professionally. The use of maps in jobs is limited for employees in district offices of districts located next to the river Rott, Inn and Danube and members of emergency services.

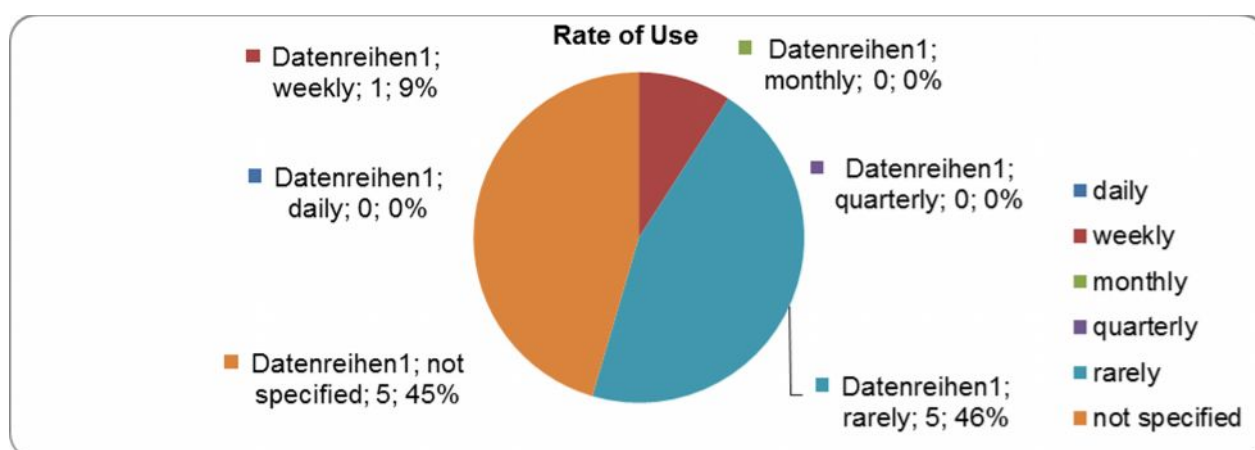


Figure 7.12: Evaluation of the rate of use of flood maps

Figure 7.12 shows the rate of the use of flood maps, not specified in flood hazard and flood risk maps. The majority uses flood maps rarely or did not specify the answer. The rare use can be explained through the rare occurrence of flood in the catchment areas of the river mentioned above.

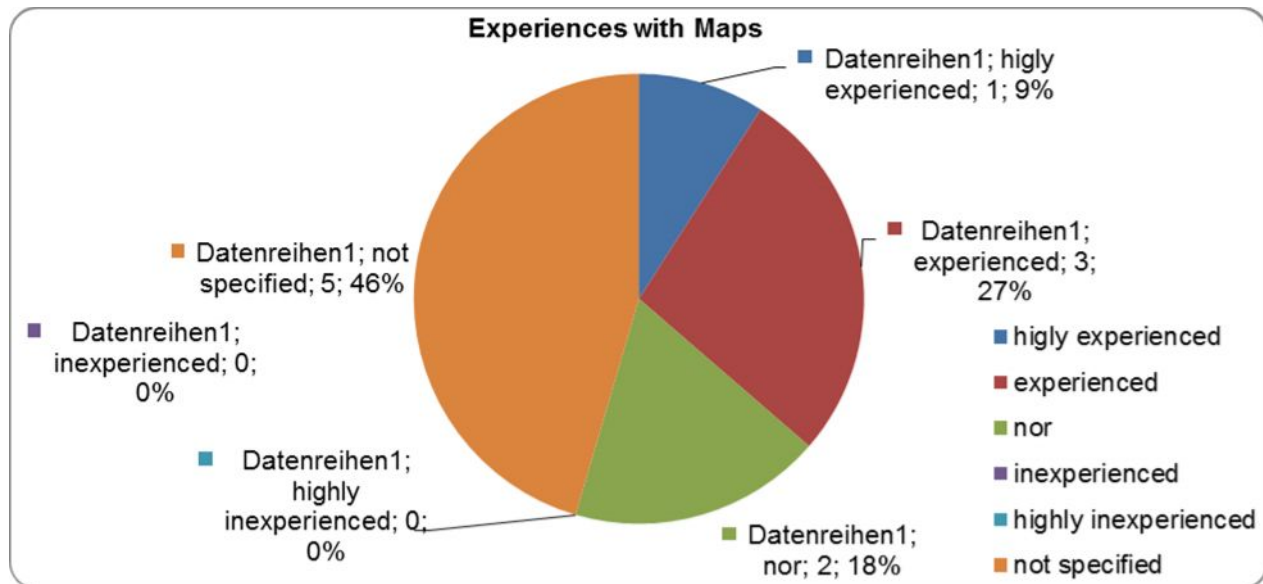


Figure 7.13: Evaluation of the experiences with flood maps

The experiences vary from highly experienced to none experienced at all. The number of none experienced stakeholders matches with the number of stakeholders who do not use flood maps in jobs, see Figure 7.13.

Content and design of different flood maps were tested with flood maps from Saxony³⁵. The supply of Bavarian flood maps is rather small. The tests helped gathering different opinion about current flood maps. Different questions were asked about the considered usefulness of following maps.



Figure 7.14: Intensity Map HQ100

HQ100: For further planning activities in flood protection, the flood event HQ 100 is of particular importance. For example, the protection of settlements, infrastructure and industry is often focused on this event. The map shows the flooded area at HQ 100 of water bodies at first order and the Elbe, the water depth is shown by colour gradation.

³⁵ Source: Saxon State Office for Environment, Agriculture and Geology /Saxon Flood Center:
<http://www.umwelt.sachsen.de/umwelt/wasser/en/index.html>

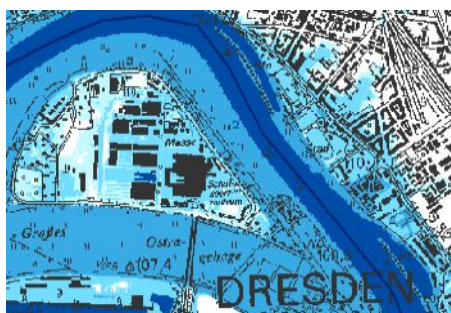


Figure 7.15: Flood Hazard Maps for Sites

Site: The flood hazard is determined by the occurring water depth, flow velocity and also by the annuality (statistical recurrence interval in years). The map displays the hazard for settlements (villages) shown for water bodies of the first order and the Elbe. Annuality can be chosen from 20, 50, 100 and 200/300.



Figure 7.16: Hazard Map

Hazard Note: The hazard map consists of two different parts. I. damage potential maps: shows possible potential damages in case of extreme flood events. II. Flood maps: shows flood areas of different flood events and also the intensity on the basis of water depth and specific discharges for extreme events.

Inundation Area: Authorities define flood areas by regulations. In fixed areas certain requirements have to be applied, to avoid aggravating flood risks through constructional activities or other. The flooded areas have been identified for water bodies at first and second order by the WHG (Wasserhaushaltsgesetz) and defined by SachsWG (Sächsisches Wassergesetz).



Figure 7.17: Flood Inundation Map

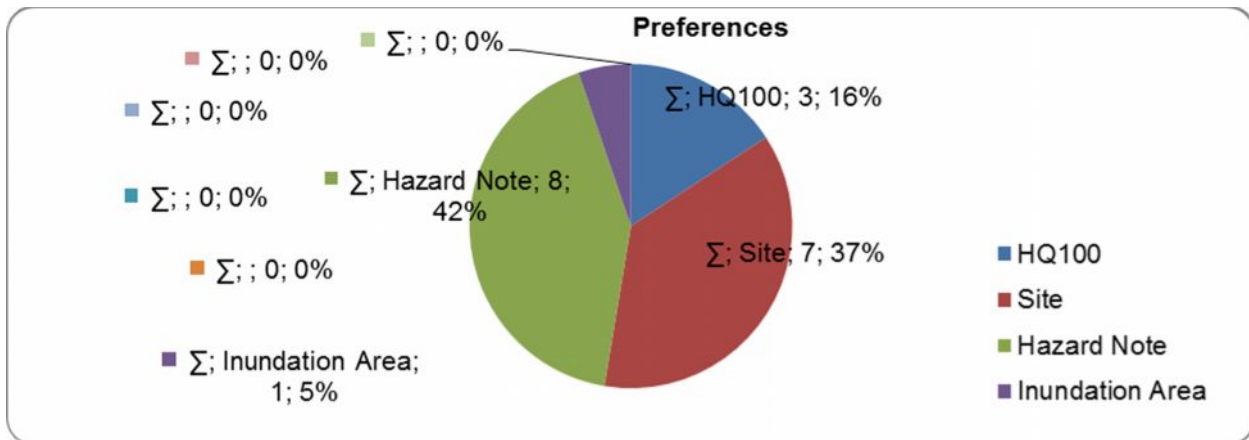


Figure 7.18: Mapping preferences

After looking at the different maps and discussing the differences, the majority of the stakeholders figured out flood hazard maps for residential areas and hazard maps in general to be the most effective and efficient maps. The so called “damage potential maps” shows the damage potential and the potential risk for selected objects, the hot spots. Showing the exact locations of different objects at risk, mainly corresponding to social risk like hospitals, kindergarten, etc. the stakeholders, representatives of emergency services and disaster control considered the maps as most reasonable.

7.8.5.4 Mapping preferences

In the first step colours were tested. Different colour categories for the visualization of hazard (inundation area and water depth) were preferred by the user groups of the disaster control and emergency services. The graduation of colour had been retained in different classes, but the colour was changed. Gradual shades of blue stayed the same for areas without technical flood control measurements. Gradually shades of red turned out to be preferred for flood protected areas.

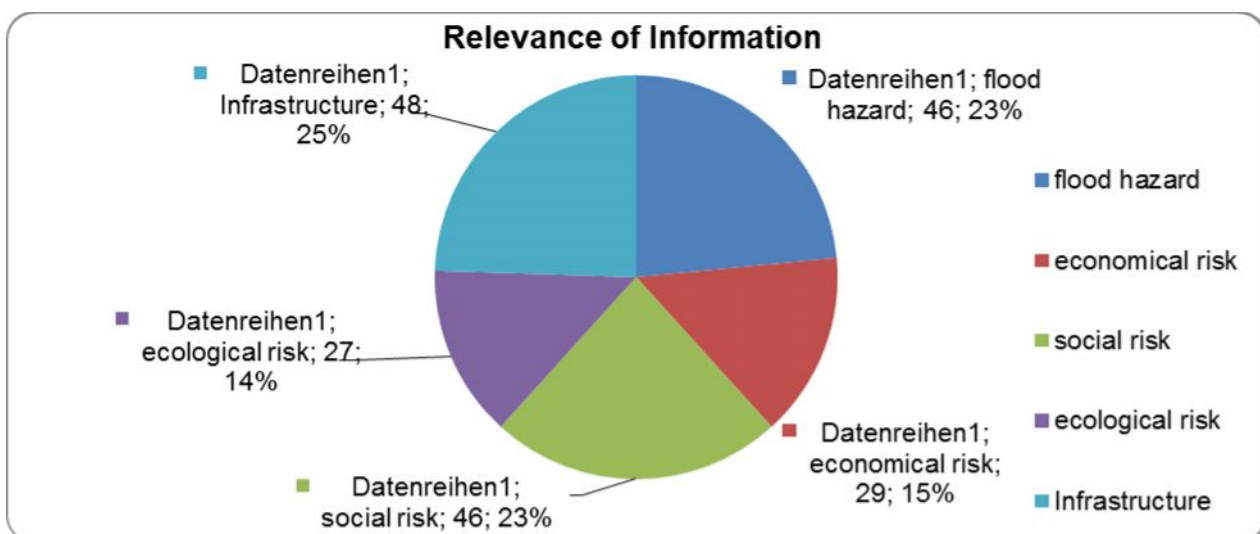


Figure 7.19: Relevance of Risk Information

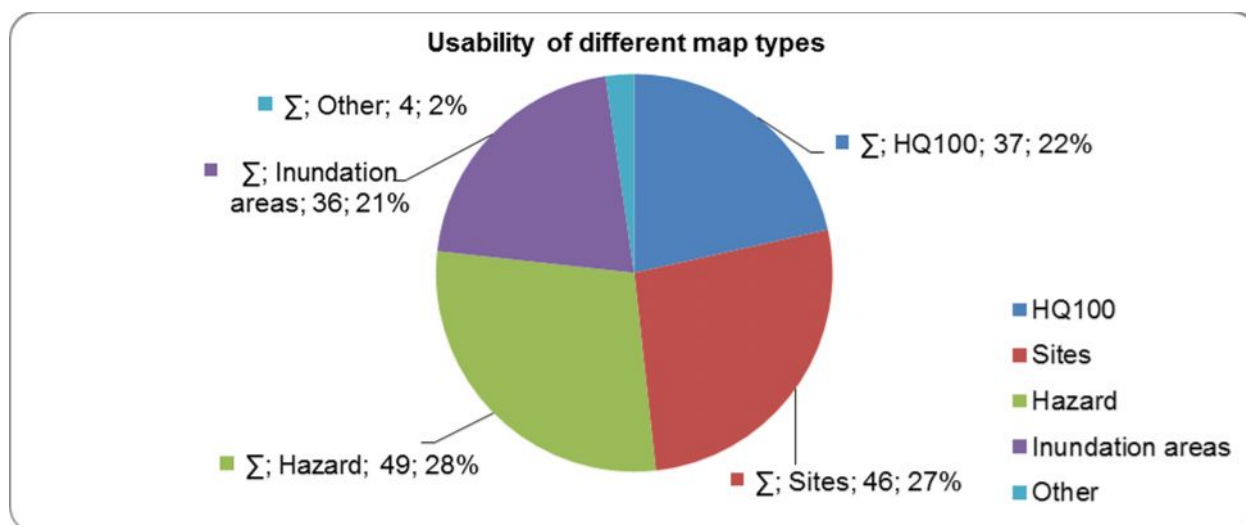


Figure 7.20: Usability of different Map Types

In the second step the mapping of risk elements was tested. The mapping of risk was carried out by adding significant symbols of or at risk (poison sites, hospitals, sheltered workplaces etc.) or the risk (economical, ecological or social risk) was presented by using colour gradations. An addition to areal information might be the selective presentation of the so called risk hotspots. Risk elements can be separated into economic (industrial sites, commercial or business premises, etc.), ecologic (agricultural areas, biotopes, etc.), social schools, etc.) and infrastructure [Sprachinger 2008]. The researchers and stakeholders recommend both, the areal and selective pointed presentation of risk. Issues mentioned are related to large scales (>1:25.000).

Depending on the need of information, other scales are required. Up to now large scale maps play an important role in flood hazard and flood risk mapping. The different user groups of disaster control and emergency services ask for maps of mid-scale (1:100.000 – 1:500.000). Some groups of the disaster control depend on larger areas for the planning of far-reaching actions or for an overview of the endangered area.

As shown in Figure 7.19 the stakeholders evaluated the information on social risk and infrastructure plus the actually information about the flood event – the hazard, including water depth, flow velocity, etc. – as most relevant. Combining all three of these, water depth plus infrastructure plus hot spots at social risk, information about evacuation routes can be drawn. Providing just mentioned information will make disaster management a lot easier. Figure 7.20 shows the usability of the different flood maps used in Saxony. The parts of the pie are fragmented very equally. Although stakeholders of disaster management an emergency services prefer only two of the presented maps, all maps have their own circle of application and circle of influence.

The maps (Figure 7.21) include the mentioned needs and requirements of participants of disaster control and emergency management. The maps are a first try of integrating risk information via pictogram, for social hotspots and hazardous substances, but also the possible use of different evacuation routes. The maps will be presented to the stakeholders during the second workshop. Changes in content and design, the needs and requirements of flood risk maps can be discussed again.

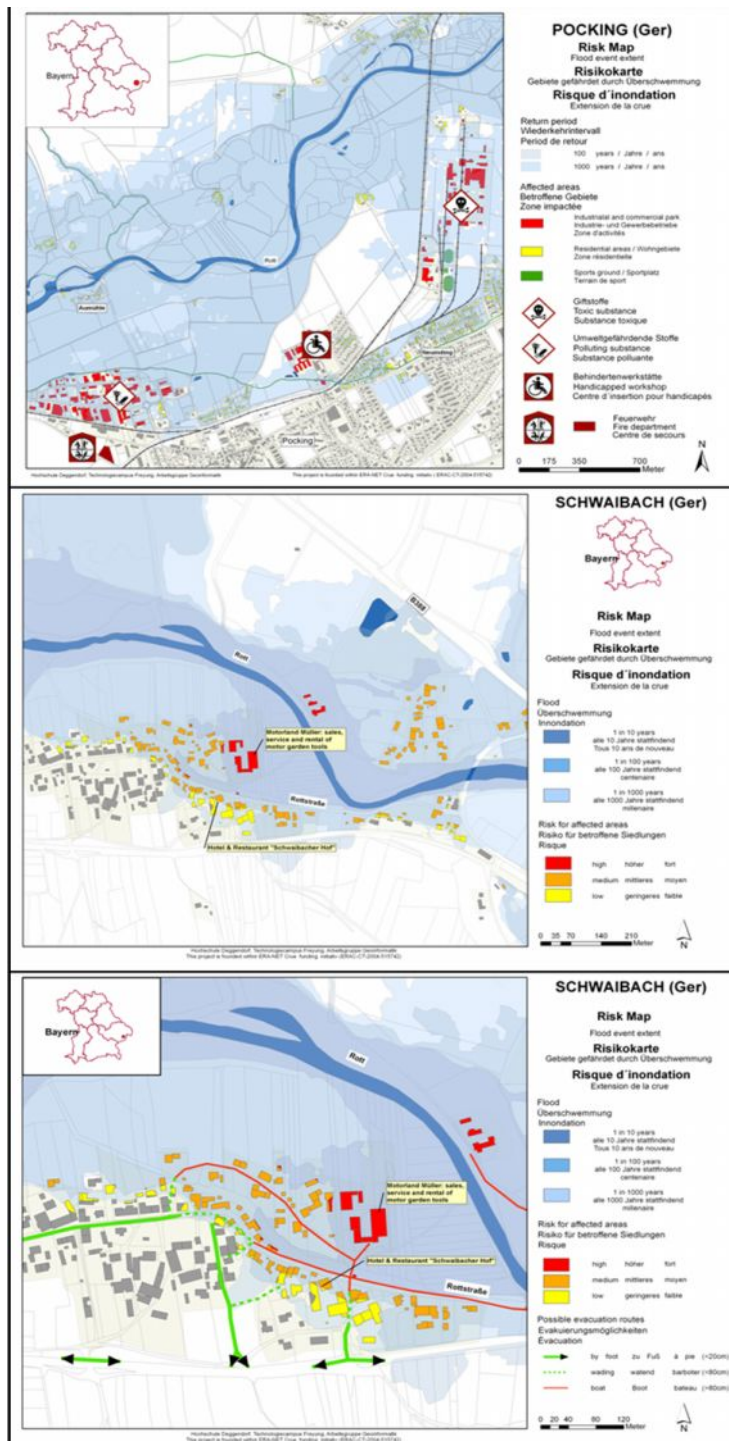


Figure 7.21: Remodelled maps from the EGS-test in Tours, France, presented at the 2nd workshop

7.9 Case study-specific recommendations

Clear preferences and results have been evolved out of the cognitive survey and the eye-tracking tests for content and visualization of flood hazard maps and flood risk maps. The stakeholders' of the workshops and interviews in the Bavarian case study recommend following aspects. The aspects are separated into 3 different classes, content of maps, visualization of content and visualization in general.

Content of maps:

- Social risk: the relevance is associated to facilities with a high concentration of immobile persons, such as residential areas for the elderly, hospitals and care facilities. The risk for humans was figured out to be most important
- Infrastructure: providing information about different elements at risk does only make sense, when also providing information about usable infrastructure in case of a flood.
- Hazard information of different events (water depth, flow velocity water level, etc.) is linked to infrastructure because it gives detailed information about the possible use of evacuation routes related to different water depths. Hazard information is an important factor for operational planning, because flood hazard maps work as a basis for decision making. Parameters like flood extent, depth and flow velocity describe the intensity of a certain flood event. These parameters are of major constraints for the scheduling of material and personal needs and in particular the access to areas or even the way out through evacuation routes.

Visualisation of content:

- Routes of evacuation and possible use of routes: is directly linked to hazard information and should be separated into routes of evacuation only usable by foot, wading, and by boat.
- Pictogram for different buildings and different uses and capacity: Flood risk maps can either be complemented by distinctive symbols (e.g. poison sites, sheltered workshops or hospitals) or present risk economically, socially or ecologically with the help of gradated colours. The participants favour the selective (point) presentation of risk information.

Visualisation in general:

- Different scales (large scales for details (evacuations routes, hot spots, etc.) and small scales for overviews): In matters of the scale the participants showed a large band width for possible visualization formats. Depending on the area of interest and responsibility the opinion of the participants went from large-scale maps for detailed observation of specific areas up to small-scale representation at the level of whole districts and federal states.
- Pie charts and bar charts as information devices in connection to HQ100 and higher: as large band width in scales is needed by stakeholders from emergency management and disaster control, information about person at risk or hazard information has to be displayed on smaller scales, like 1:100.000 and down. Therefore pie charts and bar charts can be used, for example bar charts: the longer the bar, the greater the risk and the pie chart: the larger the pie, the greater the risk, separated into different colours, presenting social risk, etc.

Additional recommendations:

Very important seems to be the visualization of storages of material and technical equipment of disaster control and emergency services. The visualization of hot spots for storage for technical equipment but also hazardous materials, monuments or hospitals, etc. was considered as positive. Further aspects concentrated on the safety of different areas at risk, such as dikes and possible weak spot, and on buildings which pose a danger, such as power plants.

8 Case study France (Le Val de Tours)

Kamal Serrhini, Gaëtan Palka

8.1 The case study area

(For more details see Section 12.3 French case study.)

8.1.1 Physical geographic features

8.1.1.1 Le Val de Tours

The Loire is the longest river in France (1020 km) with a pluvio-oceanic hydrological regime meaning that flow rate is very variable according to rainfall and place.

The Val de Tours-Val de Luynes is an area between the Loire and Cher, extending over 26 km from the cliffs of Montlouis-sur-Loire to the confluence of the Loire and Cher. Its total surface area is therefore around 4600 hectares.

The Val de Tours-Val de Luynes is the reference area for the Flood Risk Prevention Plan (*Plan de Prévention des Risques d'Inondation* or PPRi) undertaken over the agglomeration of Tours. From east to west, this includes 19 boroughs³⁶ affected by flood risk.

The Val de Tours is a highly urbanized area. Tours is the main city and extends through the whole of the central area of this part of the valley. Other towns like Saint-Pierre-des-Corps, la Ville-aux-Dames or la Riche are also entirely located within the Val de Tours and highly urbanized. Saint-Genouph and Berthenay, small towns which retained their rural character until recently, are now quickly becoming more built up, and are also entirely located within the lower part of the Val. Montlouis is upstream with part of its territory within the Val.

On the Loire's right bank, other towns under threat of flooding are Rochecorbon and Saint-Cyr-sur-Loire, as are the Tours suburbs of Sainte-Radegonde and Saint-Symphorien.

South of the river Cher, the floodplain includes all or part of the towns of Larçay, Saint-Avertin, Joué-les-Tours, Ballan-Miré, Savonnières and Villandry.

³⁶ In Villandry, Berthenay, Savonnières, Saint-Etienne-de-Chigny, Luynes, Saint-Genouph, Fondettes, Ballan-Miré, la Riche, Joué-les-Tours, Saint-Cyr-sur-Loire, Tours, Saint-Pierre-des-Corps, Saint-Avertin, Rochecorbon, la Ville-aux-Dames, Larçay, Vouvray and Montlouis-sur-Loire.

8.1.1.2 Flood defences

The Val de Tours is entirely diked. There are three main levees as well as other reinforcements: The levée, along a 28 km stretch of the Loire, extends from the cliffs at Montlouis as far as the confluence of the Cher and the Loire. This levée has been reinforced several times and diking has been enhanced in two places at Saint-Genouph and Berthenay.

The dike along the Cher known as the Levée de Rochepinard, is upstream from Tours and has been reinforced along its full length. Downstream, going through Tours, certain pieces of ground have been banked up so a new district (Les 2 Lions) could be built. These embankments serve as flood protection.

The third levee is the along Cher valley downstream from the ring road to the west of Tours. Winding over 18 km, it connects with the Loire levee at the confluence between the Cher and the Loire.

The A10 highway, built along the line of the former canal joining the Loire and the Cher and which is diked to either side, could also be an effective rampart for the City of Tours.

8.1.2 Human geographic features

A large population at risk

With **284 885 habitants**, the *Tour(s)plus* agglomeration is the largest urban area in the Centre Region and makes up **47,7%**³⁷ of the total population of the Indre-et-Loire department.

By itself, the City of Tours has **137 046 inhabitants**. 40 000 people live in an area at risk while the Figure increases to over 75 000 people directly at risk of flooding, when people coming to work in such areas are included.

Therefore, the employment area that Tours represents is a hazard characteristic of flood risks: **38 % of companies** in this area of employment are located within the flood area³⁸.

Tours further has a university teaching hospital (CHRU) with potentially over **2000 patients**³⁹. It is also the biggest employer in the Centre Region with a staff numbering close to **7700**.

8.2 Previous experience of flooding

The Department of Indre-et-Loire is under threat of 4 types of flooding⁴⁰:

River flooding:

Plain floods are an important factor in the Department of Indre-et-Loire due to the many rivers: the Loire, the Cher, the Indre, the Vienne and the Creuse. The agglomeration of Tours is affected by the Loire and Cher rivers alone. Concerning the Loire, the floodplains are, as was said above, protected by levees or dikes. If these defences are not submerged, the system should limit the spread of flooding and contain the water within the riverbeds that are diked.

Dike collapse:

37 See: <http://www.agglo-tours.fr/index.php?idtf=178>

38 C. Larue, N.-G. Camphuis, N. Bauduceau, D. Andrieu, H. Beraud, C. Blondel, A. Bournot, Ch. Demazière, A. Paget, Y. Hassani, K. Serrhini, « Développement d'une méthodologie de mise en perspective des dommages économiques à l'échelle du bassin fluvial de la Loire -METHODOLOIRE », rapport final pour l'EP-LOIRE, décembre 2009, 152 p.

39 See: <http://www.chu-tours.fr>

40 See: 'Dossier Départemental des Risques Majeurs', DDE37, Préfecture d'Indre-et-Loire, SIDPC, 2005, 96 p.

Building dikes along the Loire and Cher has meant that flooding could potentially be more violent and dangerous, leading to **flooding caused by dike collapse**.

It was this type of flooding that affected the city most seriously on three occasions when levels of the Loire rose in **1846**, **1856** and **1866**. Serious damage to the City of Tours occurred during these three flood events.

During the **1856** flood (highest known level), the levee on the Loire collapsed by La Ville-aux-Dames, and the dike at Rochepinard was breached. The flood affected the historic areas of the city. Loire flood levels reached **+7,52 metres** by the Wilson bridge and the flow rate **6800 m³/s**. In some places in the city centre, water levels reached depths between 1 and 2 metres.

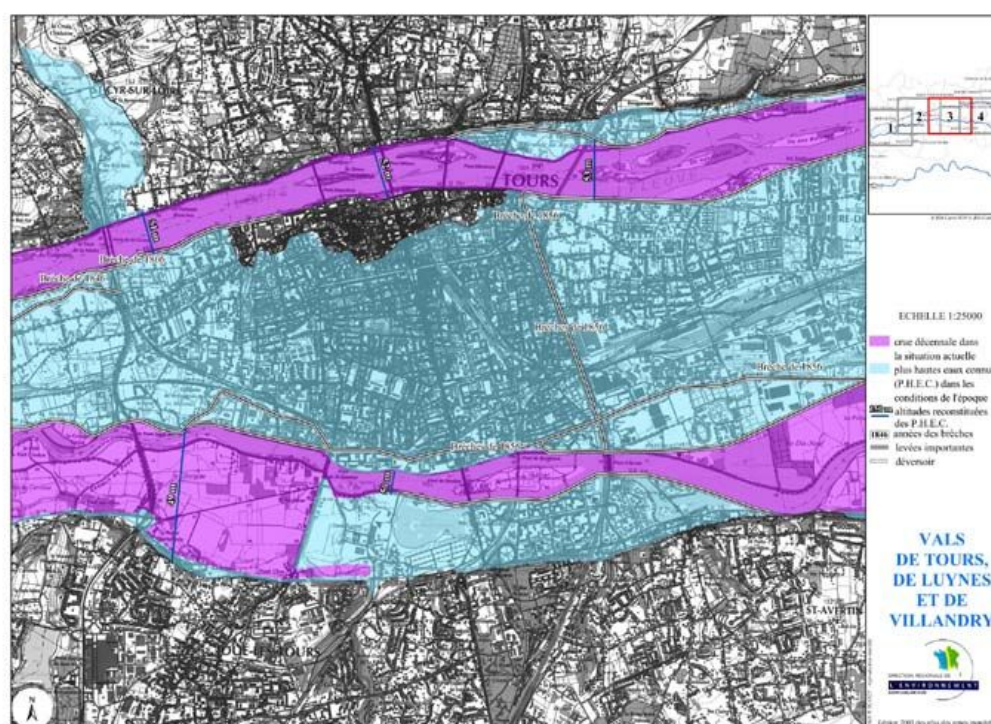


Figure 8.1: Highest known flood levels⁴¹

Flooding caused by increase in water table:

Floods caused by an increase in the water table are not usually high but can be so during a flood (basement flooding...).

Flash flooding due to water runoff and mudslides:

Can be caused by heavy rainfall and storms.

Summary of previous flooding:

The Val de Tours is diked along its entire length⁴² and has been subject to many floods, the most serious of which occurred in the 19th century (see Table 8.1⁴³ below).

⁴¹ These atlases can be consulted on: <http://cartorisque.prim.net/>

⁴² According to the *Service Interministériel de Défense et de Protection Civile* (SIDPC) from the Préfecture of the Indre et Loire department, the worst scenario would be the collapsing of a dike. A flood due to the banks bursting can be foreseen roughly 48 hours ahead and the *Plan de Secours Spécialisé* details steps to be taken for evacuating and protecting people and property. Yet the Plan depends entirely on the dikes' resistance. Damage caused by the banks bursting is completely unforeseeable.

Table 8.1: Historic flood levels in Tours

Date	Height (m)	Flow m3/s
October 1846	7,15m (Wilson bridge level) (Z0 = 44,60 m NGF)	5900 m3/s
May-June 1856	7,52m (Wilson bridge level - Loire) 6,25 m (Sanitas bridge level – Cher)	6800 m3/s (Wilson bridge level)
September 1966	6,59 m (Wilson bridge level)	6200 m3/s (Wilson bridge level)
October 1907	5,61 m (Wilson bridge level)	
January 1982	3,82 m (Wilson bridge level) 4,07 m (Sanitas bridge level)	3400 m3/s (Wilson bridge level)
December 2003	3,40 m (Wilson bridge level)	3000 m3/s (Wilson bridge level)

8.3 Val de Tours – background information

8.3.1 Legislative context of flood risk mapping and development of the current flood map and online information service

Law dated 22 July 1987, an Act concerning civilian safety, forest fire protection and major risk prevention:
Art. 1: 'Civilian safety involves risk prevention of whatever nature as well as the protection of people, property and the environment against accidents, disasters and catastrophes. Making ready safety measures and implementing the means necessary to deal with major risks and catastrophes is ensured by the present Act. Details are set out in the emergency aid plans known as **Plans Orsec** and **Plans d'urgence**.'

Art. 21:

'Citizens have a right to be informed about the major risks they face in certain areas of France and the safety measures concerning them. This right applies to technological risks and foreseeable natural risks.'

Law concerning water dated 3 January 1992:

Article 16:

'In floodplains and other floodable areas ... the preservation, restoration or extension of flood areas.'

Interministerial Circular dated 3 January 1994 concerning the prevention of flooding and flood area management:

Suggests 'that human activity be banned in the most dangerous areas, where people's safety cannot be fully guaranteed no matter what the defence systems are, and limited in flood-prone areas.'

Law dated 2 February 1995 on increased environmental protection, the so-called '**loi Barnier**':

Suggests establishing the Risk Prevention Plan (**PPR**) which will 'restrict the areas exposed to risk while taking into account the nature and intensity of the risk involved [...], to restrict areas that are not directly exposed to risk but where building, engineering and development projects [...] might aggravate the risks[...]'

⁴³ "Plan communal de sauvegarde (PCS) de la ville de Tours". Mairie de Tours (City Hall), April 2010.

The Law to modernise civilian safety dated 13 August 2004:

Art 1:

'Civilian safety will prevent risks of whatever nature, and inform and alert residents as well as protect people, property and the environment against accidents, disasters and catastrophes by laying down and implementing appropriate steps and means that are the responsibility of the State, local and regional authorities and other public and private entities'.

Art. 13: obliges boroughs concerned by the Risk Prevention Plan to set up a **Municipal Safety Plan**: *Plan Communal de Sauvegarde* or PCS.

'The Plan is set out in a series of documents, which are the municipality's responsibility to establish, and will inform residents and provide preventive protection. In relation to the risks known, it determines the immediate steps to be taken for residents' safety and protection; it establishes the procedures for alerting people to the safety measures; it lists the means available; it defines how the measures to assist and support residents will be taken [...]'

European Directive 2007/60/CE concerning flood risk assessment and management:

Art. 6:

'Member States shall, at the level of the river basin district, or unit of management referred to in Article 3(2)(b), prepare flood hazard maps and flood risk maps, at the most appropriate scale for the areas identified under Article 5(1).'

Art. 10:

'In accordance with applicable Community legislation, Member States shall make available to the public the preliminary flood risk assessment, the flood hazard maps, the flood risk maps and the flood risk management plans.'

The European Directive considers maps as an aid to diagnosis, reflection and decision. If moreover the fact is taken into consideration that many landmark elements (reference floods) have been updated, mapping flood risk will become an important topic for study in Europe.

8.3.2 Roles and responsibilities for mapping and users of flood maps

French legislation divides responsibility for flood risk prevention between three types of actors: the **State**, the **Mayor** and the **residents** living in a flood area.

8.3.2.1 The State

The State has an obligation to inform Mayors concerning the risks present in their community. To this end, the Prefects are responsible for risk 'awareness'. Each Prefect must set out a **Departmental Report of Major Risks** (*Dossier Départemental des Risques Majeurs* or **DDRM**), which, commune by commune, describes the risks, their foreseeable consequences, as well as the measures for prevention, protection and safety available in the Department in order to contain the event. The Prefect is mandated to publish the DDRM, with any existing **risk maps** and the **flood risk prevention plan** (*plan de prévention des risques d'inondation* or **PPRI**) if there is one.

The State is equally responsible for defining **rules governing urban development** in floodable areas. The Prefect advocates, sets out and implements the **PPRI**. The Prefect adopts the PPRI after a public enquiry



and advice has been taken from the local councils of the communities concerned. The Prefect also defines a method of concertation for the plan to be set up.

He adopts the civilian safety response plan known as **ORSEC** (*Organisation de Réponse de Sécurité Civile*) brought in when the law on civilian safety was updated⁴⁴, and which includes all the former aid, emergency and specialized assistance plans. The plan also involves the DDRM (Departmental Report of Major Risks), with its chapter on 'special risks and risk sites' from the Departmental Analysis and Risk Cover Scheme (*Schéma Départemental d'Analyse et de Couverture des Risques* or SDACR), and operational measures, providing a gradual response from warning to alert and progressive mobilization.

The State is also in command of the **River Police**. In this respect, it has to ensure that the safety of dikes against flooding is carried out, whether the dikes are state-owned or not. The State therefore carries out a national census of all dikes with regard to public safety, imposing on the owners special recommendations (diagnostic monitoring, checks, maintenance and repair work).

Maps play a major role in a Prefect's mandate regarding flood risk management. Another responsibility is to draw up maps for the PPRI, DDRM and ORSEC plans, and flood defence facilities locations.

8.3.2.2 The Mayor

The Mayor's mandate includes **order and safety**⁴⁵ within the borough. Policing powers mainly involve:

- Preventing flood risk and dike collapse while taking 'appropriate precautions';

Crisis and aftermath management. The Mayor becomes "Director of Safety Operations" in case of a disaster occurring within the borough (this mandate becomes the Prefect's duty as soon as flooding extends beyond the borough boundaries). In order to discharge this duty, the Mayor must carry out the **community safety plan** (*Plan Communal de Sauvegarde*; for the **PCS** in Tours, see below).

The Mayor is also in charge of **land use**⁴⁶ within the borough. The issuing of building permits must comply with the PPRI, if the borough has one.

The Mayor must inform residents⁴⁷ of flood risk by:

- The Document on Major Risk Awareness (Document d'Information et de Communication sur les Risques Majeurs or DICRIM; for the one concerning Tours, see below), and placarding notices that list the risks and instructions to be followed,
- Instilling an 'awareness' of floodable areas Atlas des Zones Inondables (AZI) and the Plan for Preventing Natural Risks (Plan de Prévention des Risques Naturels or PPRN) that can be foreseen when they exist,
- Providing a talk on flood risk (at least every two years if the borough is covered by a PPRI),
- Signalling previous flood water peaks in the floodable area.



Maps and other visual documents play a major part in a Mayor's flood risk management duties, especially when it comes to applying the data mapped in the PPRI, drawing up maps accompanying the community

44 See: law updating civilian safety n°2004-811, dated 13 August 2004.

45 See: Article L 2212-2 of the Code général des collectivités territoriales.

46 See: Décret n°95-1089 dated 5 October 1995, updated.

47 See: Law n°2003-699 dated 30 July 2003. Law n°2004-811 dated 11 August 2004 and Articles L 125-2 and L 563 from the Code de l'Environnement and Articles R 125-9 to R 125-27 from the Code de l'Environnement and Décret n°2005-233 dated 14 March 2005.

safety plan (PCS), or communicating information mapped in the floodable areas atlas (AZI) and the major risk awareness document (DICRIM).

8.3.2.3 Residents next to water courses

Residents next to water courses are solely responsible⁴⁸ for their protection against flooding. They cannot require the State or local authorities to build dikes or other defences. This law does however admit certain exceptions, notably for the Loire, the Rhine and the Rhone in which cases the State has taken responsibility for protective defences.

In other circumstances, local and regional authorities are able to carry out flood protection work when there is a general interest or in case of an emergency. But such intervention on their part is in no way mandatory. They may require those who have rendered work necessary or others whose interest is involved to contribute to the expenditure⁴⁹.

Camp site and caravan park owners and managers located in an area of natural risk (flooding in particular) must⁵⁰ fulfil certain requirements to inform, alert and evacuate users so that occupants' safety is ensured. These measures are stipulated by the authority for urban development.

Owners of dikes and hydraulic structures are first and foremost responsible⁵¹ for the maintenance and safety of their facilities. Should any damage be caused to a third party, they may be prosecuted on grounds of civil liability for misconduct, negligence or carelessness, and even when no misconduct has occurred.

Residents next to water courses are not concerned as authors of maps as Mayors or the State are, but the fact that they are solely responsible for the risk involved means that they must be able to understand the documents concerning their situation with regard to the risks. This highlights the importance of tailoring documents to users' needs and preferences (RiskCatch, RiskMap).

8.3.2.4 Other actors concerned by flood risk

Apart from national and local levels, there are other intermediary actors concerned by flood risk and management. Such actors are: the DREAL, the DDT, EPTB, etc.

The case of local and regional catchment basin agencies:
Établissements Publics Territoriaux de Bassins (EPTB)

The law dated 30 July 2003 acknowledged that local and regional catchment basin authorities (Établissements Publics Territoriaux de Bassins or EPTB) are actors involved in flood prevention, balanced water resource management, wetlands conservation and management, in relation to basins and sub-basins.

EPTB are public agencies acting on behalf of local and regional authorities. In France, EPTB are structured variously, with different modes of action in flood risk prevention.

In 2002, the State called for projects in order to develop **action programmes for flood prevention**: *Programmes d'Action de Prévention des Inondations* or **PAPI**). Such action programmes deal on the one

48 See: Law dated 16 September 1807 regarding the draining of marshlands (art. 33).

49 See: Article L 221-7 from the Code de l'Environnement and Décret n°93-1182 dated 21 October 1993 modified by décret 2005-115 dated 7 February 2005

50 See: Articles R 125-15 to R 125-22 from the Code de l'Environnement

51 See: Articles 1382 to 1384 from the Code Civil.

hand with catchment basins from an overall, sustainable development perspective and on the other hand through information campaigns that foster genuine risk awareness.

Table 8.2: Synthesising the actors and documents involved in flood risk

Actor	Legal Responsibility	Official Documents	Actions on the ground
State	Prefect :DOS (departmental level)	ORSEC Plan including the DDRM and SDACR	Crisis management from warning to mobilization
	Set out by the Prefect	DDRM	Informing mayors and residents
	Adopted by the Prefect	PPRi	Regulating development of floodable areas
	In command of River Police	(Dike census)	Monitoring dikes (State owned or not)
Mayor	Informing residents	DICRIM, AZI, PPRN	Awareness Placarding notices and setting up public meetings Signalling previous flood peak levels...
	DOS (local level)	PCS containing the DICRIM, PPRN and AZI	Crisis management from alert to return to normal
	Land use	PPRi	Issuing / refusing building permits
EPTB			AAR, PAPI, Research and Training mandates
Local and Regional Authorities			Local projects for preventing natural risks (SCoT)
Sellers and Lessors		Establishing risk, listing disasters	
Camp and Caravan site Owners			Informing, implementing alert and evacuation
Owners of Hydraulic Structures	Liable for safety of structures		Maintaining dikes and hydraulic structures
CARIP	Under the Prefect's authority		Data collection, drawing up legal documents, communicating information on prevention

AAR : Call for Research projects –*Appel à Projet de Recherche*

CARIP : Risk Analysis, Preventive Information Unit - *Cellule d'Analyse des Risques et d'Information Préventive*

DOS : Director of Aid Operations - *Directeur des Opérations de Secours*

EPTB : Local, Regional Catchment Basin Agencies - *Etablissements Publics Territoriaux de Bassin*

ORSEC : Civilian Safety Response Plan - *Plan d'Organisation de la Réponse de la Sécurité Civile*

PAPI : Action Programmes for Flood Prevention - *Programme d'Action et de Prévention des Inondations*

SDACR : Departmental Analysis & Risk Cover Scheme - *Schéma Départemental d'Analyse et de Couverture des Risques*

It will be seen that there is an overlapping of levels of responsibility and documents. This could hamper the optimum handling of a crisis situation, especially if coordination between the many actors is not effective.

8.4 Current flood mapping practices

Print: see Maps 1 and 2.

Online: <http://cartorisque.prim.net/>

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Écrivez-nous Infos légales Qui sommes nous ?

Figure 8.2: Cartorisque

8.5 Flood hazard and flood risk (damage potential)

8.5.1 Data sources

Municipal and departmental Archives (historic parishes), IGN (BD TOPO), DREAL / EP-Loire (flood simulations)⁵², etc.

⁵² See: Équipe pluridisciplinaire Plan Loire Grandeur Nature, « Étude de la propagation des crues et des risques d'inondation en Loire moyenne », April 2004.

8.5.2 Flood hazard: highest known flood levels (*Plus Hautes Eaux Connues: PHEC*)

Definition of relevant probabilities, discharges and critical flow velocities, water levels, and intensity criteria

May-June 1856 (PHEC)	7,52 m (Wilson bridge level - Loire) 6,25 m (Sanitas bridge level – Cher)	6800 m ³ /s (Wilson bridge level)

Below, risks as mapped in the Atlas for floodable areas in Tours:

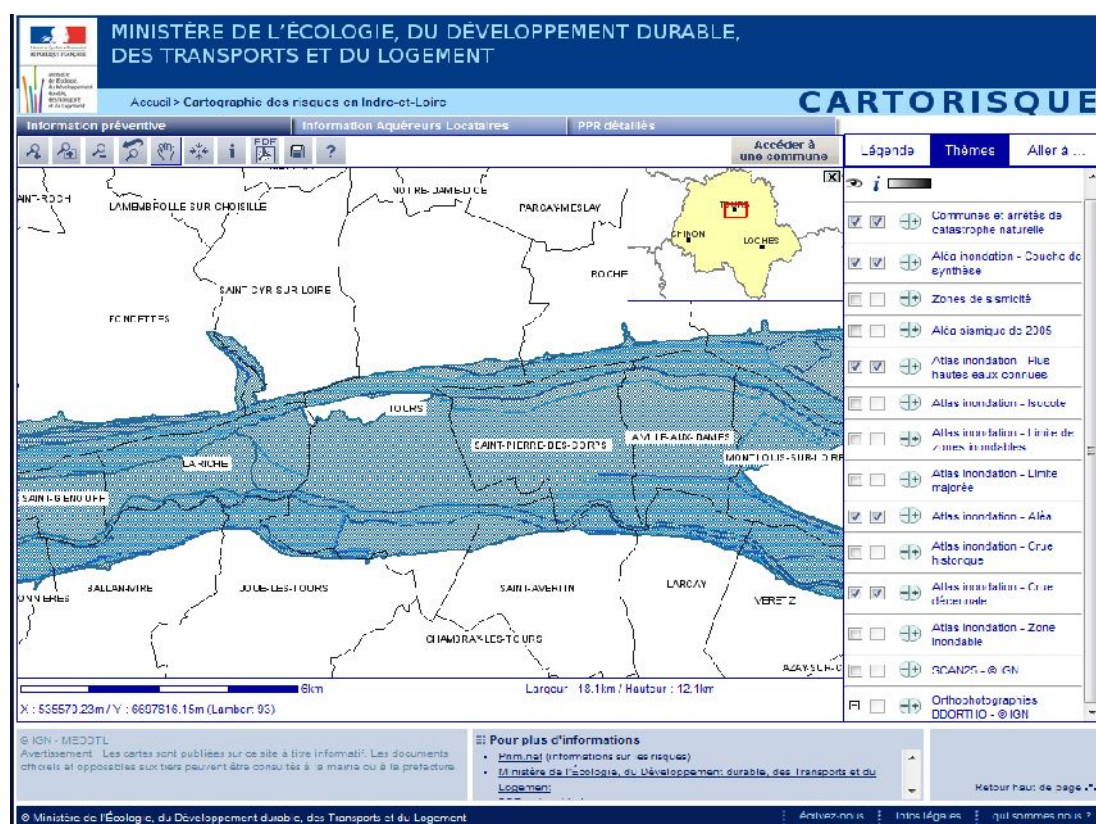


Figure 8.3: Cartorisque for Tours

8.5.3 Flood risk prevention plan: Plan de Prévention du risque d'Inondation (PPRi)

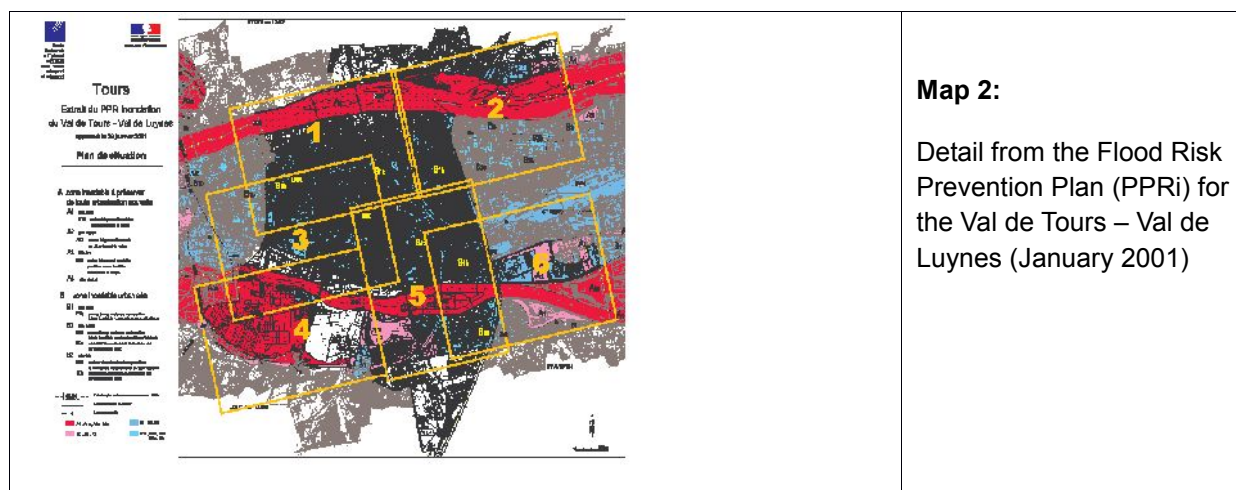


Figure 8.4: Economic, social, ecological and special risks (critical infrastructure)

8.6 Risk Analysis

Specific definition of risk and methodology for its assessment

Definition:

'A potentially dangerous event, a HAZARD, only becomes a MAJOR RISK if it occurs in a place where there are life-threatening, economic or environmental STAKES.'⁵³

Developing a flood prevention plan (PPR):

'Developing a PPR involves four main stages over which several technical maps and one regulatory one are drawn up:

- Map informing of the natural phenomena
- Map of the hazards
- Map assessing the stakes (whether formalized or not by a map)
- Plan of the flood prevention plan (PPR) zones.'⁵⁴

8.7 Map design

8.7.1 Map scales

Generally speaking, a PPRi is drawn up on the scale of the group of boroughs affected by flood risk: cf. the case study for the Val de Tours.

⁵³ See: <http://www.risquesmajeurs.fr/definition-generale-du-risque-majeur>

⁵⁴ See: Ministère de l'Environnement, Ministère de l'Équipement, « Plans de prévention des risques naturels prévisibles (PPR) : guide général », La Documentation Française, 1999, p.25.

8.7.2 Colour schemes

Below, the current key to flood hazard mapping (Cartographie de l'Aléa d'Inondation or AZI):

Table 8.3: Current key to flood hazard mapping (Cartographie de l'Aléa d'Inondation or AZI)

	Low velocity	Medium velocity	High velocity
Height < 0,50 m	Low risk	Medium risk	Medium risk
0,50 < Height < 1 m	Low risk	Medium risk	Medium risk
1 < Height < 2 m	Medium risk	High risk	High risk
Height > 2 m	High risk	Very high risk	Very high risk

With⁵⁵:

Low risk: submersion depth less than 1 metre and no marked current velocity;

Medium risk: submersion depth between 1 and 2 metres with no or low current velocity, or depth less than 1 metre but with marked velocity;

High risk: submersion depth over 2 metres with no or low current velocity, or depth between 1 and 2 metres and with medium or high current velocity, and water spreading 300 metres beyond the levées;

Very high risk: submersion depth over 2 metres with medium or high current velocity or areas at particular risk (downstream from spillways? or facility outlets).

Below, the future key, as suggested by DREAL-centre, for mapping flood hazard:

Table 8.4: future key for mapping flood hazard, as suggested by DREAL-centre

	Low velocity	Medium velocity	High velocity
Height < 0,50 m	Low	Medium	High
0,50 < Height < 1 m	Medium	Medium	High
1 < Height < 2 m	High	High	Very high
Height > 2 m	High	High	Very high

A comparison of the two keys shows greater flood hazard accountability.

8.7.3 Graphic map background

The background for PPRI maps is usually taken from information on BD TOPO[®] IGN maps. On the **Cartorisque Website**, the background is from either Scan 25 or BDORTHO[®] IGN.

⁵⁵ Emmanuel DIDON, DREAL-Centre, « La révision des PPRI de la Loire », Réunion EP-Loire, 24 November 2010, Orléans.

9 Findings

9.1 Findings from participation in all case studies (including an overview of participants)

Joanna Pardoe, Sally Priest, Christian Kuhlicke, Simon McCarthy

9.1.1 Introduction

The literature on hazard mapping highlights a range of barriers to effective awareness raising as a consequence of problems in mapping. Figure 9.1 highlights some of these barriers and how they might impact upon the role of the map in communicating flood risk. Broadly defined, these barriers relate to issues such as a lack of trust in those producing and distributing maps, difficulties in understanding and interpreting maps and inaccuracies which undermine map utility and credibility. Many participation studies indicate that a participatory approach to mapping may overcome these crucial barriers.

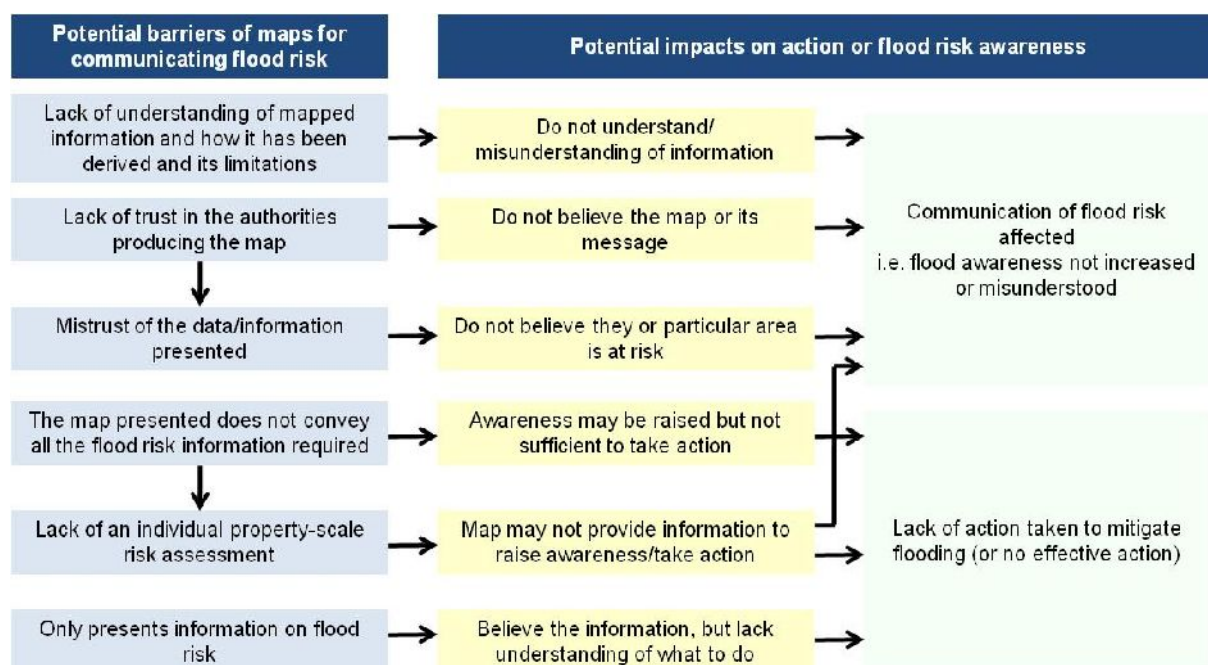


Figure 9.1: Potential barriers of maps as devices for communicating flood risk

The instrumental rationale in participation suggests that including stakeholders, in particular, end-users in the mapping process, provides a platform for trust to be enhanced. In addition, the substantive rationale suggests that participatory approaches to mapping can allow knowledge to be shared, increasing the

accuracy of maps. Through such processes, stakeholders are also able to convey their preferences and highlight aspects of the maps that are not clear open to inaccurate interpretation.

There is a considerable body of literature regarding the development and incorporation of participatory processes. Many papers report on techniques for participation and highlight the importance for tailoring the process to suit the subject. The Risk Map project was designed to incorporate and test the theory and literature on participation. As a reminder the aims of the project were to improve flood maps through participation but equally to test whether flood mapping is an effective means and process through which to facilitate participation.

9.1.2 Synthesis of case study findings

The project investigated these aims through a series of workshops across four case study locations (as described in Sections 4-7). The locations are Chertsey in the UK, The Vils and Rott in Germany (Bavarian partners), the Mulde River in Germany (Saxon partners) and Wartschenbach and Vorderbergerbach in Austria. Each case study invited a different set of stakeholders to participate. These stakeholders are outlined in Table 9.1 below.

Table 9.1: Stakeholders in the case studies

England (Chertsey)	Local residents experienced and at risk from flooding
Germany (Bavaria)	Professionals from emergency management
Germany (Saxony)	Professionals from a range of agencies and organisations
Austria	Professionals from the Austrian Torrent and Avalanche Control Service

For all partners the stakeholder groups involved consisted of groups relatively unfamiliar with participatory workshops such as in this project (i.e. most stakeholders within the Bavarian, Saxon and Austrian case studies had not been involved in participation workshops in the past and the English case study focussed on public participation with residents at flood risk). As a result, the workshops were tailored to take this into account and additional steps were undertaken by partners where necessary to introduce the workshops or to help tailor the process to suit the participants. In the Saxony case, for example, pre-workshop interviews were conducted to help identify the most relevant stakeholders. In the Bavarian case a pre-workshop meeting was held to introduce the facilitators and the aims of the workshop. In contrast, the UK case study was able to introduce the project through the recruitment process and thus went straight to the workshops.

This tailoring process reflects the understanding that different stakeholders have a different 'participation culture'. Some groups are able to be engaged with almost immediately whereas others require a longer process of introduction to ensure they feel comfortable enough in the workshops to contribute effectively.

The results of the workshops and analysis of the process and results show variations in the effectiveness of workshops for facilitating participation. From these results it is possible to deduce some elements that contribute towards effective participatory strategies. These results will be discussed below.

9.1.3 Saxony, Germany

Table 9.2: Characteristics of the Saxon case study

<i>Key Characteristics</i>	
Flood characteristics:	River Mulde , Saxony. Fluvial flooding, system represents both flood sources in areas in the uplands with high discharge dynamics including flash floods and receptor areas in the lowlands.
Case study area characteristics:	Non-navigable, tributary to the Elbe River. Densely populated valleys, study site area has population of approx. 22,000 inhabitants.
Flood experience:	Extreme flood occurred in 2002
Participation group:	Professionals from a range of capacities from the state level, regional and district levels down to the local level.
Participation experience/culture:	There is a lot of experience with intersectoral cooperation (both vertical and horizontal) but only few examples of public participation, especially on a higher level
Status of flood mapping:	Flood mapping has been completed, even prior to the time table of the EU Floods Directive

The Saxony case study (see Section 6 for full description) involved the participation of professionals from different levels ranging from the local and federal to state level. These stakeholders do not normally collaborate closely together on a regular basis. Based on the interviews, it was apparent that there was to a certain extent a pre-existing tension between some of the stakeholders attending.

The workshops in the Saxony case brought together these stakeholders from different levels to collaborate and this enabled some confrontation of the opinions of the other levels and their work. Rather than making assumptions to give support to these opinions, the workshops, particularly working in small groups, allowed the different stakeholders to discuss the issues and to develop an alternative perspective. The workshops were thus deemed very successful in that the participants were cooperative and learned about each other's work and objectives. More specifically, they developed an understanding of the perspectives of other stakeholders and understood their rationales and underlying interests and needs.

Although the workshops were not able to fully resolve the long standing and embedded perceptions of the stakeholders towards each other, they were seen as a starting point for enhancing communication and understanding between the levels, as participants developed new contacts and established a dialogue. If this process could be repeated and built upon it could establish stronger working relations between the different groups. However the "costs" of such a workshop series, in terms of personal resources to be invested, is quite considerable and therefore such a series would need to be clearly connected with a benefit for the participants.

From a substantive perspective, the workshops allowed the stakeholders to share their expertise and knowledge. The facilitators⁵⁶ learned about mapping preferences and which information is most valuable to the participants. They found that the workshops did not confirm the RISK MAP team's previous expectations that the economic aspects would be the risk criteria that stakeholders are most interested in. Stakeholders were instead more interested in social risks and critical infrastructure. In turn the participants learned about tools that could help them in their work. Furthermore, the participants all commented that they learned from each other during the workshop and the facilitators and participants also felt they had learned from each other.

⁵⁶ In each of the case studies, RISKMAP project partners undertook facilitation and henceforth in the context of the workshops, the term facilitator refers to this role.

The final task introduced to the participants was a computer mapping programme which allowed the participants to explore how such a tool might be useful to them. In this way the workshops enabled both facilitators and participants to learn something new.

9.1.4 Bavaria, Germany

Table 9.3: Characteristics of the Bavarian case study

<i>Key Characteristics</i>	
Flood characteristics:	Rivers Vils and Rott, Bavaria.
Case study area characteristics:	Tertiary hill landscape, densely populated, agriculture as dominating factor
Flood experience:	2006, 2009, 2011 damage of agricultural areas, roads and forest areas, local flooding of buildings
Participation group:	Professionals of disaster control and emergency services (professionals of fire brigade, military, regional and district offices and professionals of order of Maltese)
Participation experience/culture:	All of the stakeholders had no previous experiences with participation or in particular participatory workshop.
Status of flood mapping:	Flood hazard and flood risk maps are not publicly available in print format yet. Flood maps are only available online. The map service displays flood plains of frequent, medium and infrequent flood events and water sensitive areas. Water depth, inundation areas and the wrap-around of observed areas can be shown when available. The interactive web map service is available to everybody and is provided by the Bavarian Environment Agency.

The Bavarian case study (see Section 7 for full description) held workshops for stakeholders from emergency management and therefore formed a homogenous group, unlike the Saxon case study described previously. The facilitators observed that during the workshops there was a reluctance to be particularly open and forthcoming in the discussions. This may be attributed to the lack of participatory culture and shyness at this first experience of a workshop. However, it may also be that as the participants were colleagues, they may have been more concerned with representing their department, than taking on a more individual role to represent their personal perspective more specifically. As such, from an instrumental perspective, the workshops achieved more limited success than the Saxon study described previously. There was thus less scope for building new contacts as the workshop involved actors in already established networks.

From a substantive perspective, the workshops provided an opportunity to share knowledge and understanding. The workshops were successful at informing participants about the Floods Directive and how it may be achieved in addition to providing more information on risk maps more generally. Through this process, the facilitators were able to gain a greater understanding of the criteria that would be most important for representing on maps from the perspective of the participants. The facilitators were surprised to find that social vulnerability aspects were deemed the most important features to be mapped. They also found that other features such as the economic or environmental aspects of flood risk were of lesser importance and were only valued if they had an impact on people directly. This contradicted the facilitators initial expectations and shows the value of participation for highlighting preferences that would not be easily anticipated.

9.1.5 Austria

Table 9.4: Characteristics of the Austrian case study

<i>Key Characteristics</i>	
Flood characteristics:	River Wartschenbach and River Vorderbergerbach . Alpine flooding experienced (i.e. high velocity, fast onset, high debris)
Case study area characteristics:	Very localised flood risk.
Flood experience:	Wartschenbach previously flooded in 1999/2000. Vorderbergerbach previously flooded in 2003
Participation group:	Professionals from the Austrian Torrent and Avalanche Control Service
Participation experience/culture:	A lot of experience during the last decade due to national (e.g. FloodRisk) and international (e.g. IMRA) research projects.
Status of flood mapping:	Hazard maps available highlighting flooding in addition to other natural hazards.

The Austrian case study (see Section 4 for full description) workshops comprised professionals from the Austrian Torrent and Avalanche Control Service. As such, similarly to Bavaria, there was limited potential for networks to be developed as the participants were already working in the same department and familiar with each other. In addition, the participants in this case study had been obliged to participate in the workshops by the Head of the service who was keen to support the project that had been part funded by the service. The effect of this obligation was that some of the participants were not interested in the workshops and thus did not participate as fully as those more interested.

During the blank mapping task, the Austrian case study found that participants tended to recreate the existing maps, using the same red and yellow colours that the existing maps harness. In this case, the conclusion drawn was that by providing a range of colours and options the participants were free not to use them and to stick to what they were already familiar with. In such circumstances it was felt more creativity could be gained by providing a more restrictive approach, such as limiting the colours so that red and yellow were not available or using the puzzle map approach where a range of layers are already designed and can be worked from rather than starting with a completely blank canvas.

From a social learning perspective, the workshops are considered successful and improved both knowledge of the Flood Directive amongst participants and reassurance that the Directive targets were achievable. In this respect, the process comprised an informative session for participants. From the facilitators' perspective, there was less learning from the participants but the value of the workshop was in establishing an ongoing participative process. Following the workshops, the facilitator has been able to continue developing these connections to further support the projects research aims.

The idea of mixing professional participation with public participation in the future was met with some concern. The Austrian case study highlights apprehension that opening up participation to the public risks a loss of faith in the Agency and their work. It was felt that under such circumstances the professional participants would be concerned to maintain appearances and may not thus be as open and honest in the discussions as they would be when working with colleagues. Comparing this idea with the results of the Saxon case study, it appears that this view could be challenged as the Saxon case study showed a greater degree of openness as a result of mixed participation compared to the Austrian and Bavarian cases where participants were more of a homogenous group, representing the same agency.

9.1.6 Chertsey, England

Table 9.5: Characteristics of the English case study

<i>Key Characteristics</i>	
Flood characteristics:	River Thames and tributaries flowing through Chertsey just south-west of London. Within the case study area there are also areas at risk from surface water flooding and groundwater flooding
Case study area characteristics:	Urban area of around 12 km ² and population of around 16 000 (2001 census).
Flood experience:	Chertsey last suffered from a major fluvial flood in 2003 with other notable events in 1947, 1978 and 2000.
Participation group:	Local residents from Chertsey including some members of local community groups such as the Chertsey society.
Participation: experience/culture	Participants had no previous experience of participation through workshops.
Status of flood mapping:	Floods maps available through Environment Agency website. Maps show flood extents for the 1 in 100 and 1 in 1000 year flood events, including defences and areas benefitting from defences.

The UK case study (see Section 5 for full description) held workshops in Chertsey with the public rather than professionals. The workshops focussed on public perspectives of local risk and mapping preferences. The workshops were successful in facilitating an exchange of knowledge both between participants and between participants and facilitators. All participants felt that they had learned something new and many commented that they had gained a greater understanding of their flood risk as a result of participating in the workshop. The local residents had an in depth knowledge of flooding in the local area and were able to use this to verify flood extents and to provide background on the physical mechanisms that underlie the flood risk in Chertsey.

From an instrumental perspective, the workshops helped improve understanding of the maps but trust in the maps and mapping processes was not clearly enhanced. Rather than feeling more trusting of maps, participants felt that they better understood the maps and their purpose. The workshops were however, successful in raising awareness as participants were clearer on the meaning of risk and the degree to which they face flood risk.

The second round of workshops held in Chertsey took place following the development of the draft maps and adjustments made based on the first workshops and the EGS at Tours. The second workshops were highly effective at facilitating the instrumental rationale. By returning, participants were able to see how their input had been taken into account and how it had influenced the new maps. In addition, the changes made (autonomously) to the Agency maps, was presented to emphasise how the maps are being adapted to better reflect the public's requirements. The residents responded very favourably to this presentation and were pleased and proud to have been involved. The project has therefore created a positive legacy, where the residents that participated would be more likely to participate in similar events in the future.

Discussing participation, the residents highlighted that they were keen to be involved in mapping. Most felt that it was important to involve members of the local community in mapping, however, they felt that this could occur at the draft stage rather than at the very beginning before any maps had been created. The participants also raised the issue of incentive payments. They felt strongly that incentive payments were not necessary and would be keen to participate regardless of whether they would receive financial reward or not. They felt that participation should also be selective, that only some members of the community should be consulted, such as those with a good knowledge. However, the groups were very diverse and failed to recognise that their selection criteria may have precluded themselves in some instances. The

results of the workshops, however, emphasise the value of an open and non-selective process. With such a diverse range of participants many ideas were discussed, covering a wide range of issues and perspectives and this was found to be particularly valuable.

9.1.7 Summary and some key principles/ findings/ conclusions?

- The type of participation and its organisation need to be linked to the experience and roles of the participants
- Importance of the status of flood mapping
- Need to carefully consider the users of the map?

Following the completion of the series of the workshops in the four case study areas there was the opportunity to learn from the findings described above and hold a further workshop in the English case study to further refine and test the participation approach based on the experiences of the first round of workshop.

9.1.8 Participation in action: testing a participatory approach to mapping

The aim of this workshop was to test the findings of the first round of UK workshops and the findings from the other partners' workshops. A similar format to the first workshops was retained but the key difference was the participation of different groups of stakeholders together, rather than focussing on one particular group, such as the public. This case study highlights key issues that impacted on engagement within the approach. The location of Croston, England was used as a test study and was selected for a number of reasons:

- Provides a typical example of a community at risk from flooding in England and Wales.
- Suffers from fluvial flooding from a river that runs through the village, but similar to many areas also suffers from other sources of flooding: in this case surface water flooding.
- Some residents in the community have experienced flooding in their present properties, but flooding in recent memory is limited – thereby there is a good mix of experience and awareness of flood risk. In addition, there was already some interaction between some members of the local community.
- A local and engaged Environment Agency team were particularly interested in participating in the research and improving their flood maps.
- New flood modelling had been undertaken in 2010 which has led to the maps being updated following the results: thereby making it a suitable period for discussion about any changes.

Participatory flood mapping in practice: The case of Croston, Lancashire

Characteristics of Croston, England

Croston is a 7th century English village of 2,679 residents (UK Census 2001) and civil parish in Lancashire, NW England located between the towns of Chorley and Southport. The village is affected by flooding from the River Yarrow which runs through the village and also from brooks and other drainage channels which run through the village. It is also impact by flood protection provided to low lying areas of agricultural land to the east of the village which is at risk of flooding from the confluence of the Rivers Douglas and Yarrow.

Flood history

The most severe recent event in the village was in 1987 where over 200 properties in the village were inundated in floods that also affected other local communities (EA REF).

Figure 9.2 presents the Environment Agency's historical flood event outline for the 1987 event. These data aim to record the extent of the flooding during the event and those properties flooded (although not all properties will have had water above the threshold) will be located within this boundary. Flooding was also recorded in the village in 2000 however this event affected significantly fewer properties and was not on the same scale as the event 13 years previously. In addition to these fluvial events, Croston in recent years has experienced surface water flooding. Two main areas were affected by flooding Grape Lane which was flooded in 2008 and a more minor event in January 2011 and recorded as events to the Environment Agency. During both the workshops and recruitment process addressing the SWF issue in Croston was one of the main flood-related concerns of residents.

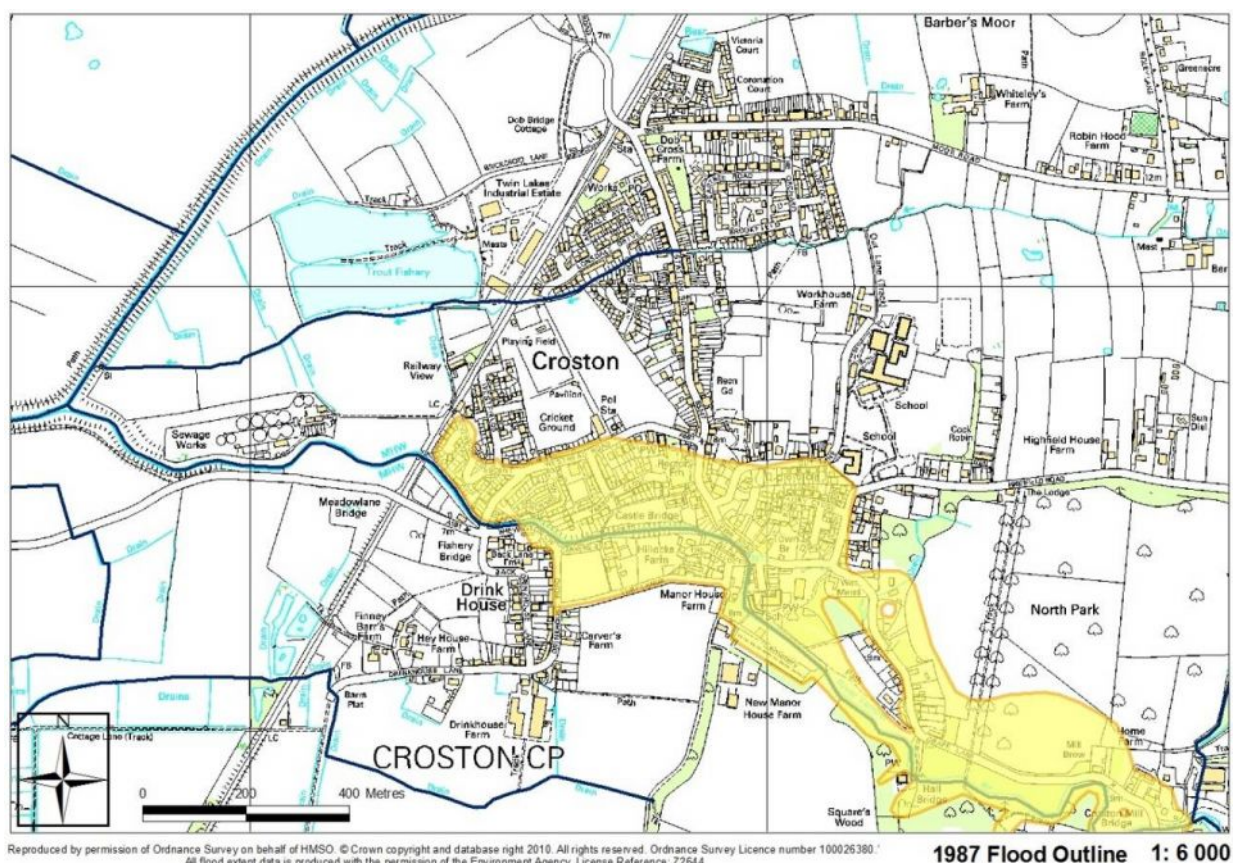


Figure 9.2: Historical flood outline for the 1987 flood event (Environment Agency data)

Mapped flood risk

Figure 9.3 and Figure 9.4 illustrate the current Environment Agency flood map for the community of Croston and the surrounding area at two scales: 1:6,000 and 1:10,000. These are illustrated at two different scales to illustrate the complicated flood risk situation to the East of the village and the image that residents will see when they access the map online. Within the village the Environment Agency identify that 337 properties are at risk of fluvial flooding with a return period of 1 in 100 years or greater and that a further 696 properties are at risk from between 1 in 100 and 1 in 1,000 years (Environment Agency Area data manager, pers. comm.).

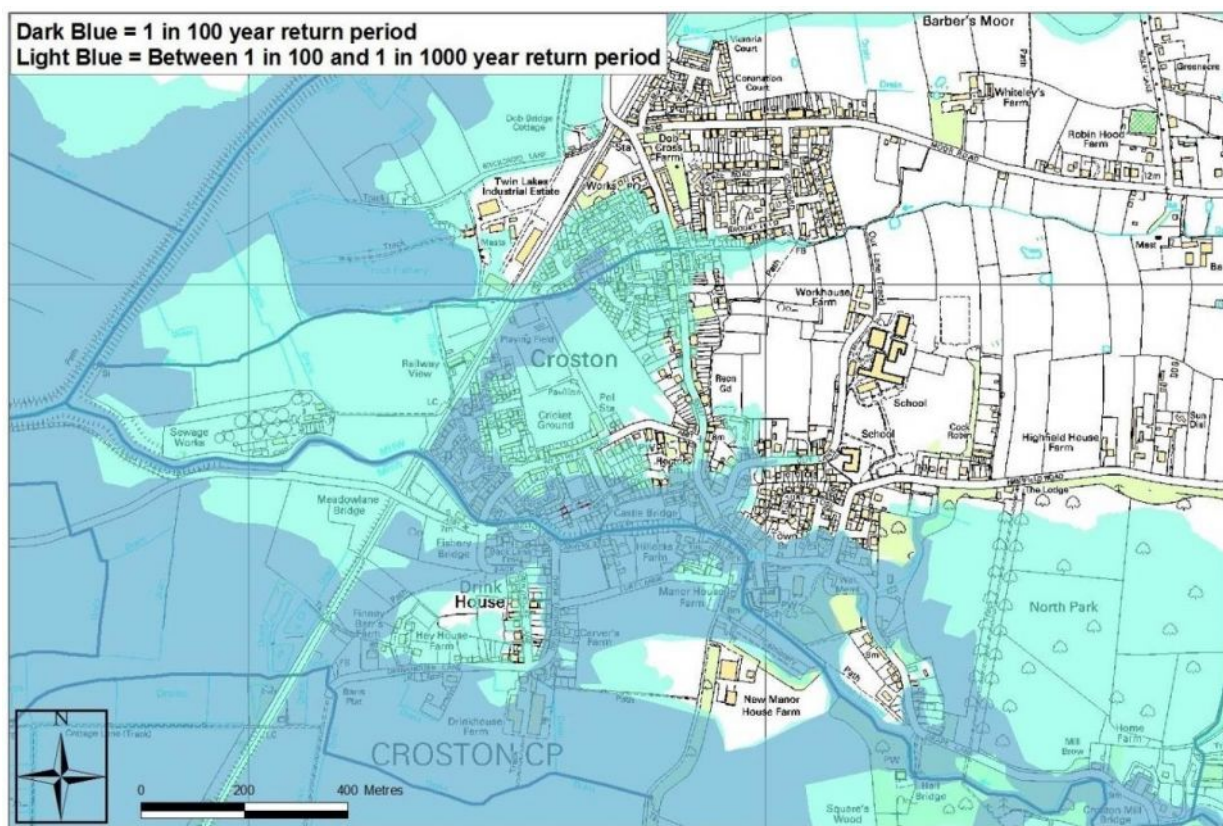


Figure 9.3: Current online Environment Agency flood map at 1:6,000 scale

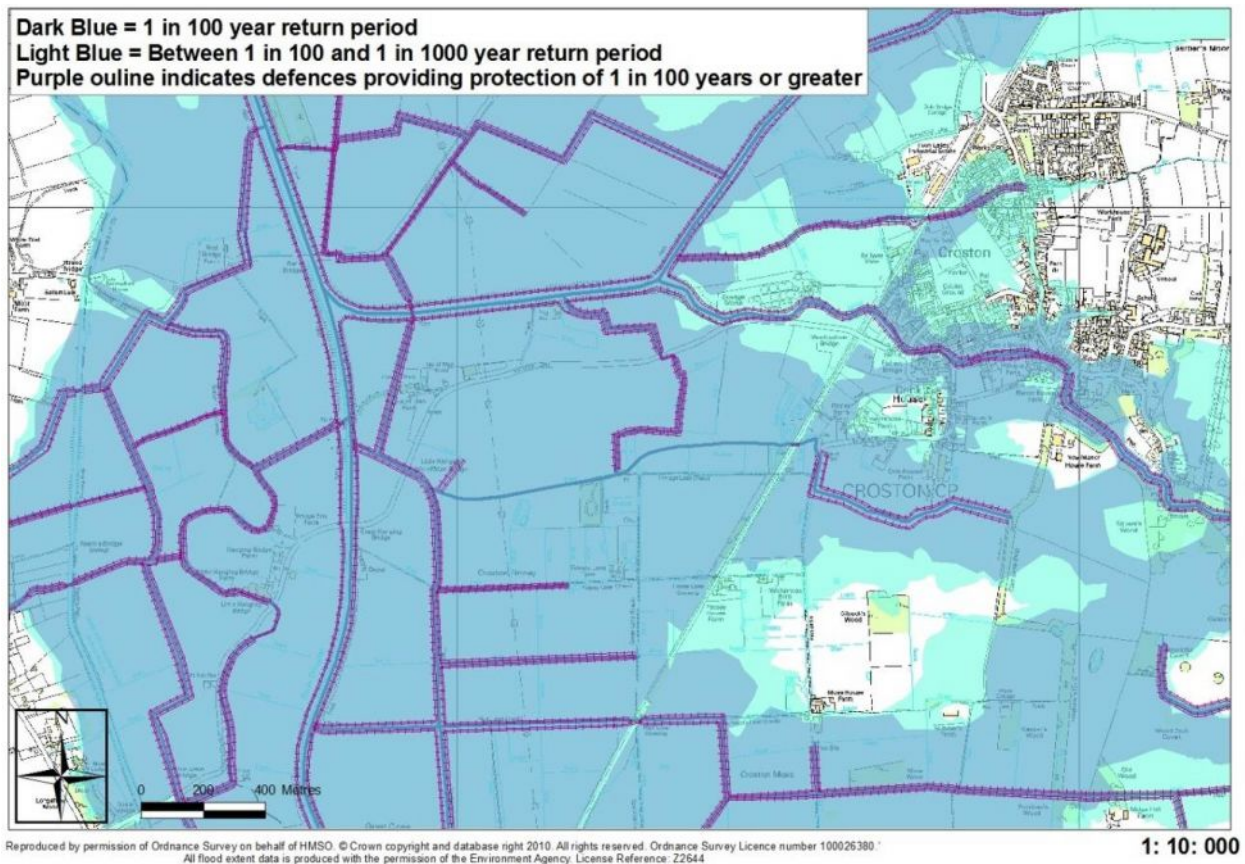


Figure 9.4: Current online Environment Agency flood map at 1:10,000 scale

Workshop organisation

Stakeholders

- Residents directly affected by flooding of their homes
- Residents at-risk of flooding but with no flooding of their homes
- Representatives from the Environment Agency working in the following capacities:
 - Flood risk map development
 - Flood incident management (including flood warning)
 - Management of defence assets
 - Senior Advisor for Mapping and Modelling (active observer)

Workshop Design

The design of the content of the workshops was retained from the development workshops held previously in Chertsey. The format of the workshops involved introductory presentations to the whole group and then participants dividing into two smaller groups to undertake the tasks (blank maps and puzzle maps, based on the current map and other Environment Agency outlines for the area). The workshops concluded with residents completing a background and evaluation questionnaire.

Stakeholder Interaction

Of the 15 residents who attended roughly two thirds were men and the same proportion were over 60 years of age. They had all lived in the village for more than 6 years and the majority owned their house. Older more affluent participants attending the workshop may reflect the profile of the village but the difficulty of recruiting younger, less affluent and female participants to this type of workshop was also an

issue in the development workshops in Chertsey. More overt recruitment regime over a longer period of time might be required to secure the involvement of the less well represented groups. Interestingly only 4 of the resident participants had experienced inundation of their home and thus the at-risk participants comprised the majority, although these participants had predominantly born witness to local flooding.

The majority of the resident participants worked with each other through the mapping activities either as pairs or larger clusters within the groups testing their knowledge and experience. One group had specific technical issues forcefully presented to the Environment Agency participants while the other group explored various wide ranging issues and were more political in their interaction with the Environment Agency participants. This was also observed in the development workshops illustrating that although the content can be structured the response of the participants will depend on their individual character, knowledge, experience and issues of interest. The facilitator was challenged to be flexible in order to maintain the agenda whilst involving all of the participants as much as possible.

The residents have interests wider than purely the representation of flood risk on the map and that representation has wider more immediate consequences for residents than risk of inundation from flood water 'do insurance companies have access to that (maps)?' Maintaining this balance in content during the interaction is a key facilitation role considering a key objective of the workshop was to generate awareness and interest in the flood risk and not just populating the mapping information.

The interaction between the Environment Agency participants was grounded in their understanding of each other's work roles referring questions and issues to each other or for further investigation when answers were not clear. Interaction between the residents and Environment Agency participants in the more technical group started immediately and with specific questions but in the other group the interaction took time to develop. This reflected the expertise of the Environment Agency participants in each group and when issues arose during the mapping activities. The Environment Agency approach was more formal in dealing with the residents' interaction but they were not averse to discussion and recognition that certain issues were not clear and more complex than immediately apparent. They were able to provide additional support and reassurance to residents' concerns (e.g. that the condition of the defences are regularly checked). It was noted that they regularly used technical terminology (e.g. return periods, flood zone, fluvial, asset, modelling, resolution, grid squares) and it was not voiced or apparent if all the resident participants understood. However, it is logical that a common language is desirable between the stakeholders to facilitate communication.

Substantive features of the participation process

It was observed that a sharing of expertise and experience occurred throughout the workshop between residents in Croston and the EA representatives, emphasising a process of mutual learning. The focus of substantive input to the workshops was on verification of the flood outline. In one such case the at-risk outline on a map included a group of houses that the residents considered had never flooded. The Environment Agency participant admitted 'Oh yes it hasn't flooded has it'. Equally there was recognition by the residents that their knowledge may not be complete. When one group was told that residents from a certain road were present in the other group and one resident commented 'well they will know if they have been flooded or maybe not'.

Compared with the development workshops where just residents were present, the attendance of the Environment Agency participants in this second event obviously coloured the discussion. A political dynamic often informing the tone and direction of group discussion was commented on by one resident participant:

R5. 'If we want the Environment Agency to kick ass and put a lot of time and money into Croston then we should say it (flood risk) is serious and we expect a deluge in the next year or so.' ... 'The message for the Environment Agency is that we expect to be under water imminently and for the insurance companies it is going to be a bit like the Sahara' (Group 1).

When research photos were taken by a facilitator of the group the same participant said ‘should we all put our heads in our hands so we look worried’ which was supported by the rest of the group. The presences of a neutral facilitator can moderate such approaches and can ensure that the focus remains on the subject and does not deviate to less related issues that residents wish to raise given the opportunity to discuss with the Environment Agency. Indeed, one Environment Agency participant commented that he had appreciated the presence of an independent facilitator to manage the interaction and ‘referee’ discussions.

Instrumental features of the participation process

Observation by the researchers of the workshop indicated positive interaction where all the stakeholders appeared to gain knowledge and understanding. In addition the feedback questionnaires and post-workshop surveys and interviews provided a view from the participants themselves.

For the resident participants two thirds claim to have been aware of the Environment Agency map before the workshop and only one participant claimed on a prompted scale to be not confident in the information at the end of the workshop. Half of the participants were ‘quite confident’ in the information and the rest of the participants were undecided. All except one participant felt they had learnt something new in the workshop and half of them endorsed that they had learned ‘a lot’. The source of the information was considered to be split equally between the workshop materials used and from other participants/facilitators. Only one participant felt they had not been given the opportunity to communicate their ideas and opinions and of the other participants half endorsed that they ‘always’ had the opportunity. Two thirds of participants considered that they were able to add information to the maps. Almost all the participants felt their opinions were valued and taken into account. On a scale of satisfaction with the outcomes of the workshop resident participants were, apart from two participants, positive but were very/quite satisfied rather than completely satisfied. This is perhaps due to the nature of this participation which was focused on engagement and interaction rather than coming to a decision or solution. The risk to the residents remains and the residents’ issues so far are unresolved.

The Environment Agency professionals reported a very positive experience in the workshops which compared better to previous Agency led approaches to engagement with the public. One of the Agency attendees was particularly impressed with the detailed local knowledge and level of understanding that the public participants demonstrated. As such, the workshops improved impressions of the value of public participation for sharing local knowledge. All three attendees from the Agency were able to learn from the participants and found points were raised that either answered questions that the Agency had over the flood maps for the area or highlighted issues requiring further attention. Although the Agency participants were reluctant to solely rely on public information to make changes, they did say that they would take action and investigate further some of the issues that had been raised during the workshop with a mind to inputting this knowledge into the maps.

The Agency participants were particularly positive regarding the potential to include participation in their mapping activities. They felt that participation had an important role to play in supporting and verifying modelled information. The Agency particularly welcome public input to improve maps and to help them develop accurate historical outlines and record where flooding has occurred.

The difference between the workshop held under Risk Map and previous participatory activities undertaken by the Agency was that this workshop featured neutral facilitation. This was seen as an important element contributing to the success of the workshops; in particular in areas of recent flooding or areas with very emotive issues. The Agency commented that neutral facilitation was important to keep the discussion on the subject of mapping and to ensure that the discussion was not hijacked:

“as it allowed the discussion topics to focus purely on the Mapping rather than the maintenance and political issues surrounding flooding. We could not refuse to answer such questions so it was helpful to have that protection”

A second Agency member supported this with the comment:

“at some meetings, workshops etc. there tends to be a “Them and Us” attitude towards the Agency probably because we don’t always tell them what they want to hear, a neutral facilitator allowed discussions to move along.”

9.1.9 Lessons for a participatory approach to flood risk mapping

The results of the workshops and related activities have demonstrated the value and importance of participation in mapping. Highlighted by the results are the opportunities for participation in mapping to enable and facilitate a two-way learning process, network building and improved understanding of maps and their interpretation. In addition to these findings, the research has identified other important lessons and implications for participatory mapping. This section will now explore what the lessons the findings point to for participatory flood risk mapping specifically.

9.1.9.1 Differing roles of participation during the flood risk mapping cycle

Before a discussion of the importance of considering the timing of participation, it is necessary to introduce the notion of a flood mapping cycle and the different potential stages at which participation might be considered. Figure 9.5 provides a simplified diagram of the cyclic nature of flood risk mapping, this represents the update procedure following the development and introduction of the first flood risk maps for a location.



Figure 9.5: The flood mapping cycle

During the Risk Map workshops, timing was explored through the implementation of three mapping exercises which simulate participation at different stages in the mapping process.

The first task, ‘Blank Mapping’, presented participants with maps of the case study area depicting very basic physical information (such as roads or rivers). This simulates participation prior to the production of maps where no decisions have been made and where participants experience no constraints to their input. During this task it was clear that participants struggled with such a blank canvas and instead would prefer to work with something more defined and restricted, perhaps to enable them to work against

something. This impression was confirmed by the survey results that demonstrated that participants would prefer to be involved in a later stage of map production, most popularly when drafts maps had been produced.

The second task 'Puzzle Mapping', simulated stakeholder involvement at a stage where draft maps have been produced. Here participants were able to make choices from a range of draft map layers and they were also able to edit the layers and make suggestions as to changes that could improve them. This task facilitated considerable discussion which drew out participant preferences towards map styles and contents. At this stage participants were afforded considerable opportunity to influence the maps, simulating a draft mapping stage where considerable alterations may still be made.

The third task 'existing maps' provided a similar experience to consultation, where participants were encouraged to verify the maps and were able to make only minor changes (if any) to the presentation. This stage represented participation following production of final draft maps.

In the Croston workshop, the participation process most closely represents a consultation. However, the participants were able to verify the information and changes may still be made if the maps are demonstrated to be incorrect. However, the scope for such influence is limited and as the Agency representatives highlighted, the participatory process would be able to highlight problem areas but that changes would not be made purely on the comments and ideas of participants, but that other verification would be necessary to make the changes.

The findings from Risk Map emphasise that it is important to involve participants at a stage where major changes can be made, however, the findings also illustrate that participation is best at a stage where major changes are possible but where a draft version has been produced. If participation takes place before even draft maps are available, it is of limited value as participants find it easier to work on an existing map than on a blank slate. However, it is vital for both the substantive and instrumental rationales that participation takes place prior to final map production and at a point where significant changes to the visualisation and content of the maps can be fully taken into account. During this task participants engaged with each other and the facilitators to discuss a vast range of mapping issues. This task provided considerable substantive and instrumental success and represented a stage of mapping akin to the presentation of draft maps for consideration and discussion. In contrast, the blank mapping task which simulated the earliest stage of participation, was less successful as participants struggled to address important mapping issues such as language used in legends as they did not think to consider this at that stage. These findings were also backed up by the questionnaire results which suggested that participants would prefer to be involved in mapping where they have a draft map to work from.

By involving participants early on in the process, as the literature supports, enables changes to be easily incorporated into the maps, ensuring the maps benefit from a greater level of accuracy from the outset. As the Croston workshop highlights, presenting maps that are inaccurate only acts to discredit the producers, however, by including local residents in this process, such inaccuracies can be reduced. As such the findings agree that early participation, where participatory influence is still high is ideal but that the earliest stage (prior to draft production) is less effective. This is in order to enable participants to have maximum opportunity to influence the outcomes, thus improving the quality and accuracy of the products.

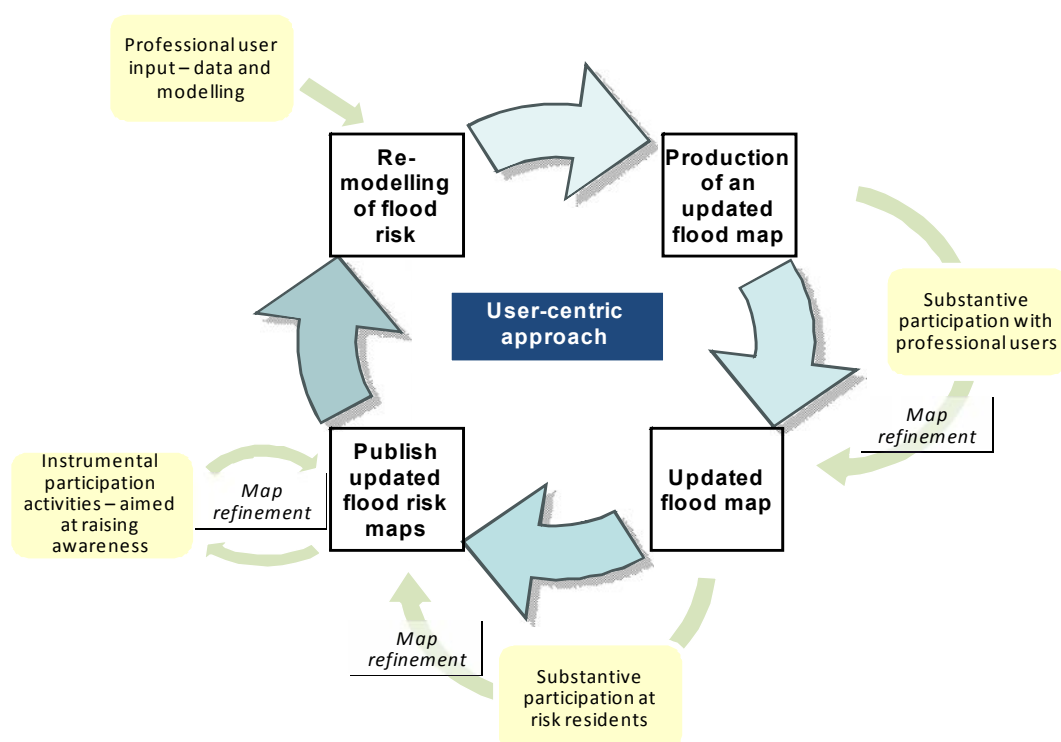


Figure 9.6: Timing of participatory approaches in the risk mapping cycle

9.1.9.2 Iterative process of participation

In order to achieve the instrumental rationale, where participants feel their contribution has been valued, the literature has been supported by the risk map findings which highlight that participatory processes should be iterative. According to the literature, participation should occur early and *often*, advocating returning to stakeholders after initial involvement to demonstrate how their ideas have been taken into account. The Risk Map project achieved this iterative process to a degree by returning to stakeholders for second workshops in many cases. The second workshop in the UK was specifically designed to feedback to residents the results of their input and the maps that had been produced from this. This session also allowed for further comments to be made which could be taken into account, providing they were of a minor nature. In the Saxony case study the second workshop was also of major relevance as it enabled the team to present their results to the stakeholders. This resulted both in a validation of the maps produced but also in a reassurance about the participatory process itself: Participants felt that their input and views were of relevance and their knowledge and contributions had a direct impact on the final product.

The results of the second workshops demonstrated that such an iterative process is essential to consolidate positive perceptions of participation. Following the second workshops, participants emphasised that they were happy with the results and glad to see how their input had made a difference. For the public participants, the experience appeared to be one likely to be remembered by participants in a very positive manner, increasing the chances of their being willing to participate in the future. From this perspective, the workshops were very effective at overcoming obstacles discussed in the literature, where negative experiences in participation lead to an abandonment of the process altogether. The Risk Map findings emphasise the importance of leaving a positive legacy, but demonstrate that this can be achieved by ensuring the process is iterative rather than a one-off.

From the professional perspective, particularly where professional stakeholders were present from different departments and organisations, the project highlighted a value and importance to on-going participation in order to develop networks established by the first workshop. Different to the public stakeholders, professional stakeholders require further opportunities to collaborate with the other stakeholders in order to enhance cooperative networks and to overcome problems in traditionally separated departments that need to work together on the same subject area.

As professional stakeholders have a different role to play in the process, the value of an iterative process for these stakeholders can be found in providing opportunities for them to develop the networks and working relationships that the first workshop established. This has been particularly prominent in the Saxon case study where the workshops enabled a reduction in negative views by providing a platform for stakeholders to share their knowledge and intentions. The results of the different workshops show that different stakeholder groups were able to begin to break down their pre-conceptions, but it was felt that for a permanent shift in this more positive direction to continue, it would be necessary to hold further workshops or similar opportunities to collaborate and build upon the foundation. However, there are limitations to achieving such repeat workshops. For example, many stakeholders involved in the workshops are involved in various other duties and their available time is limited. In addition, for the process to function best, the same individuals should return for the second workshops and this is not necessarily possible due to timing or because some people might move on to new roles.

9.1.9.3 Tools for participation in hazard mapping

There is an abundance of methods and tools for participation in mapping. The literature presents many options but in Risk Map the focus was on workshops with interviews and questionnaires to support these. The findings of this research highlighted the value of workshops for both substantive and instrumental aspects of participation.

From a substantive perspective, the workshops enabled participants to directly share their knowledge of flood risk with colleagues and neighbours. This method was strong in providing a platform for two way learning and knowledge exchange where not only the stakeholders but the workshop facilitators were also able to learn from the exchanges. From an instrumental perspective, this is where the workshops were strongest. They enabled different stakeholders to engage with each other promoting the establishment of new networks and cooperation. In addition, the workshops enabled stakeholders to develop a better understanding of existing maps, mapping processes and the work that others are doing to improve these which supports the instrumental rationale.

The interviews were seen as valuable in supporting the workshops and in adding substantive information in particular. This method was favoured for its ability to extract more in-depth, detailed knowledge from the participants, which they may not have had chance to demonstrate during the workshops. However, from an instrumental perspective, interviews were less successful. As the interviews were conducted with only one or two individuals and those individuals were from the same groups of stakeholders, the potential for achieving the instrumental rationale was severely limited.

Questionnaires were useful to capture the participants' perspectives and evaluation of the workshops in addition to any additional information they may not have been able to contribute. A background questionnaire was also administered to assist with developing an understanding of the groups' composition. The questionnaires were particularly useful in evaluating the success of the workshops which was highlighted as important for facilitating a learning process of participation in practice as suggested by the literature.

9.1.9.4 Tailoring of the participatory approach

The broad literature on participation emphasises the need to tailor participation processes to the subject matter and participants. In Risk Map the participation was designed around the medium of maps to

facilitate a discussion on mapping processes and requirements. The workshops were conducted by different partners in other locations and with different groups of stakeholders. As such the general structure of the workshops was adapted to suit the needs of the different case studies. Enabling a flexible research design resulted in a positive experience where participants were able to fully contribute as the parameters had been designed around them and not another group. Where tailoring was less possible, such as for the questionnaire for the EGS, this posed problems where questions were asked that were only relevant for some, not all, participants. Confusion resulted which could have been avoided if tailoring had been extended to this process too.

As such, the Risk Map findings highlight that tailoring is important but also achievable. The workshops were similar enough to permit comparison but were tailored to ensure efficient and effective participation by different stakeholders.

9.1.9.5 The specific role of maps within a participatory process

In Risk Map, maps have been central to the facilitation of participation and equally participation has been important in aiming to improve maps. As discussed above, the workshops used maps in different ways to engage with participants over the broader issues of flooding and flood risk awareness in addition to focussing on mapping preferences specifically. The different tasks each enabled a different focus point of participation.

In the blank mapping task, the maps were predominantly useful in order to 'break the ice'. The maps facilitated participation by challenging the participants so that they were encouraged to work together and help each other in the tasks. The more blank the map, the more likely it was that participants would need to work together. In the second UK workshops at Croston, for example, the blank maps were only partially successful at facilitating this collaboration but these maps were more elaborate in their contents than the Chertsey maps. Where the participants were easily able to locate themselves there was a reduced need to collaborate. In addition, collaboration was highest where participants familiar with each other were in the same group as they often initiated discussion. The findings therefore suggest that a challenging initial task is important to set the tone for collaboration throughout the rest of the workshops. Furthermore, it is not necessarily a problem to have some people in a group that are already acquainted, although this reduces the potential for achieving the instrumental rationale, as participants are already connected.

The blank maps in the UK case study were important to allow participants to discuss their personal experiences of flooding. Through the maps they were able to describe and annotate their story, allowing them to discuss a shared experience with neighbours.

The success of the puzzle map round suggests that having a draft or options to work with is most effective for facilitating discussion and substantive and instrumental rationales. In this task participants were provided with one set of maps per group and in partner cases studies sometimes the whole group collaborated on just one map. The result of such group collaboration was to facilitate a discussion on a wide range of related issues. The maps highlighted many flood risk and awareness raising subjects such as interpretation of flood zones and language used to describe risk, trust in mapping and discussions on the hydrogeology and causes of flooding as participants perceive it. Such discussions provided a considerable amount of substantive information on flooding in the case study location.

In addition to sharing knowledge, the exercise with maps also facilitated the instrumental rationale as participants were able to collaborate together along with workshop facilitators to develop an enhanced understanding of the production of maps, their intended uses and interpretations. In some cases this was reassuring, however, others simply gained a greater understanding of the complexity of the process which was not necessarily reassuring but did enhance their ability to interpret and balance the information presented to make more informed judgments.

9.1.9.6 Techniques in flood risk management participation

The maps used as a basis for the workshops were important tools for facilitating discussion and participation in mapping. However, the research project highlighted other important factors in participation.

Facilitation

Crucial when involving professional stakeholders is the need to have neutral facilitators. Neutral facilitators are discussed in the literature as important for mediation and moderation, however, in the Risk Map workshops, neutral facilitators were seen to play an important role in a range of other important areas.

Neutral facilitation for mediation was not an overt issue in the workshops as no major conflicts erupted. As such this mediation role was considerably more subtle, acting instead to provide and safeguard an open environment in which all parties could discuss and contribute to the subject. The facilitators assisted the moderation of the workshops by ensuring that the discussion remained on map related issues. In workshops with the public and professionals, such as Croston, such moderation could not be achieved by the professionals alone as they may be accused of avoiding issues of importance to the public. By having a neutral facilitator rather than a professional ensured that discussion could be moderated without risk of such accusations.

In addition to moderation and mediation, the neutral facilitators were able to assume a position of leadership. This had the consequence of placing other participants, regardless of whether they were professional or public, or from national or local departments, they were all at a similar level under the facilitators. The results of such set ups allowed traditional hierarchies to be suspended and participants were able to collaborate on a more even level.

Mixed groups

The project found greatest success in achieving the instrumental and substantive rationales where different stakeholder groups were brought together in a workshop. The wider the variety in stakeholders, the greater the potential for shared learning and network building. In workshops where professionals from within the same department or agency comprised the total sum of participants (Austria), there was limited effectiveness of the workshop for shared learning and instrumental objectives to be achieved. However, where different groups that had not collaborated previously were brought together (such as Saxony), the workshops provided a good basis for the establishment of new working relationships and at the very least, a new understanding of the positions of the other stakeholders, as opposed to a pre-conceived expectation or impression.

In addition to hosting groups with mixed types of stakeholders, working in small groups was also found to be beneficial in the workshops. Small groups allowed time for each participant to contribute and prevented groups from breaking up into smaller discussions. If the group is too large, it is often difficult to ensure that they are each able to look at the maps appropriately. Large groups may naturally begin to break up into smaller units if participants are not polite enough to allow each participant to speak at a time. The small groups of four or five appeared to be ideal in the UK case studies, where larger groups of 7 or 8 proved more difficult to keep focussed as a group.

Interested participants

Within the project there were different techniques for recruitment. In the public case study (UK) recruitment focussed around knocking on doors within the local area to invite participants. In other cases invitations were sent to professionals or personal/departmental connections were called upon. In the project it became clear that open recruitment was vital to successful and productive participation. Where participants were keen to attend for their own interest, participation was most informative and interesting. However, in the case (Austria) where participants were recruited through less open means and were instead obliged to attend, participation was less effective and less positive an experience. Many of these participants would have left with a negative impression which may have impacted on other participants originally keen to attend. However, some may not have been willing to attend but would equally have enjoyed participating. It seems that the most positive method for ensuring a successful participatory

process would be to have an open recruitment system, ideally where no restrictions are placed on the type of stakeholder invited, so that all interested parties, whether for personal or professional reason are able to participate to the benefit of the process overall.

Discussing motives for participation leads to an interesting question that was raised during the workshops regarding incentive payments for participation. For the public workshops in the UK case study, participants were offered a payment as thanks for participating in the research. This was seen as a fair exchange for participants time and input. However, questions were raised as to whether such a process was necessary. Some participants commented that they did not wish to receive payment for their input as they were glad of the opportunity to give their opinions. Others supported this view saying that they would be willing to participate for no financial reward. In addition the professional participants were concerned that a financial incentive might set a precedent for future participatory events and exercises, a precedent that they might not be able to satisfy. Some participants felt that a financial reward might encourage ‘the wrong kind’ of participants, fearing that people would attend the workshops purely to reap the reward. However, the facilitators felt that all participants were genuinely interested in the mapping workshop, suggesting that this last point is not commonly experienced. The facilitators also felt a financial incentive enabled them to ask considerable input from the participants and it ensured that participants did not leave the workshop before completing the tasks and questionnaire.

The debate over incentive payments in an important one raised by this research and its findings. It may be that incentive payments are suitable for some participatory events and not others. Or it may be that incentive payments are not and should not be necessary. This is an important debate to be continued.

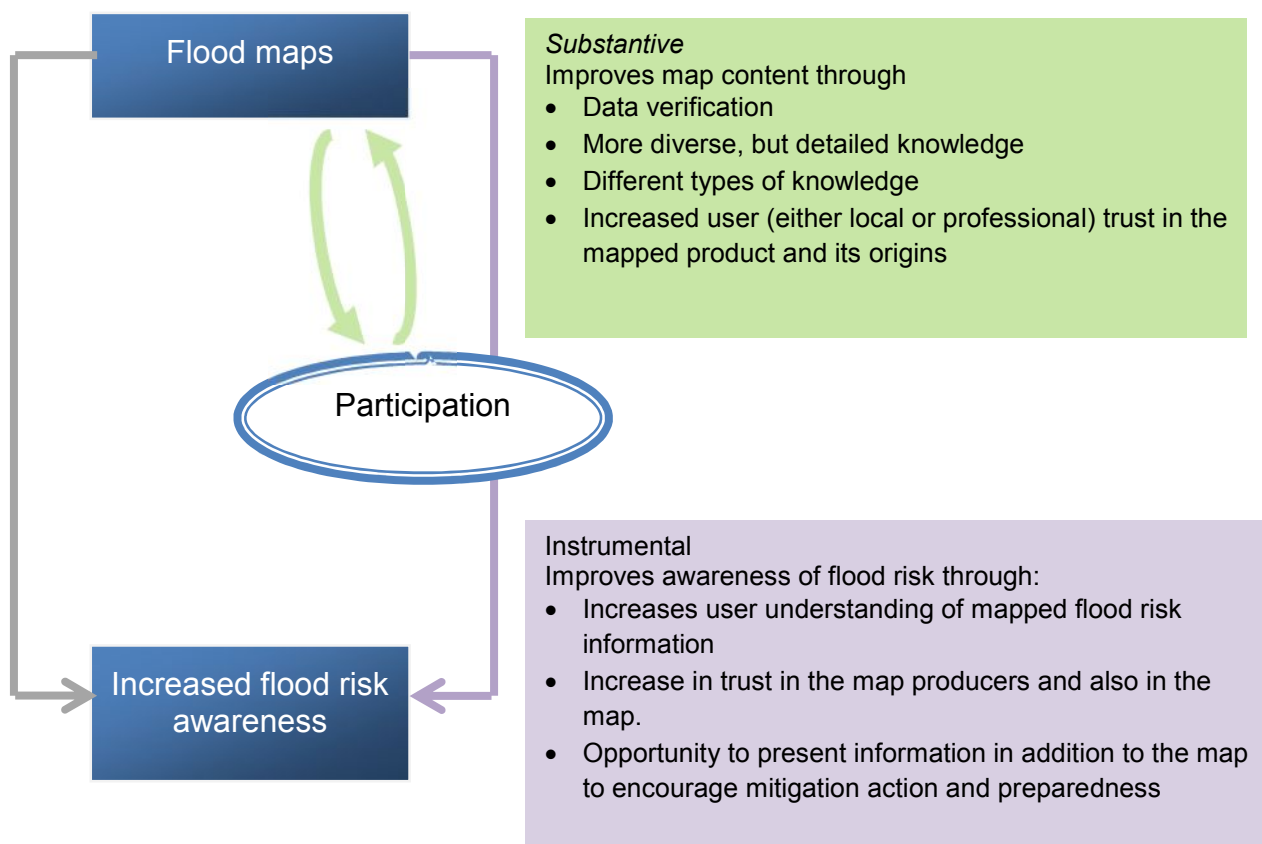


Figure 9.7: Participation framework

The results of the Risk Map project experience highlight the pivotal role of participation in increasing flood risk awareness. In traditional approaches, flood maps are viewed as tools to raising risk awareness, however, the literature finds that maps are less effective at raising awareness than expected. The Risk Map project finds that the participatory process which facilitates both the substantive and instrumental rationales is effective at raising risk awareness.

The Instrumental rationale is central in overcoming the main barriers to effective flood risk maps by confronting participant concerns and explaining more clearly how maps are constructed and how they should be interpreted. The results are that participants generally feel they have a better understanding of the level of risk and accuracy of the mapped information. The instrumental rationale can be attained and benefit all participants, regardless of their prior knowledge, expertise or understanding.

The substantive rationale differs from the instrumental in that it is mainly achieved by the participation of 'experts'. Experts are broadly defined and under the substantive rationale, experts are seen as any stakeholder with detailed knowledge of the flood history or mechanisms of the area in question. The type of knowledge the 'expert' has may be derived from experience or similar informal sources. The substantive rationale encourages including a variety of different stakeholders to maximise the breadth and depth of knowledge considered, beyond traditional formal sources. As such, the substantive rationale requires stakeholders with such 'expert' knowledge. It may be that some stakeholders do not possess such detailed understanding of flooding in their area. These stakeholders may not be able to contribute as effectively to the substantive rationale, which aims to improve and verify the accuracy of the map, however, they will be able to employ the instrumental rationale regardless of this.

Whilst the substantive element of participation may improve the accuracy and detail of maps, the instrumental rationale and therefore flood risk awareness may still be achieved without participants having to contribute to the substantive. Indeed, the results of Risk Map emphasise that many participants felt it was important to conduct the substantive approach to flood risk mapping, however, they did not feel it was important that they themselves were directly involved in this. They commented that they would be satisfied and more trusting of a map if they knew someone, preferably a local expert, had been consulted in the map.

There may be a long lasting effect from the participatory process, in that once completed, participants may not need to participate directly in the future to feel confident and understand the information presented in the maps. Having undergone one process of participation, the instrumental aspects of improving trust and understanding by opening the mapping process to stakeholders may be sufficient to create a lasting trust in the maps and mapping process. This may be an important area for future study, to consider how participation in one process may be able to create a lasting instrumental impact on participants to improve trust in future updates.

9.2 Findings from the MCA-Tool

Sebastian Scheuer

In this section, the proposed flood risk assessment ontology and its use within FloodCalc shall be described in more detail. Firstly, the ontology captures expert knowledge. Figure 9.8 and Equation (E7) and (E8) describe the notion of a flood as one type of hazardous event in the flood risk assessment ontology. This notion follows the definition of Cardona (2004), according to whom a given type of hazard H is defined as a given intensity I with specific occurrence probability P within a confined region for a specific period of time:

$$H \sim (P, I) \tag{E6}$$

where the probability P can be derived from the recurrence interval T so that $P=1/T$, with P and T being values of the data type double. Subsequently, a hazardous event in the ontology is defined as an OWL class *HazardousEvent*. This class is then associated with a recurrence interval by an object property *hasRecurrenceInterval*:

$$\exists !\text{HazardousEvent: (hasReccurenceInterval(HazardousEvent, Recurrence Interval))} \quad (\text{E7})$$

The statement in Equation (E7) needs to be read in the following way: Each *HazardousEvent* has assigned exactly one (denoted by the existential quantifier $\exists !$) object property named *hasRecurrenceInterval*, which in turn has the domain *HazardousEvent* and the range *RecurrenceInterval* (representing a concept itself). Furthermore, a recurrence interval has exactly one datatype property *hasValue* pointing to a double literal value holding the recurrence interval T . In doing so, each hazardous event has exactly one recurrence interval, but for a given recurrence interval several hazardous events may be defined.

Another object property *describes* (or its semantically inverse relation *isDescribedBy* respectively) is used to link intensity measures and hazardous events. The intensity of each hazard is described by at least one intensity measure (denoted by the existential quantifier $\exists$, read *some* or *at least one*), which also allows for the use of a set of intensity measures to describe a hazardous event.

$$\exists \text{HazardousEvent: (isDescribedBy(Hazard, IntensityMeasure))} \quad (\text{E8})$$

Finally, the concept *Flood* is defined as a subclass of *HazardousEvent*, making use of the *rdfs:subClassOf* taxonomic constructor. Thereby, the definitions made for a hazardous event also account for a flood event (or for any other type of hazard defined in this way).

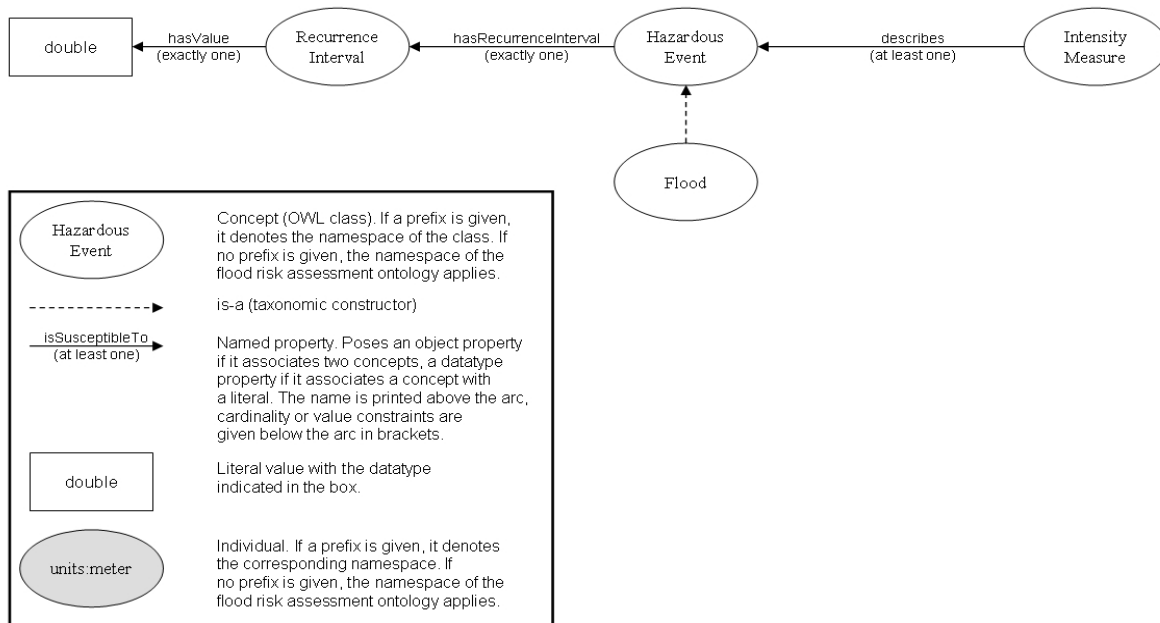


Figure 9.8: Graphical illustration of the semantic network describing the notion of a hazardous event as applied in FloodCalc and the respective flood risk assessment ontology. This notion follows Cardona (2004), after which any hazard can be defined using its intensity and recurrence interval or probability of occurrence, respectively. Hence, the ontology captures this expert knowledge by several object properties (associating the relevant concepts as illustrated above) and a data type property as a means to store the respective recurrence interval. Flood events are defined as a subclass of hazardous events, which is indicated by the use of a taxonomic constructor.

Various intensity measures are defined in the flood risk assessment ontology as subclasses of *IntensityMeasure*, encompassing the inundation depth (*FloodDepth*), extent (*Extent*) and duration of hazard impact (*Duration*, cf. Figure 9.9). A restriction has been used to account for the meaning of the term *FloodDepth*. In the scope of the flood risk assessment ontology, flood depth is defined as an intensity measure suitable only to describe a flood event. This is done using an universal qualifier denoted $\forall$ (read: *only*) to restrict the range of the object property *describe* to *Flood* as shown in Equation (E9):

$$FloodDepth \equiv IntensityMeasure \sqcap \forall (describes(FloodDepth, Flood)) \quad (E9)$$

Equation E9 needs to be read in the following way: *FloodDepth* is defined as an *IntensityMeasure*, and ($\sqcap$) the object property *describes* must be ($\forall$) of the range *Flood*. This excludes the use of *FloodDepth* as intensity measure with non-flood hazards. No restrictions are imposed on the classes *Extent* and *Duration*, which may therefore describe the intensity of any type of hazardous event.

Intensity measures defined in the flood risk assessment ontology are also associated with their respective base unit by a *requiresBaseUnit* object property, on which a value constraint (*owl:hasValue*) is being imposed (Figure 9.9). Base units are defined in the units ontology, which is part of the Semantic Web for Earth and Environmental Terminology (SWEET⁵⁷) upper-level ontologies. This ontology shall be prefixed and thus referred to as "units:" hereafter. The SWEET ontologies are produced by the Jet Propulsion Laboratory and define about 4600 terms in a modularized form. SWEET comprises faceted, integrative ontologies to describe natural phenomena, human activities and related entities (Raskin & Pan, 2005).

⁵⁷ <http://sweet.jpl.nasa.gov/ontology/>

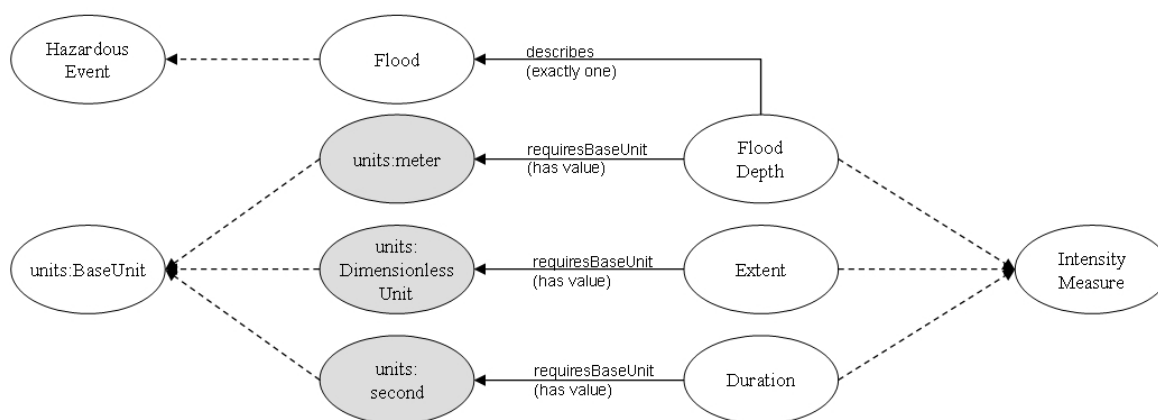


Figure 9.9: Intensity measures defined in the flood risk assessment ontology. Each measure is a subclass of the *IntensityMeasure* superclass. A value constraint is imposed on the requires BaseUnit object property, which associates each intensity measure with its base unit. These units are defined in the units ontology being part of the SWEET upper-level ontologies. This is indicated by the *units*-prefix in the relevant labels. See Figure 9.8 for an explanation of symbols.

The notion of a hazard, and flood event respectively, as described above and illustrated in Figure 9.9), has been directly implemented into FloodCalc. Hence, to add a hazard into a FloodCalc flood model, the user needs to specify a recurrence interval as well as one or more intensity measures with their respective unit of measurement. These measurement units are derived from the respective base unit by querying the units ontology.

Elements at risk in the flood risk assessment ontology are described as a union of material infrastructure, population and environmental components, thus accounting for the different dimensions of flood risk (Figure 9.10). The term material infrastructure refers to different types of facilities. In the flood risk assessment ontology, nucleus infrastructure and network infrastructure is being distinguished to resemble the corresponding spatial pattern of different types of material infrastructure (Figure 9.11). The former refers to point systems, i.e. localised facilities; the latter refers to network systems which are spreading across the land area (Buhr 2003). Furthermore, both types of material infrastructure are further partitioned into different categories to account for the function and use of their corresponding member items. For example, to consider hospitals which pose a nucleus infrastructure item, a category "Health Nucleus" is being created (Table 9.6).

The types of infrastructure considered in the ontology have been elicited from interviews and workshops carried out in the Saxon case study (WP4, cf. section 6.5). In these interviews, mostly social community facilities, roads, evacuation routes and critical nucleus infrastructure (tunnels, bridges etc.) were deemed most important and were thus captured in the ontology. Table 9.6 lists all considered facilities and network infrastructure.

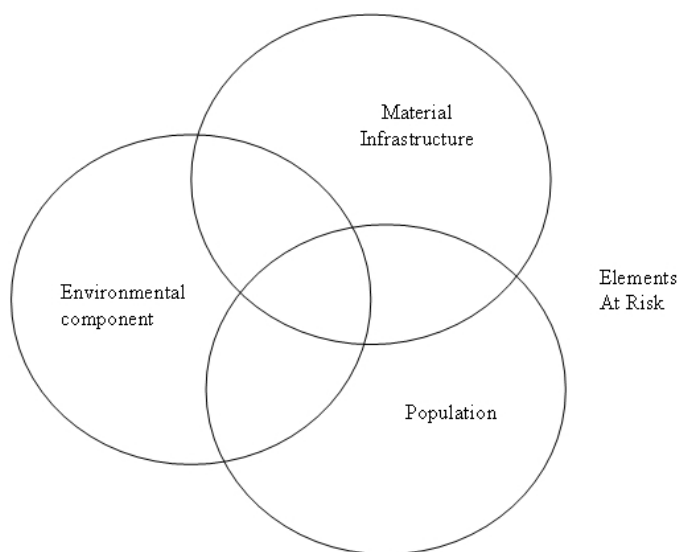


Figure 9.10: Graphical representation of the notion of elements at risk in the flood risk assessment ontology as a union of material infrastructure, population (comprising either the total population or distinct cohorts) as well as environmental components to account for all dimensions of flood risk.

Table 9.6: Description of material infrastructure as element at risk.

Spatial pattern	Function or Use	Conceptualized Facility	
Nucleus Infrastructure	Health Nucleus	Retirement Home	
		Hospital	
	Education Nucleus	Kindergarten School	Primary School
			Secondary School
			Grammar School
	Mobility Nucleus	Train Station	
		Bridge	
		Tunnel	
	Emergency Management Nucleus	Crisis Management	
		Fire Brigade	
Network Infrastructure		Meeting Point	
		Staging Point	
		Material Depot	
		Emergency Accommodation	
		Hazard Spot	
		Tidal Outlet	
		Barrage	
		Road Block	
	Provisioning Nucleus	Relay Station	
	Mobility Network	Roads	
		Railways	
	Emergency Management Network	Evacuation Route	
		Embankment	

For the population, stakeholder interviews unfolded that the total population affected of flooding is considered relevant, but that additionally the number of affected children or elderly, i.e. the population age cohorts which are seen most susceptible to flooding, might be also of interest. Therefore, the population class is structured so that either the total population can be assessed, or that different population cohorts may be used in the risk assessment. The ontology currently proposes the aforementioned age cohorts, i.e. children (aged 0-10 years) and elderly (>65 years of age). It additionally includes a class *AllOtherAgeCohorts* to account for the population aged 10-65 (Figure 9.11). Unfortunately, OWL does not include the possibility to impose numeric value restrictions on properties. Therefore, no axiom is available to restrict individuals of the class elderly to be of age greater than 65 years. This restriction can only be communicated to the user by the glossary of the class, and coherency and compliance must be ensured by the user in this case.

Finally, environmental components are considered as elements at risk (which could comprise e.g. biotopes sensitive to a long-term inundation). Since the environmental flood risk was regarded unimportant by the interviewed stakeholders, no further distinction has been made to account for this risk dimension within the flood risk assessment ontology.

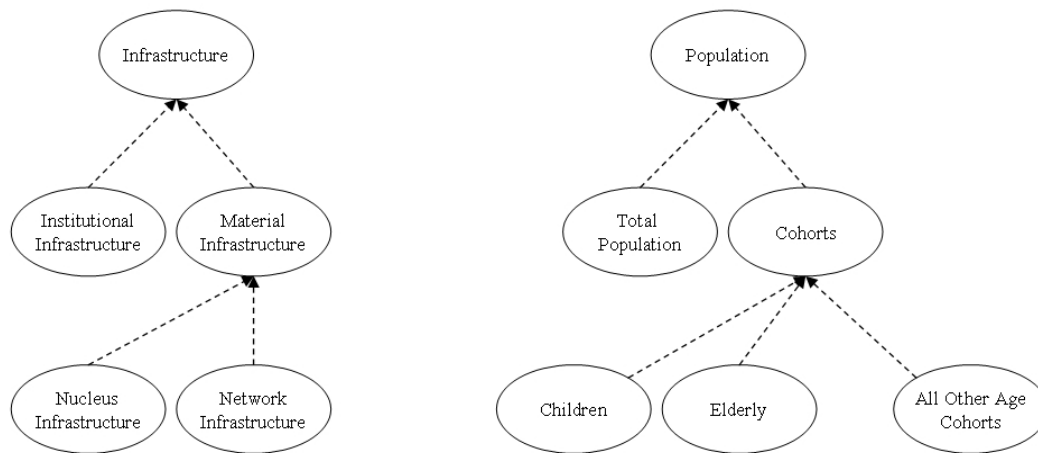


Figure 9.11: Semantic network of the infrastructure and population class. Infrastructure includes both institutional infrastructure and material infrastructure, which in turn poses on set of elements at risk. Table 9.6 lists the considered material infrastructure in more detail. Another set of elements at risk is the affected population, which includes the total population or the cohorts as shown in this Figure. Although numeric value restrictions apply for the depicted age cohorts (children: 0-10 years of age; elderly: >65 years; all other age cohorts: 10-65 years of age), these restrictions cannot be imposed on the different classes, since the current version of OWL does not allow for such a numeric value constraints. See Figure 9.8 for an explanation of symbols.

In order to foster the development of knowledge-based mapping applications, the flood risk assessment ontology also captures various types of maps following directive 2007/60/EC (The European Parliament and the Council of the European Union, 2007). This directive names flood hazard maps and flood risk maps to be created for each river basin or management unit. These map types (*FloodHazardMap* and *FloodRiskMap* respectively) are captured in the ontology as subclasses of a *Map* superclass. Furthermore, directive 2007/60/EC lists the required or suggested map content. Flood hazard maps shall depict extreme floods and flood events with a medium probability (with a recurrence interval ≥ 100 years), and may include high-probability floods where appropriate. For each of these items, the extent needs to be shown, with flood depth or additional intensity measures to be included if appropriate.

These specifications are realized using two object properties: *hasContent* and *visualizesContent*. The former object property associates a map type with its appropriate content items, again making use of quantifiers and cardinality restrictions where applicable. The latter object property denotes how a content item which is linked to a map type using the *hasContent* object property is visualized in the map, i.e. which measure or values are shown. Hence, flood hazard maps are firstly defined as maps having only flood events as content (Martini & Loat, 2007):

$$FloodHazardMap \equiv Map \sqcap \neg (hasContent(FloodHazardMap, Flood)) \quad (E10)$$

The proposed flood risk assessment ontology considers two specific types of flood hazard maps (Martini & Loat, 2007): flood extent maps (depicting the spatial extent of one or more flood events, formalized as OWL class *FloodExtentMap*) and flood depth maps (depicting the inundation depth for a given flood event resembled by the corresponding OWL class *FloodDepthMap*). Subsequently, these map types are defined as flood hazard maps, with their *visualizesContent* property restricted to the intensity measure shown in the given map type, and cardinality restrictions if required.

A flood extent map is thus defined as shown in Equation (E11), with the *visualizesContent* object property being restricted to the range *Extent* as intensity measure, and at least two flood events need to be included (i.e. the medium-probability event and the extreme flood event as required by directive 2007/60/EC):

$$\text{FloodExtentMap} \equiv \text{FloodHazardMap} \sqcap \geq 2 \text{hasContent} \sqcap \vee \quad (\text{E11})$$

$$(\text{visualizesContent}(\text{FloodExtentMap}, \text{Extent}))$$

Again, since OWL does not support numerical value restrictions, the probabilities of the flood events to be included in an extent map cannot be codified or asserted, but must be communicated to the user. Likewise, flood depth maps are defined to include exactly one flood event, which is visualized using the flood depth intensity measure:

$$\text{FloodDepthMap} \equiv \text{FloodHazardMap} \sqcap = 1 \text{hasContent} \sqcap \vee \quad (\text{E12})$$

$$(\text{visualizesContent}(\text{FloodDepthMap}, \text{FloodDepth}))$$

Similarly, flood risk maps are defined in the ontology. Such maps have flood risk (class *FloodRisk*) as content, which is in turn determined and visualized by a risk measure (being e.g. the annual average damage), and thus:

$$\exists \text{FloodRisk: (isDescribedBy}(\text{FloodRisk}, \text{RiskMeasure})) \quad (\text{E13})$$

$$\text{FloodRiskMap} \equiv \text{Map} \sqcap \sqcup (\text{hasContent}(\text{FloodRiskMap}, \text{FloodRisk})) \sqcap \vee$$

$$(\text{visualizesContent}(\text{FloodRiskMap}, \text{RiskMeasure}))$$

The implemented ontology serves as knowledge base for the FloodCalc tool. The tool has been enhanced accordingly to be able to parse OWL files. Moreover, the graphical user interface of the tool has been extended to allow a user to browse the knowledge base (i.e. show information on classes and properties). Finally, tool functions have been extended to make use of the KB:

- The user is displayed all hazard types defined in the ontology, and can select appropriate intensity measures for each hazard type.
- For each intensity measure, suitable measurement units are derived from the KB and presented the user for selection. The tool is furthermore able to convert between different units during damage ratio assessment. I.e., if the intensity measure data for flood depth is provided e.g. in centimetres, but the corresponding stage-damage-function uses meter, FloodCalc automatically converts these units.
- For each type of hazardous event, suitable (i.e. susceptible elements at risk/evaluation criteria) are elicited from the KB and displayed for selection. This way, the user is supported firstly in choosing appropriate items per type of hazardous event; and secondly can rely on a list of criteria which are deemed the most relevant by stakeholders. Thereby, the elicitation of elements at risk/evaluation criteria to be considered in a study is supported.
- For each term captured in the KB, a glossary entry is available.

The proposed ontology currently includes the described expert knowledge on the semantics of flood risk assessment as well as the preferences articulated by stakeholders in the Saxon interviews and workshops (cf. section 6.5). It is in principle independent from FloodCalc and thus sharable and extendable, and may therefore serve as the basis for other tool's KB. By adding classes, properties and restrictions as required, the ontology may be extended to include additional preferences and flood domain knowledge, or may serve as a multi-hazard KB. The Tables Table 9.7 and Table 9.8 list the most relevant classes and properties which may be considered for an extension. Moreover, the ontology captures mapping requirements as e.g. formulated in directive 2007/60/EC. It could prove feasible to extend the ontology so that it also captures the preferences of stakeholders in regard to visualization of map content (i.e. the

number of classes, colour graduation etc.) as elicited in Tasks 2.3 and 2.4 (cf. Section 3.3). Such knowledge could then be queried by the mapping component so that a map is created which conforms to the codified visualization preferences. This is subject to further research though.

Table 9.7: Description of core OWL classes in the flood risk assessment ontology.

OWL Class ID	Description
<i>HazardousEvent</i> ¹	Superclass of all hazardous events defined in the ontology. Core subclass in the scope of this ontology is the class <i>Flood</i> .
<i>IntensityMeasures</i> ¹	Superclass of all hazard intensity measures defined the ontology.
<i>ElementAtRisk</i> ¹	Class defining all elements at risk as a union of individual classes and super-classes: $ElementAtRisk = \{ MaterialInfrastructure \cup Population \cup EnvironmentalComponent \}$
<i>MaterialInfrastructure</i> ¹	Superclass of all material infrastructure elements defined in the ontology. Has two subclasses representing nucleus infrastructure (<i>NucleusInfrastructure</i>) and network infrastructure (<i>NetworkInfrastructure</i>). Each subclass serves in turn as a superclass for different types of infrastructure elements.
<i>Population</i> ¹	Superclass defining the element at risk population. Has subclasses describing different age cohorts which are assumed to be more vulnerable (<i>Children</i> (i.e. the population < 10 years of age), <i>Elderly</i> (i.e. the population >65 years of age), the population aged 10-65 (<i>AllOtherAgeCohorts</i>) as well as <i>TotalPopulation</i>).
<i>EnvironmentalComponents</i> ¹	Superclass for all environmental elements at risk. This class currently does not contain any subclasses, since the environmental risk dimension was deemed unimportant by most stakeholders.
<i>Map</i> ¹	Superclass for different map types (flood extent map, flood risk map) defined in the ontology.

¹⁾ Defined in the flood risk assessment ontology

Table 9.8: Description of core OWL object properties and datatype properties in the flood risk assessment ontology.

OWL Object Property ID	Description
<i>isSusceptibleTo</i> ¹	This object property describes which elements at risk are susceptible to which type of hazardous event. If no restrictions are imposed on given OWL element at risk classes, it is assumed that all types of elements at risk are susceptible to any hazardous event. The inverse of this object property is defined as <i>threatens</i> : <i>threatens</i> ⇔ <i>isSusceptibleTo</i> .
<i>describes</i> ¹	This object property is used to denote the type of hazardous event which is described by a given intensity measure. The intensity of a flood may e.g. be described by the following intensity measures: <i>FloodDepth</i> , <i>Extent</i> , <i>Duration</i> etc. If no restriction is imposed on a given OWL intensity measure class, it is assumed that the intensity measure in question can be used to describe the intensity of any type of hazardous event. In the flood risk ontology, the object property <i>isDescribedBy</i> is defined as the inverse of <i>describes</i> : <i>describes</i> ⇔ <i>isDescribedBy</i> .
<i>requiresBaseUnit</i> ¹	This object property is used to link an intensity measure with its respective base unit from the units ontology ² . For instance, <i>Depth</i> has the base unit <i>meter</i> ³ , or any unit which is derived from this base unit (the inundation depth may e.g. also be given in centimetre, decimetre etc.). This knowledge allows FloodCalc to automatically convert between measurement units in the damage ratio assessment.
<i>derivedFromUnit</i> ²	This object property is defined in the units SWEET ontology and denotes the base unit of any derived unit (e.g. the unit centimetre is derived from the base unit meter). It is used by FloodCalc to elicit any units which may be attributed to a given type of intensity measure as unit of measurement.
<i>hasPrefix</i> ³	This object property is defined in the units SWEET ontology. It associates derived units with a prefix (e.g. the prefix <i>centi</i> for centimeter, being derived from the base unit meter). FloodCalc makes use of this property to derive the prefix for a derived unit (which in turn serves to derive a conversion factor) in the automatic unit conversion during damage ratio assessment.
<i>hasValue</i> ³	This data type property is defined in the units SWEET ontology and has the domain <i>Prefix</i> . For each prefix, it holds a double value resembling the conversion factor between derived unit and base unit (for example, centimeter is derived from meter by the conversion factor 10 ⁻²). This property is used in FloodCalc to determine the conversion factor for automatic unit conversion in the damage ratio assessment.
<i>hasContent</i>	This object property is used to associate a map type with its respective content item.
<i>visualizesContent</i>	This object property is used to associate a map type with the intensity measure which is used to graphically visualize the content items of the respective map type.

¹) Defined in flood risk assessment ontology

²) This ontology is part of the NASA SWEET upper level ontologies

³) Defined in units ontology of SWEET

9.3 Findings from visualisation & from EGS (*including a comparison between old and new maps*)

Sven Fuchs, Kamal Serrhini, Gaëtan Palka

Risk management for flood hazards is based on risk assessment techniques, including methods to determine the hazard potential and procedures to analyse and evaluate the elements at risk exposed. For such management issues, risk maps provide the basis (1) for any planning and implementation of mitigation measures by public authorities as well as for the prioritisation of these measures, and (2) for any activities concerning regional development, land-use and construction engineering. Thus, the overall aim of risk mapping includes (1) the delineation of areas endangered by defined risk thresholds, (2) the assessment of exposure levels in such areas, and (3) the communication of risk to various stakeholders, e.g. politicians, residents and other people concerned. However, as many of these maps are produced by natural hazards specialists rather than cartographers, they often ignore cartographic principles, which results in overloaded and unbalanced maps that are difficult to interpret and to deduce suitable management strategies (Kunz and Hurni, 2011). Therefore, the impact of information on different stakeholder groups and end users has to be assessed in order to provide these issues appropriately.

Using the method of experimental graphic semiology had shown that the structure of maps influences the visual strategy of the readers; therefore, map perception is iconographic. The more accessible visual information is, the more effective it will be in terms of visual transmission of information. Moreover, particular reading behaviour of specialists, sensitised people and laypersons led to the conclusion that perception is anthropic. Hence, risk maps should be compiled according to these different needs, in particular bearing in mind that approximately two thirds of the observation time of individuals is devoted to less than one fourth of the map surface (Fuchs et al., 2009). Taking the results from the RISK CATCH project as a basis certain aspects are of general importance with respect to an appropriate visualisation of flood risk; these aspects were taken as an overall framework within the RISK MAP project:

- Coloured zones and written information concentrated approximately 90 % of the number of fixations of the individuals tested.
- The concentration of information in the legend needs to be visible (according to the contrast and colour used) and accessible (only a limited number of information), to attract the eye and deliver information.
- The spatial localisation of information considerably influences the perception by the reader.

The analysis of the visual strategies of the individuals tested and the results of an expert survey enabled us to identify some shortcomings of current practices in flood hazard visualisation and to suggest general improvements for visualisation of certain map elements:

A visual variable colour hue, value, or saturation is most frequently used for the depiction of hazards processes and large-scale maps are dominated by a spatial symbolisation filled in different colour schemes. The choice of a colour scheme has to be carefully performed as it is not only important for a visually attractive map but also to facilitate the distinction between data classes and the general visual exploration of the data by different stakeholder groups.

The potential of texture and symbols was found to be underestimated by mapmakers, as only few maps exhibit the use of such features, although they can associate map symbolisation with the characteristics of natural phenomenon which facilitates the intuitive interpretation of the map. Apart from the coordination of these elements, maps also have to be adjusted to the needs of different user groups. Therefore, icons indicating major cumulative risks, evacuation pathways or simply the direction of water body flow may be indicated in individual map templates.

The approach of toponomy may be used in addition to the traditional visual variables such as colour hue, colour value, colour saturation; and the shape, size, orientation, texture and transparency of individual elements in order to support the efficient orientation of end users; and to improve the visual accessibility of the map.

As the user group of flood hazard visualisations is heterogeneous, digital interactive environments can offer solutions to customise different map elements according to differing end user needs. We strongly recommend compiling flood risk maps of different content for specific user groups, which can be undertaken by GISs and similar digital environments efficiently from the underlying data sources. As such, an intervention map (produced for emergency management actors) will include different symbolisation than a flood risk map compiled for use in land development planning. As a consequence, supplementary information can be organised according to these different needs, e.g., the legend for lay persons may contain a small number of classes to communicate the general ideas of flood risk in a specific region while for the decision maker this legend may become more complex and multi-faceted in order to deliver as much information as possible.

By using the approach of experimental graphic semiology, the visual and cognitive perception patterns of different end user groups were assessed. The overall aim was to develop rules for the production of graphic documents that are suitable to the specific needs and preferences of multiple end users. The variables that were used to build-up these rules are summarised in Figure 9.12 and include specific semiological variables (form, size, shape, txt, colour) and the overall map content in a greater extent. The variables described in Figure 9.12 are related to the primary map content such as the vulnerability to flooding (colour variable), the population at risk (colour variable) and the migration flows (commuters, colour and size variable), the impacts of the hazard on the environment (economy, ecology, population, colour variable) and the mitigation alternatives (evacuation, colour and direction variables).

The statistic, static and spatial analyses of distribution of eye movements (fixations and saccades) resulted in two significant categories of visual strategies, (1) a linear category along a given axis or direction and (2) a dispersive category originating from the centre of the main graphic element in the map (Figure 9.13). With respect to the latter, the phenomenon of spatial concentration was observed, that is when the spread of the eye movements is limited to the centre and neglecting the peripheral areas of the graphic element. Accordingly the question of scale has to be addressed when compiling risk maps since these neglected peripheral areas provided the hint that the central elements may be depicted by using a larger map scale and therefore focussing on the core information to be delivered. These results confirmed the strong iconographic character of a risk map reported by Fuchs et al. (2009) as a main result from the RISKATCH project.

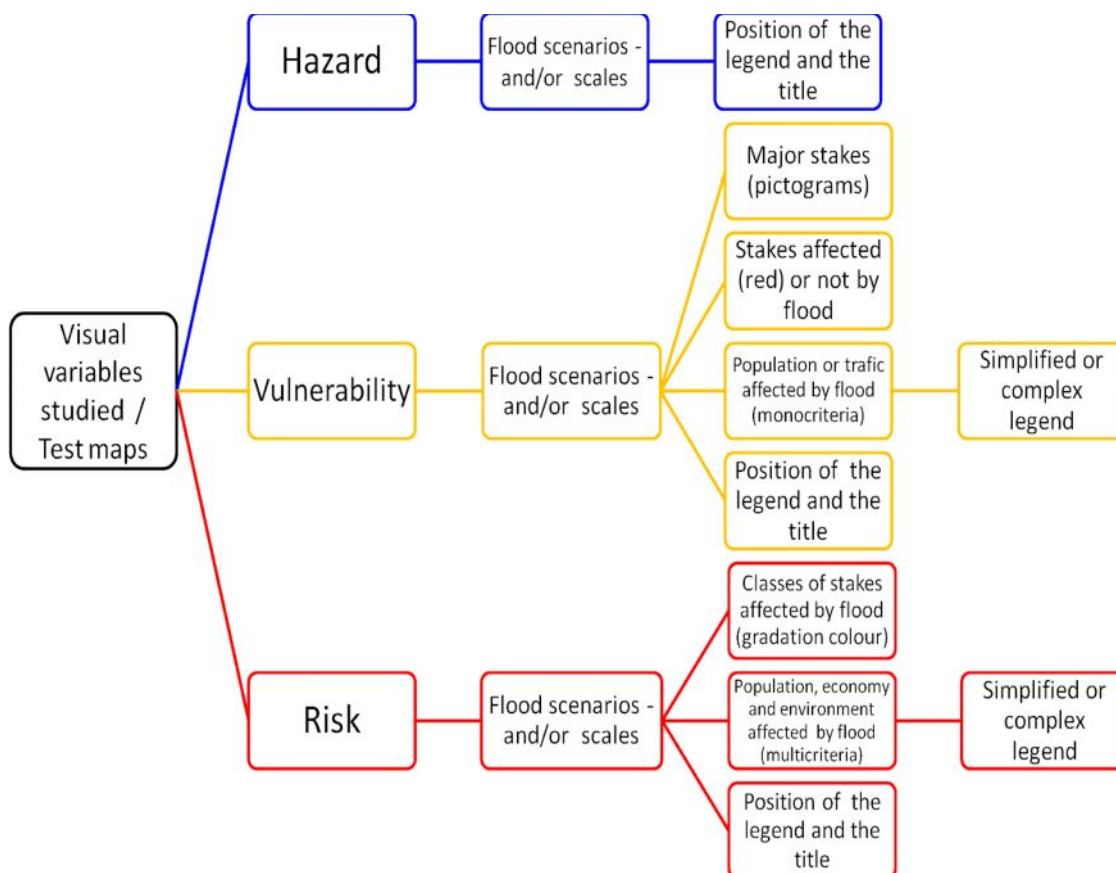


Figure 9.12: Global logigram for the visual variables studied, in blue variables related to the hazard, in yellow related to the vulnerability and in red related to the summarising risk information (Serrhini 2011).

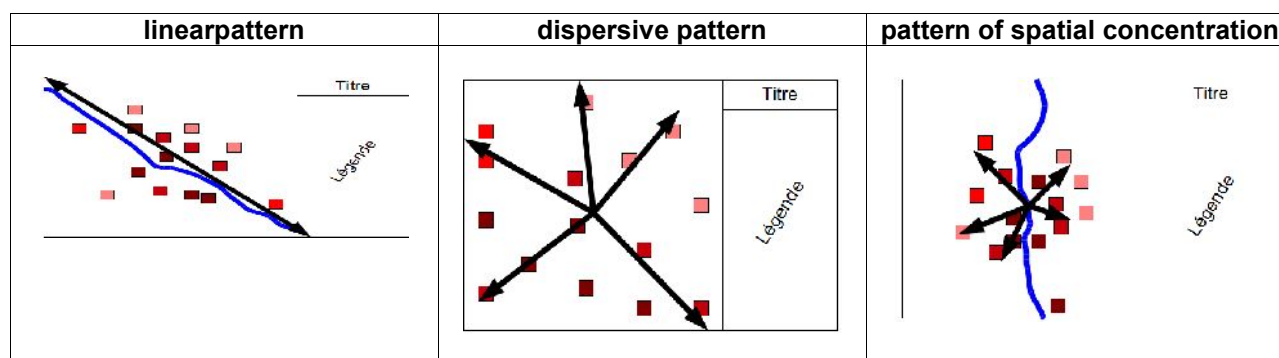


Figure 9.13: Different patterns in the visual strategy of map reading.

In general the sectorial analysis of the test results confirmed the strong attractiveness of graphic elements such as pictograms, contrast, and textual information to the gaze; as well as toponymy and (for mitigation purpose) linear elements of evacuation and access.

As analysis of the cognitive survey that accompanied the eye tracking tests showed strong correlations between the *density of information* provided and the *complexity* of the map, as well as between the *usefulness for application in flood risk management* and the *aesthetic aspect*.

The interactive elaboration of an idealised flood risk map (puzzle map) attempts to assess the preferences of map-readers by giving them the opportunity to draw their preferred maps and to define the individual needs and semiological preferences of map design. Such an approach tends to be very helpful in terms of the analysis and assessment of different stakeholder preferences, and resulted in considerable differences in map design (cf. Section 3.3.5).

In accordance with the results of the eye tracking test and the stakeholder preferences a set of adjusted risk maps was produced in order to acknowledge the recommendations achieved with respect to form and content of risk maps (Figure 9.14). A complete set of maps is provided in the Appendix 12.2.

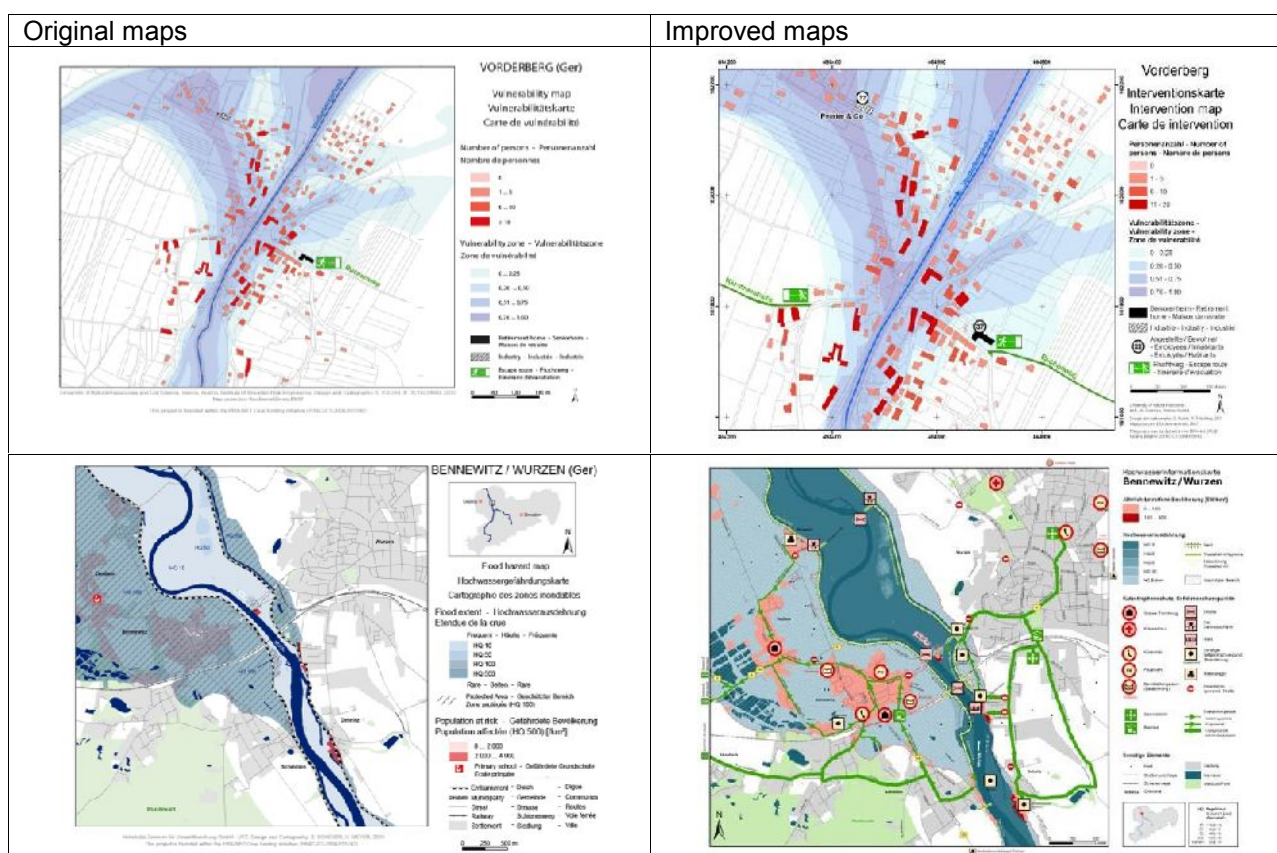


Figure 9.14: Original risk maps (left) and improved maps according to the findings of visualisation and experimental graphic semiology. Top: risk map pair from Vorderbergerbach, Austria: Improvements included the scale of the central graphic element, the toponymy, and more specific information on people at risk and evacuation possibilities. Bottom: risk map pair from Bennewitz/Wurzen, Germany: Improvements included the hue, the depiction of areas at risk including population at risk, and strategic pictograms highlighting risk hot spots and evacuation pathways.

A risk map compiled according to these conclusions would result in a visual strategy that is composed from three clear sets of ocular movements (Fuchs et al., 2009): Starting from the centre, the eye moves to the title of the map, following a vertical axis downwards the legend section and returning back to the central element of the map. If there is sufficient time, the additional peripheral elements of the figurative part are explored subsequently.

However, due to budget constraints, the results of this pilot study are not yet fully representative. They can only provide first hints for further research, with respect to a larger group of test persons as well as with respect to further refinements of the method. In particular concerning the European Flood Risk Directive, but also with respect to the overall aim of building hazard-resilient communities, future studies might include the applicability of risk maps within flood risk management plans. This is of particular relevance since different methods and guidelines exist in European countries in order to deal with hazard and risk, based on different national legislation. Hence, there is no commonly accepted guideline or template of how risk maps have to be compiled according to scale, design, content, etc. Moreover, due to different administrative organisation (e.g., centralised vs. federal) and multiple technical responsibilities on national scales (e.g., Torrent and Avalanche Control Service vs. Hydraulic Engineering), the compilation of necessary information remains often un-coordinated and even mono-disciplinarily organised between multiple stakeholders. Apart from these constraints it is still not sufficiently discussed which target scale to be used for the compilation of risk information (generalised using aggregated data vs. specific using object-based data). Therefore it might be necessary to compile different risk maps according to different scales, but also to deliver diversified risk information to different target groups and stakeholders.

Nevertheless, the study has proven that a stakeholder-oriented compilation and design of risk maps is of considerable importance in order to deliver information target-oriented. Therefore it is necessary to identify precisely the specific needs of different target groups and stakeholders.

10 Common recommendations: How to come to user-friendly flood maps

10.1 Summary of the project

The central objective of RISK MAP was to improve the content and visualisation of flood maps through a participatory process but equally to test whether flood mapping is an effective means and process through which to facilitate participation. By following this objective we asked whether the content and visualisation of existing flood maps really fulfils the expectations and needs of different end-user groups. Based on our project findings (cf. Section 9), we will give in this concluding section recommendations regarding the following points:

1. How should stakeholders be involved in the mapping process (creation and updating of flood maps) and what are appropriate participatory processes?
2. Which contents should be included in flood maps for which user-group?
3. How should flood maps be visualised in order to produce user-friendly and understandable maps?

Before giving an overall summary of the project findings we outline the empirical basis of our study as well as the methodological design. Our findings and recommendations are based on research done in five different European case studies: Two small Austrian torrent catchments; the Lower Thames River area in England; a section of the Vereinigte Mulde River in the Federal State of Saxony, Germany; the Rivers Vils and Rott in the Federal State of Bavaria, Germany; and the City of Tours at the Loire River in France.

In each of the case studies first the current practices of risk mapping, legal frameworks and existing flood maps were analysed. Interviews and workshops were carried out with stakeholders in order to identify shortcomings of existing maps and the specific needs of different stakeholder groups. New maps were created based on these needs and tested by means of eye-tracking tests, i.e. the reading behaviour of stakeholders was recorded and analysed. Again maps were adjusted according to the findings of these tests and were discussed again with stakeholders in order to come to case-study specific but also overall recommendation for flood mapping. Furthermore, a risk mapping software tool has been developed which facilitates an integration of stakeholder knowledge and preferences into the final map product.

The results of our research underline the value and relevance of participation in mapping. Participation in mapping enables and facilitates a two-way learning process, network building and improved understanding of maps and their interpretation both on the side of the map producers as well as end-users. The main end-user groups considered in RISK MAP are strategic planners, emergency managers and the public. In the following section we provide an overview of the most important insights on the structure previously presented, namely aspects that relate to participation, content as well as visualisation.

How should stakeholders be involved in the mapping process and what is an appropriate participatory processes? There is not one single best way of conducting a participatory mapping process. Within the case studies the participatory process was conducted by partners in different locations, in institutional and cultural contexts and was hence adapted to the specific requirements and

contextual conditions. However, as an overall finding we conclude that the appropriateness depends largely on the purpose of the participatory process. Defining the purpose is hence an important step that should ideally be clarified at the beginning of any participatory process. In a general sense we propose to distinguish between *substantive* and *instrumental* rationales. If a participatory process follows a *substantive* rationale, it aims to increase the breadth and depth of knowledge contributing to the final product by including more contextualised forms of knowledge that cannot simply be reproduced by modelling. The *instrumental* rationale aims to build trust between different actors or stakeholders in the public and administrative spheres. It may also attempt to contribute to raising people's awareness and motivation for taking actions to mitigate the impacts of hazards. In this sense, the answer to the question "What should be achieved by the participatory process?" is essential as it has implications for the choice of actors to be involved during the process, the intensity of the process as well as the outcome of the entire process. More specific recommendations are provided in section 10.3.

Which contents should be included in flood maps for which user-group? RISK MAP confirms the finding that for target-oriented communication, the contents of flood maps need to be adjusted to the end-user's requirements as these vary between different end-user groups. For example, *Strategic planners* require maps that show where areas of high risk are, i.e. where there is a need for risk mitigation efforts. Maps also serve as an intermediate product for economic appraisal of flood risk mitigation measures. With regard to hazard information, detailed information on inundation depth is particularly important for events with different probabilities. Regarding information on the consequences of flooding the following contents are of importance: Information on the consequences of specific events should be shown, but also maps showing the annual average damage as a basis for economic appraisals. Furthermore, not only should information on the economic damages be shown but also information on social, cultural and environmental risks in order to show a complete picture of possible consequences. This should also include critical infrastructure, like bridges, power plants, hospitals etc. An aggregation of these different social, economic and environmental risks by means of a multicriteria risk map may be supportive to show overall risk hot spots.

Emergency managers, on the other hand, need easily accessible maps to have quick access to information on affected areas, in the event of an emergency where people need to be evacuated, critical infrastructure protected and evacuation routes determined etc. With regard to the consequences of flooding the following information is most important for emergency management: The number of people at risk from a certain event, i.e. the number of people to be evacuated in case of emergency; critical infrastructure which has to be protected, secured or evacuated (i.e. hospitals, energy or water supply facilities, relevant or blocked roads and bridges). Apart from traditional hazard and risk information, information on emergency management itself should also be included, such as meeting points, evacuation routes, hospitals, gauging stations etc. Again, information should be included which details the level of flooding that these emergency facilities may themselves be at risk from, i.e. when certain evacuation routes are not usable any more.

The public also requires easily understandable and accessible maps, but with a lower density of information, including only the most crucial information: Information on the extent and depth for events with different probabilities should be presented to highlight streets and individual properties at risk. Furthermore, limited additional information such as evacuation routes, shelter, assembly points may be included providing this information does not overload the map.

More detailed recommendations for the different user-groups but also some more general recommendations on contents will be given in section 10.4

How should flood maps be visualised in order to produce user-friendly and understandable maps?

Similar as argued before, multiple topics dedicated to different user groups should not be shown on the same map. E.g. evacuation information (which is necessary for emergency managers) should not be mixed with information on economic impacts (which is more relevant for strategic planning). A map should rather be easily accessible and interpreted, not overloaded with information and high in contrast with regard to the choice of colours and brightness. This implies, for instance, that areas at risk should be

clearly visually differentiated from areas not at risk. Furthermore, the research shows that the use of self-explanatory icons or symbols to highlight major risks or the direction of evacuation routes (for example) can facilitate quick access to the relevant contents. Also text should be used within the maps in order to better and more quickly transmit important information, such as information on the number of people to be evacuated. The legend should be sufficiently large, preferably on the right side of the central element of the map, with a limited number of information (not more than five classes of discretisation) comprised from one range in colour only and arranged in decreasing values. The topics in the legend should be organized in a way that it really helps comprehension: Firstly hazard information, secondly major risks, then secondary risks, finally background information. More specific recommendations will be given in section 10.5.

10.2 Producers and users of flood maps

The following recommendations are dedicated to various actors involved in flood risk management and more particularly on the development, production and dissemination of flood hazard and risk maps. A particular group within this setting are persons or institutions responsible for producing such maps: To be more specific, the recommendations in this section focus on the persons who decide how floods mapping should be conducted. These people often belong to public bodies responsible for flood risk management. Maps are either produced in the same public agencies where flood risk management is carried out, or they are created by external consultancy and engineering companies according to mapping guidelines published by these agencies.

One main finding of RISK MAP is that different users or user-groups have very different needs with regard to flood maps, which might not necessarily be in accordance with the needs and views of those producing the maps. This confirms Zeisler's (2010) argument that the map creation process should be led by the requirements of the users. There is a large variety of users who use a different "language" and pursue different objectives. It is a major aim of the project to inform map producers or decision makers on the specific needs and appropriate processes for engaging different users in mapping and risk communication. The project aimed to encourage a more inclusive approach towards maps production, going beyond the closed circle of those usually involved in producing maps. The rationales for including the different users are outlined below. Before giving a more detailed account, we suggest to distinguish three major user-groups which were considered in the RISK MAP project⁵⁸:

1. Map users from strategic planning:

Persons from this group are often from the same agency responsible for the creation of flood maps. In some cases, the producer and user of a map might even be the same individual. However, in other cases end-users are members of regional branches of the agency responsible for flood risk management. Maps are used here as a basis for strategic decisions on flood risk management/flood protection measures. People in this group are usually experts by profession in using flood maps and they use them regularly in their daily work. Furthermore, at least in normal decision processes, there is usually sufficient time to study the maps in detail. From our research we know, that map users of this group are able to deal with a high density of information within the maps and that they are able to comprehend more complex content, such as exceedance probabilities, annual average damages etc.

Within this group, we can differentiate between another sub-group; spatial planning end-users. This group is usually also involved in contributing to strategic flood risk management but is often located in a different agency or department. By profession they may be less familiar with flood maps and have slightly different requirements on flood maps.

⁵⁸ See also classification by the EXIMAP project which indicates spatial planners as a separate category and furthermore adds the private sector (especially insurance industry) as a fifth group.

2. **Map users from emergency management:**

Emergency or disaster management may be institutionally separated from strategic planning in flood risk management. Responsibilities are for example, in the local or regional administrations of municipalities or districts and often also fire brigades or even armed forces are involved. The main purpose of flood maps in this field is to provide quick access to information on affected areas in the event of an emergency, such as people to be evacuated, critical infrastructure to be protected, evacuation routes etc. As flooding (or water) is often not their sole responsibility, users from this group may have less experience with flood maps than map users from strategic planning who are likely to view the maps on a more regular basis. This poses problems as it may be that this group is less familiar with the scientific concept of risk, i.e. the mapping of annual average consequences, and as such, aggregated information may be less relevant for their day-to-day use of the maps.

3. **Map users from the public:**

Citizens are usually neither directly involved in producing the maps nor do they deal with them on a professional basis. However, maps, such as flood hazard maps, are often directed towards them with the aim of raising awareness. We may therefore assume that in general their use of flood maps is generally infrequent and that they have limited experience with the maps. As such, this group is likely to be unfamiliar with concepts such as exceedance probabilities or annual average damages. On the other hand members of the public are more likely to rely on a detailed contextual knowledge which has been gained from previous experiences with flooding (for example). They may hence make valuable contributions to mapping process, providing a different type of knowledge and information to enrich map content and visualisation. Aside from this, there is a further sub-group; the organised public. This group consists of environmental or business interest groups and similar, which represent particular interests.

10.3 Common recommendations on stakeholder participation processes

Purpose of participation

How a participatory flood mapping process should be set up and conducted depends largely on the purpose of the process itself. Defining the purpose is hence an important matter that should ideally be clarified at the beginning of a participatory process. In a general sense we propose to distinguish between a substantive and an instrumental rationale. In this sense, the answer to the question “What should be achieved by the participatory process?” is decisive as it has implications for the choice of actors to be involved in the process, the intensity of the process as well as the outcomes of the entire process.

In the following section we provide an example for a participatory process following a substantive rationale. More information on other rationales are given in Table 10.1

Substantive rationale

If a participatory process follows a substantive rationale it aims to increase the breadth and depth of knowledge contributing to the final product. Examples are attempts to include more contextualised forms of knowledge that cannot simply be reproduced by modelling exercises. This is evidenced by updated models changing flood extents but also by the very nature of flood risk as an evolving risk. Flooding risk changes over time as landscapes and climates change. In order to improve the data and information available on flood risk, traditional modelling can be supplemented by additional ‘informal’ sources of knowledge. Capturing this knowledge requires a participatory approach to flood risk mapping.

Possible participants

Participants may be both from the professional field of flood risk management (e.g. strategic planners as well as emergency managers) as well as from the public. A decisive criterion, however, would be their expertise. This expertise might be gained either by formal education and hence testified by some kind of degree and/or professional background or it might be gained by experience and personal observation as an informal process of knowledge acquisition. The latter groups may comprise local residents who may have expertise in the mechanisms and a history of flooding in their neighbourhood.

Participatory process

The process would be rather intensive and would comprise a series of meetings. Both representatives from the public as well as representatives with a professional background would be treated as equals which implies that both have an equal right to influence the decision-making process. Such a process aims at creating open and mutual exchange while allowing the identification of different or similar opinions/worldviews/values among and between different actors; on the other hand, it also aims at the participants actively influencing the final decision-making process⁵⁹.

Table 10.1: Recommendations for participatory processes for different aims

	1. Substantive (e.g. improving content)	2. Instrumental – substantive (e.g. verifying content)	3. Instrumental (e.g. raising risk awareness)
Participants	Those with 'expert' knowledge on a subject (e.g. strategic planners, emergency managers and citizens with expertise by experience.	Open to all stakeholders. Mixed groups of stakeholders	Individual members of the general public
Process	Series of meetings centred on production and verification of maps.	Intensive and iterative engagement, repeated meetings to report and check changes	One meeting to raising risk awareness. Two or more meetings to improve trust and legitimacy.
Focus	Focussed on content, in particular focussed on the development of its content but also on verification.	Content selection, verification and visualisation.	Focussed on intuitive usability for a broad and general audience
Outcome	Verified and corrected map outlines.	Raising awareness, maps tailored to end-user preferences, increased trust and development of co-operation networks.	Raising awareness, tailored maps to suit end-users, increased trust and legitimacy.

- **Recommendation 1: Participation and the degree to which the instrumental and substantive rationales are accommodated should be tailored to the project objectives.**

⁵⁹ Arbter et al. (2007), p. 9; Kuhlicke, Steinführer (2010), 89ff. Kenyon, W., Hanley, N., Nevin, C. (2001): Citizens' juries: an aid to environmental valuation? Environment and Planning C 19, 557-566.

Participation for Risk Awareness

Raising risk awareness is part of the instrumental rationale for a participatory process. Maps are useful tools in raising risk awareness and workshops offer the opportunity to consider the maps in a group situation.

In order to raise awareness of flood risk through mapping workshops, the participants should comprise small groups where those inexperienced and unaware of the risk are able to participate alongside others who have experienced flooding. By working in such mixed groups, participants may interact with each other, allowing those affected by flooding in the past to share their experience(s) and the lessons they learned with each other.

- **Recommendation 2: Participants should comprise of groups that ideally include individuals with and without experience of flooding. The process should allow time for flood experienced participants to share their experience with those inexperienced, thus raising awareness of the hazard.**

Verifying content

The substantive rationale places considerable emphasis on the value of participatory mapping process for improving the accuracy and confidence of maps through stakeholder verification. Stakeholders including some members of the public that can potentially provide additional 'expert' information to improve or verify the content of maps.

'Expert's may be any person with detailed knowledge of flood history and mechanisms in the area concerned. These experts might be those who generated their 'expert' knowledge through their professional capacity or through personal experience within the area under consideration. As the research demonstrates, and as depicted in Participants may be both from the professional field of flood risk management (e.g. strategic planners as well as emergency managers) as well as from the public. A decisive criterion, however, would be their expertise. This expertise might be gained either by formal education and hence testified by some kind of degree and/or professional background or it might be gained by experience and personal observation as an informal process of knowledge acquisition. The latter groups may comprise local residents who may have expertise in the mechanisms and a history of flooding in their neighbourhood.

Participatory process

The process would be rather intensive and would comprise a series of meetings. Both representatives from the public as well as representatives with a professional background would be treated as equals which implies that both have an equal right to influence the decision-making process. Such a process aims at creating open and mutual exchange while allowing the identification of different or similar opinions/worldviews/values among and between different actors; on the other hand, it also aims at the participants actively influencing the final decision-making process

Table 10.1 above, those with 'expert' knowledge through their professional capacity are traditionally weighted more highly than so-called local experts. As such professional 'experts' tend to achieve higher decision influence than the public 'experts'. Public experts do not necessarily have to be those with flood experience. An expert may be a person that has witnessed flooding or lived in the area for many years to develop an understanding of the mechanisms of flooding.

- **Recommendation 3: Participation can engage groups of experts that may be excluded from contributing to mapping in their traditional capacities. These 'experts' should be engaged to improve the accuracy and confidence in the map.**

Participants

In order to maximise the breadth and depth of knowledge to enhance and improve maps, it is important that participants comprise a varied group representing many different interests and perspectives.

Participants should include not only those involved in producing maps and the flood risk data depicted within them, but should also include end-users such as those involved in emergency response activities or the general public.

Participation should also aim to include professional stakeholders with different but related responsibilities. Bringing these groups together under the unifying tasks of the workshop may help to develop networks and understanding which can improve the potential for joined up working.

Participation should be open to all but should not be an obligatory process. Such obligated participants may not be interested in the process or subject and as such both their input and the benefits they receive from being engaged remain particularly limited. In addition, an overall impression of the process as being negative due to their lack of interest in participating, may be a negative impression that prevails on future opportunities to participate in different projects.

- **Recommendation 4: Participation should be open to all stakeholders and should aim to include participants representing a broad range of interests. Participation should be by choice and stakeholders should not be under obligation to attend. Such an approach promotes a productive and positive experience.**

In addition to covering a range of perspectives, a participatory process that involves both end-users and those producing the maps can raise trust in the accuracy and credibility of the maps and those producing them. In addition, the map producers can explain any unclear terms or symbols to improve the comprehension of maps. In turn the map designers are able to identify aspects of their maps that may need improvement to enhance their readability and utility.

- **Recommendation 5: End-users and map producers should be involved together to improve the usability and trust in the maps.**

Neutral facilitation

The presence of a neutral facilitator is vital to ensure that discussions are focussed on the subject matter. Neutral facilitation also plays a useful mediation role as it places all participants on a more level playing field to facilitate open discussions (Instrumental). Facilitators are able to ensure that discussions are balanced with contributions from all participants, reducing the potential for some participants or stakeholders to dominate the discussions unfairly. Facilitators need to be able to manage the process of participation in such a way, when required to do so. Whilst facilitation requires additional resources, these resources are justified as they ensure the process is efficient and remains focussed on the subject.

- **Recommendation 6: Employ neutral facilitation to ensure discussions are focussed and participants are able to contribute fairly.**

Timing

Participation at an early stage in the process of map design is important to ensure that stakeholders input can be taken into consideration and is not overly limited by decisions that have already been made. However, participation should take place at an appropriate point, where draft maps are available against which participants can work and input. Participation prior to the production of drafts may be ineffective as participants may struggle without a base for their discussions.

- **Recommendation 7: Participation should take place at an early stage where drafts are available to consider but where changes can be made and are not limited.**

An iterative process of participation is essential to promote the trust and credibility of maps and the participatory process. As such stakeholders should be presented with maps that have been modified

based on their input. This enables participants to verify that any changes made to the drafts are satisfactory in addition to demonstrating how stakeholder comments and opinions have been valued. Such an iterative process may result in a more positive impression and trust in the agency producing the maps.

- **Recommendation 8: An iterative process with follow up events should be held to demonstrate changes made as a result of participant contributions. At such events changes made in line with participant comments and input should be emphasised to reinforce the value of participant contributions.**

The workshop method

Workshops are a particularly useful method for facilitating participation. By working in small or even one large group, participants are able to share ideas and knowledge with each other and the facilitators. When working in small groups it is advantageous to allow time for the groups to report back to each other so that those points raised in the small groups may be shared with other participants.

As participants are unlikely to be already acquainted, proper attention must be paid to a suitable introduction to the project, the role of participation but also to the participants themselves. A simple round of introductions followed by an ice-breaker task which challenges participants into working together (such as the blank maps task) is essential to quickly establish an open and communicative atmosphere in which to explore the issues.

- **Recommendation 9: Including an introduction to the project, tasks and workshop attendees promotes a comfortable setting for a productive process. An ice breaker task is useful in establishing an active setting.**

Evaluation

In order to establish the level of benefit experienced by the participants, it is necessary to conduct an evaluation of the participation event. Questionnaires are a useful tool for capturing the participants' perspectives and evaluation of the workshops in addition to any additional information they may not have been able to contribute during the event. Questionnaires also allow participants to feedback their opinions anonymously which should encourage an honest account and interpretation of their impressions and experience.

Evaluation can be used to identify areas of success and areas for improvement or change. Thus the evaluation forms a key part of the design for a follow up event.

- **Recommendation 10: Conduct an evaluation of the participation process in order to capture participants' perspectives and any additional information that may be useful but not presented during the discussions.**

10.4 Common recommendations on contents of flood maps

The question concerning the kind of information (contents) that should be delivered by flood maps is of course of major importance. Flood maps are usually divided into hazard maps, showing information on the spatial extent and/or depth of inundation for flood events of different probabilities, and risk maps, showing also the consequences of these events. Hereby, flood risk maps as defined by the EU Floods Directive show the consequence for specific events with defined probabilities (often also called damage maps), while risk maps in a narrow sense show the consequences for the full range of possible flood events, measured in terms of annual average damage or consequences. Such consequences of flooding could be

e.g. the people affected, damage to buildings, inventories or infrastructure, destructed ecosystems etc. One major research question in RISK MAP was to find out which of these hazard or consequence items are of major importance for the end-users and should be therefore displayed in flood maps.

As stated above, it was a key finding of the project that different end-users require different maps, and this is of course also true for the contents of flood maps. In the following section general findings are presented followed by recommendations on the contents of flood maps before moving on to the recommendations for the different end-user groups as specified above: strategic planners, emergency planers and the general or potentially affected public. Some recommendations on the contents of flood maps for different user-groups have already been provided by the EXCIMAP project⁶⁰. These findings have also been considered for the following recommendations and have been enhanced by some additional findings from research conducted in the RISK MAP project.

General recommendations

- Hazard and risk maps, as required by the EU Floods Directive, should be only viewed as an intermediate product for risk communication and management and not as an end-product. The contents which are required in article 6 of the directive build a very good basis for communicating risks to the end users. However, they should not be seen as the final product. As outlined in the Floods Directive, these contents could be extended by other useful information. Furthermore, they should be part of the flood risk management plans (see article 7 of the Floods Directive) and could be further enhanced during the development of these plans.
- For target-oriented risk communication the contents of these maps should be further adjusted to the end-user needs as different end-user groups have different requirements on the contents of flood maps (see specific recommendations for strategic planning, emergency management and the public below).
- Where required, risk or emergency management information should be also included in the flood maps. Our case study results showed that many end-users (from the public, emergency management as well as strategic planning) find it very useful to have information on existing (or planned) defences, evacuation routes, meeting points, for example, already integrated in the maps. Such map contents have up to now not been required by article 6 of the Floods Directive but could be integrated in the maps in the process of the development of risk management plans.
- All maps should refer to a single data basis. It is frustrating for end-users if maps refer to different models or model runs. Even if different maps are produced for different end-users they should all refer to the same data basis in order to avoid such frustrations.
- Digital and printed maps should be viewed as complementary, not as alternative services. The easiest way to allow end-users to receive a map according to their needs would be of course a digital map server. By choosing map layers according to their needs individual maps can be created. However, the existence of such map servers does not guarantee that e.g. the public recognises that such maps are really at hand in case of emergency. This means user-specific print-out versions should be produced for the most important user groups. However, as the recommendations for the different user-groups in the following will show one map per user-group will not be sufficient to show all relevant information. On the other hand, the number of print-out maps should not be too high in order to ensure applicability and avoid information overload. Participatory processes can be used (see Section 10.3) to find out a good compromise.
- Frequent updating of maps or at least information on the reference date of the maps seems to be useful for all user-groups

Recommendations for flood maps for strategic planning

As specified above (section 10.2) map users in this group are usually very experienced in the work with flood hazard and risk maps. Furthermore, at least in normal working situations they have sufficient time to

⁶⁰ http://ec.europa.eu/environment/water/flood_risk/flood_atlas/pdf/handbook_goodpractice.pdf

study maps in detail. Hence, they are able to deal with a high density of information displayed on the map and complex scientific contents. The purpose of flood maps for this group is especially to show where areas of high risk are, i.e. where there is a need for risk mitigation efforts. Maps serve also as an intermediate product for economic appraisal of flood risk mitigation measures. For this flood risk has to be calculated for the situation with, and without, the planned measure(s) in order to estimate their risk reducing effect.

- With regard to hazard information especially detailed information on flood extent and depth is required for events with different probabilities. If available also information on flow velocities can also be helpful.
- Regarding information on the consequences of flooding the following contents are of importance:
 - Information on the consequences of specific events should be shown, but also maps showing the annual average damage are necessary, especially as a basis for economic appraisals.
 - As already required by the EU floods directive, not only should information on the economic damages be shown but also information on social, cultural and environmental risks in order to show a complete picture of possible consequences. This should also include critical infrastructure, such as bridges, power plants, hospitals etc.
 - For strategic planning also an aggregation of these different social, economic and environmental risks by means of a multicriteria risk map can be helpful in order to show overall risk hot spots.
 - Maps for strategic planning should also include information on existing flood protection, protected areas and residual risk in these areas.

Recommendations for flood maps for emergency management

The main purpose of flood maps in this field is to enable quick access to information on affected areas, people to be evacuated, critical infrastructure to be protected, evacuation routes etc., in the event of a flood.

- Maps for emergency management should include hazard information on the extent of events with different probabilities as well as information on critical depth and velocities (when it is no longer possible or save to access certain areas). However, a clear link to alarm stages and critical water levels at gauges upstream, for example need to be established. The question thus is not what area will be flooded during a flood event with a return period of approximately 1:25 (as this is only calculated after the event) but which area will be flooded if the water level rises above certain threshold values.
- Also for emergency management, information on existing flood defences and areas protected by these defences is important: e.g. potential weak points in the defence line, at which level a failure of defences is possible and which areas would be affected in such a case.
- With regard to the consequences of flooding the following information is most important for emergency management:
 - The number of people at risk from a certain event, i.e. the number of people to be evacuated in the case of an emergency.
 - Critical infrastructure which needs to be protected, secured or evacuated, i.e. hospitals, energy or water supply facilities, roads and bridges which may have to be closed. Furthermore, information should be given at which level of flooding e.g. roads can still be used and at which level they should be closed.
- Apart from traditional hazard and risk information, information on emergency management itself should also be included, such as assembly points, evacuation routes, hospitals, coordination

centres, gauging stations etc. (see Figure 10.1). Again, information should be included which detail the level of flooding these emergency facilities are themselves at risk, i.e. when certain evacuation routes are not usable any more.

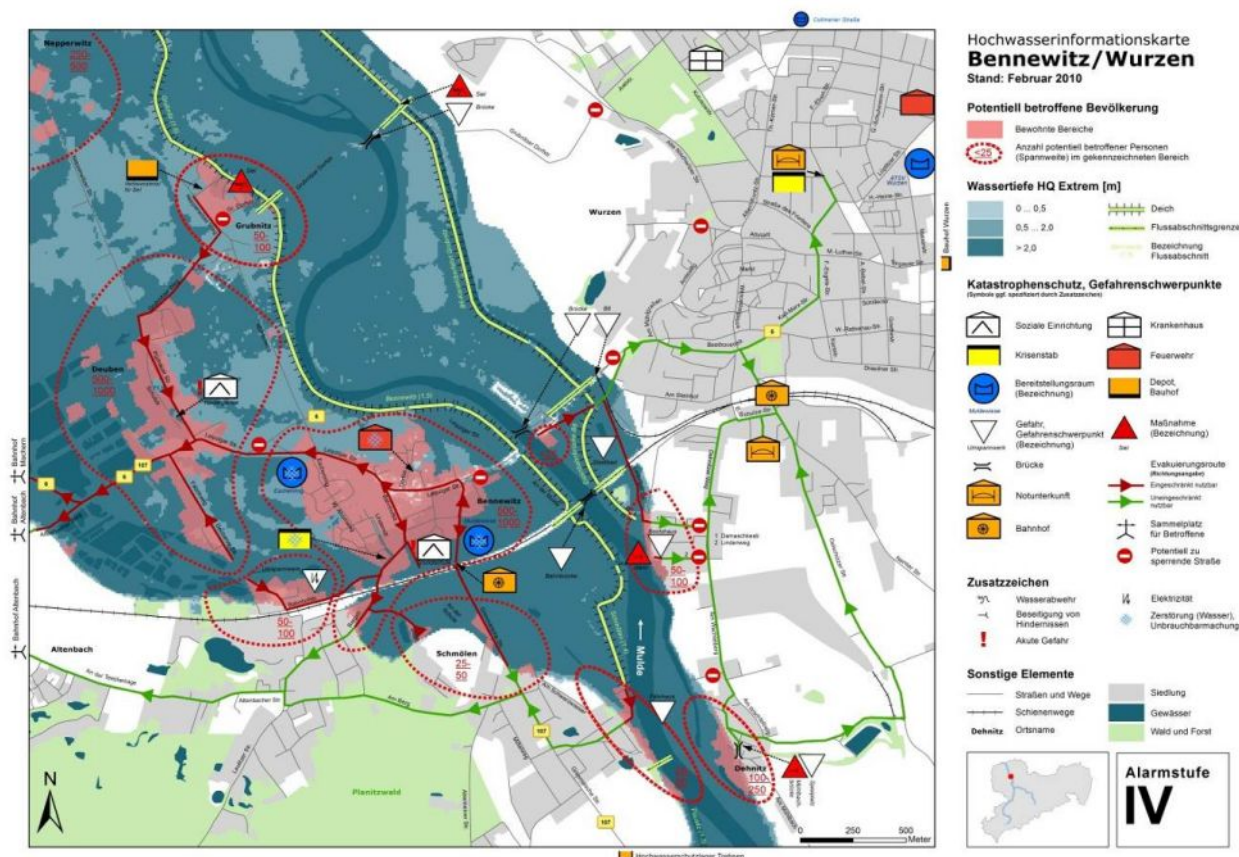


Figure 10.1: Exemplary map for emergency management (case study Saxony): Map contents include important emergency management information (coordination centre, assembly points, evacuation routes), critical infrastructure, inundation depth and affected population. However, stakeholders criticised that information on exact number of affected people, building information can still be improved.

Recommendations for flood maps for the public

Many maps are directed towards the public (e.g. to motivate them to prepare for a flood hazard). In contrast to the previous groups, people of this group, in most cases, do not use maps on a daily basis and hence have different needs and requirements in terms of its content. Generally, we recommend that flood maps for the public should not be overly complex and should contain the following basic information.

- Firstly, inundation depth information for different specific events should be shown. As normal citizens are not necessarily familiar with the concept of return periods or exceedance probabilities such terms should be avoided and rather terms like “small, medium or extreme event” should be used. Also the extent and depth of historical events could be shown as people can better relate the base information to their personal experience.
- Maps for the public do not need to include information on potential consequences of flooding in terms of damages. However, it is important that all buildings and roads in the area are shown on

the map so that people can easily orientate themselves and identify if their property would be affected in the case of a certain flood event. Therefore, affected buildings should be highlighted.

- Also for the affected population selected information on emergency management displayed in the maps is useful. In particular, information on evacuation routes and assembly points should be included in the maps in order to show people quickly how to behave in case of emergency.

Table 10.2: Map contents required by different end-user groups

	Strategic planners	Emergency planners	General public
Information density / complexity	high	high	low
Hazard	Flood extent and depth (for events with different probabilities) Flow velocities were available	Flood extent and depth (for events with different probabilities) Critical depth and velocities Link to alarm stages	Flood extent and depth (for events with high, medium, low probability, if available also for recent or historical events)
Consequences/ Risk	Event specific damage, but also annual average damages (for economic appraisals) Economic, social, cultural and environmental risks & critical infrastructure	Number of people at risk (to be evacuated) Critical infrastructure (to be protected or evacuated): hospitals, energy & water supply, traffic infrastructure	Buildings (affected) Roads (affected)
Additional information	Existing flood defence, protected areas, residual risk	Specific emergency management information: Assembly points, evacuation routes, hospitals, coordination centre, laydown etc. Existing flood defence, potential weak points, protected areas, residual risk Event specific usability of e.g. evacuation routes, hospitals: Can they still be used or do they have to be closed/evacuated	Most important emergency management information: Shelter, assembly points, evacuation routes, hospitals

10.5 Common recommendations on visualisation of flood maps

In order to communicate the above mentioned contents of maps to the end-users it is furthermore important that the maps are designed and visualised in a way which can be easily understood by the end-users. Based on our predecessor project RISK CATCH and additional insights gained from RISK MAP by means of eye-tracking tests, accompanying surveys, interviews and workshops some general and specific recommendations can be done.

General recommendations:

Some general recommendations on the visualisation of maps have already been derived in the RISK CATCH project (Fuchs et al. 2009):

- a map background should be in bright colour to increase the contrast to informative elements, and to avoid an overload of information;
- the legend should be sufficiently large, preferably on the right side of the central element of the map, with a limited number of information (not more than five classes of discretisation) comprised from one range in colour only and arranged in decreasing values;
- a sufficiently large scale that the elements of the map are recognisable sufficiently rapid.

These findings have been extended and further specified during the RISK MAP project leading to further recommendations:

- Multiple topics dedicated to different user groups should not be shown on the same map. E.g. evacuation information (which is necessary for emergency managers) should not be mixed with information on economic impacts (which is more relevant for strategic planning).
- The areas at risk should be clearly visually differentiated from areas not at risk. I.e. areas or properties at risk should be indicated with strong colours, while background information, such as properties not at risk should be kept simple and in pale colours.
- A simple background should be used in order to not dilute the legend information
- Specific icons or symbols can be used to highlight e.g. major risks, the direction of evacuation routes or the direction of the water flows. Ideally such icons or symbols should be self-explanatory. This can facilitate map reading especially for people not familiar with the site (see e.g. Figure 10.1)
- Text within the maps can enhance and speed up the transmission of important information such as information on the number of people to be evacuated in a certain district can be transmitted more easily by text than by symbols of different size or colour gradients.
- The topics in the legend should be organized in a way that it really helps comprehension: Firstly hazard information, secondly major risks, then secondary risks, finally background information.
- For hazard maps a gradient of blues should be used, and for risk maps a gradient of red.
- The native language of each categories of readers should be used in the maps

Recommendations for flood maps for strategic planning

Flood risk management actors from strategic planning are usually very familiar with flood maps and – at least in normal decision situations – have enough time to study them in detail, i.e. they are able to deal also with complex visualization of maps.

- Legends with a relatively high number of classes (4-5) can be used.

- Results showed that people from strategic planning like to have information on flood hazard and consequences in the same map.

According to these recommendations on visualisation and the recommendations on contents given in section 10.4, a typical map for strategic planning could look like Figure 10.2. However, as stated before there should not be only one map for each user-group.

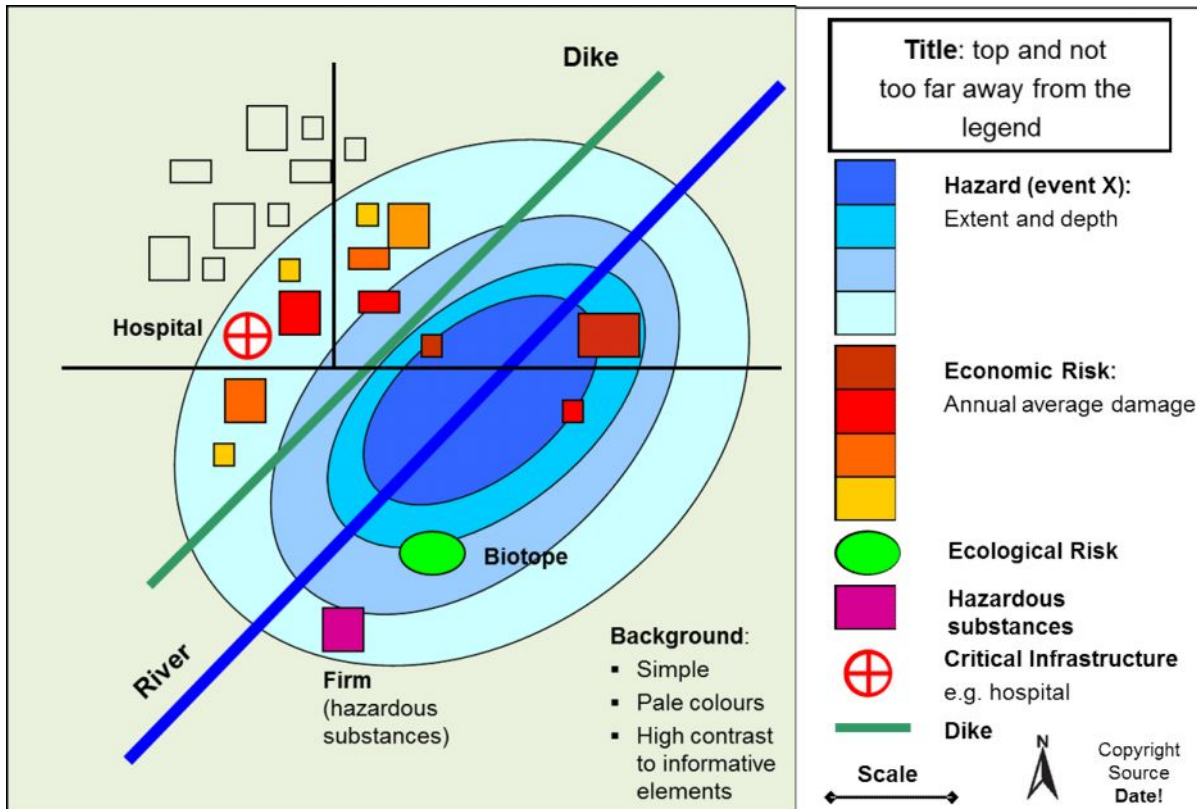


Figure 10.2: Idealised map for strategic planning

Recommendations for flood maps for emergency management

In case of emergency there is only little time to read maps. Therefore the visualization should be kept simple:

- Classifications in the legends should not have more than 3 classes at maximum
- Self-explanatory symbols and text within the map are good ways to visualize the most important information. This is particularly important when there is little time for reading maps so that users do not have keep referring to the legend to receive the information they require.
- Text is furthermore an important tool to quickly transmit information on e.g. number of people to be evacuated, names of important locations etc.
- Information on flood hazard and consequences should be shown in the same map.

According to these recommendations on visualisation and the recommendations on contents given in section 10.4, an idealised map for emergency management could look like Figure 10.3. Again, as stated before there should not be only one map for each user-group.

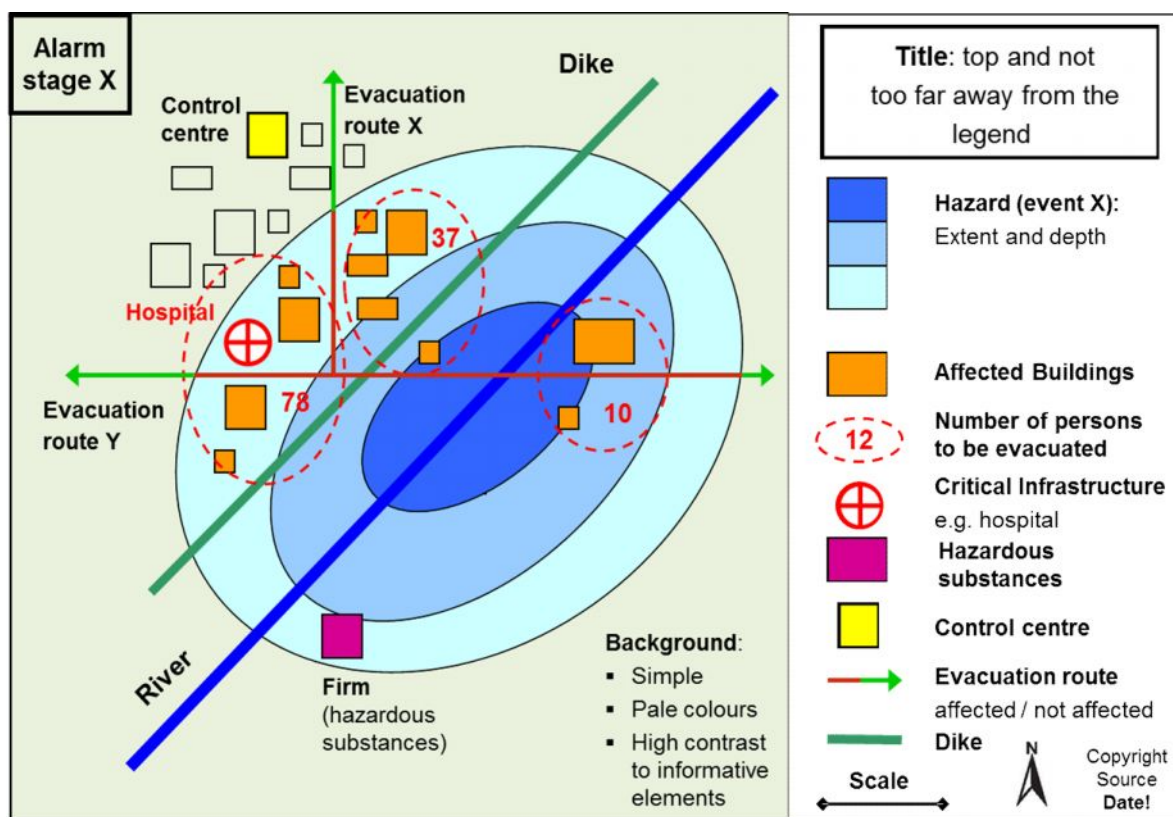


Figure 10.3: Idealised map for emergency management

Recommendations for flood maps for the public

The visualisation of maps for the public should also be kept as simple as possible, as it cannot be expected that every member of this group is very familiar with map reading.

- Classifications in the legends should not have more than 3 classes at maximum
- Self-explanatory symbols and text within the map are also good ways to visualize the most important information. Especially when there is little time for map reading maps users do not even have to fully recognize the legend to receive the crucial information.
- However, compared to maps for emergency management the complexity and density of information should be reduced and only the most important contents should be shown and visualised in the maps (see Section 10.4).

According to these recommendations on visualisation and the recommendations on contents given in section 10.4, an idealised map for the general public could look like Figure 10.4. Like stated above there should not be only one map for each user-group.

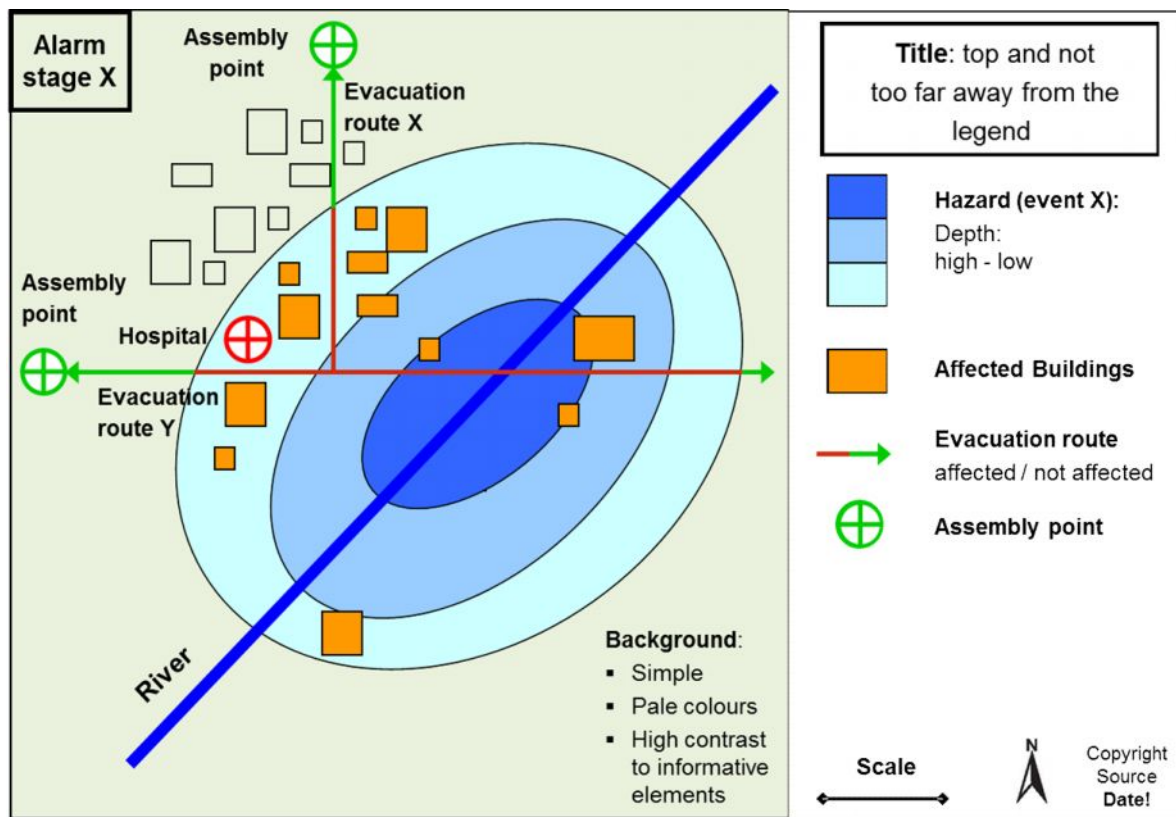


Figure 10.4: Idealised map for the general public

10.6 Outlook

Having presented these “idealised” maps it seems to be important to mention again that there is not one ideal map, even for the different user groups. First of all, as stated in section 10.4 several digital or print-out maps are required to show all important information, like e.g. inundation depth of different events. Secondly, the regional or local requirements on map contents and/or visualisation may differ a lot. Conducting participation processes is therefore in important means to unveil these local preferences, to enrich the map information by local expert knowledge and to build trust in the maps.

Of course, such participation processes require time and effort. However, such participation processes (or at least formal consultation processes) are nevertheless required by the Floods Directive in the context of the development of the flood management plans according to article 7 of the directive. The flood hazard and risk maps as required by article 6 of the Floods Directive already build a very good basis for communicating risks to the end users. However, they could be further tailored to the end-user needs during the process of the development of the flood risk management plans. With relatively little effort e.g. information on risk management or emergency management can be included in the maps. Experience from our case studies showed that it would be worth to take such efforts in order to improve flood maps and their contribution to risk and emergency management and to raise risk awareness.

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12 Appendix

12.1 Contribution of the project to the overarching topics of the call, implications for stakeholders, and further research needs

12.1.1 Connection to the Floods Directive

How does the project contribute to the implementation of

- a) preliminary flood risk assessment,
- b) flood hazard maps and flood risk maps and
- c) flood risk management plans as designated by the Floods Directive (2007/60/EC)?

RISK MAP's main aim is to contribute to the implementation of flood maps, especially risk maps. As described above the objective of the project is to give recommendations for risk mapping, with regard to 1) participation, 2) content, and 3) visualisation (see section 10 of this report).

However, these recommendations could go beyond the minimum requirements of the Floods Directive. In this context we just want to refer to three of our recommendations (cf. section 10.4):

- Hazard and risk maps as required by the EU Floods Directive should be only seen as an intermediate product for risk communication and management and not as an end-product. The contents which are required in article 6 of the Floods Directive build a very good basis for communicating risks to the end users. However, they should not be seen as the final product. As already outlined in the Floods Directive these contents could be extended by other useful information. Furthermore, they should be part of the flood risk management plans (see article 7 of the Floods Directive) and could be further enhanced during the development of these plans.
- For a target-oriented risk communication the contents of these maps should be further adjusted to the end-user needs as different end-user groups have different requirements on the contents of flood maps (see specific recommendations for strategic planning, emergency management and the public below).
- Where needed, risk or emergency management information should be also included in the flood maps. Our case study results showed that many end-users (from the public, emergency management as well as strategic planning) find it very useful to have e.g. information on existing (or planned) defences, evacuation routes, meeting points etc. already integrated in the maps. Such map contents are up to now not required by article 6 of the Floods Directive but could be integrated in the maps in the process of the development of risk management plans.

12.1.2 Participation

How did you account for interests of all potentially affected parties, i.e. general public, transboundary parties, policy maker etc. and how did that impact your results?

How has your project contributed to

- a) strengthen public participation in the establishment of future flood risk management plans,
- b) valuable lessons for public authorities/institution and
- c) good governance?

The typology of different stakeholders outlined in this report ensures that all relevant parties are taken into account. However, not all parties were involved in the different case-studies. For instance, in the Lower Thames case-study an entire workshop was dedicated to the participation of the general public, while the Mulde case-study, as well as in the Bavarian and Austrian case-studies, included the participation of emergency managers from the local and regional level, producers of maps as well as high-level policy-makers and strategic planners. All stakeholders actively contributed to how the content as well as visualisation of flood risk and hazards maps could be improved. Their experiences, knowledge, and views fed directly in the production of new maps considering the requirements and demands of the different stakeholder groups.

The project contributes directly to the strengthening of public participation in the respective case-studies and results of the interviews, workshops and surveys are outlined in each case study report (sections 4-8). A framework for stakeholder participation in flood mapping have been developed (section 3.1) and the experiences from participation activities in the different case studies have been analysed and overall findings on participation procedures have been described (section 9.1). This results finally in some common recommendations for participation in flood risk mapping (section 10.3). A summary is given in section 10.1:

“How should stakeholders be involved in the mapping process and what is an appropriate participatory process?” There is not one single best way of conducting a participatory mapping process. Within the case studies the participatory process was conducted by partners in different locations, in institutional and cultural contexts and was hence adapted to the specific requirements and contextual conditions. However, as an overall finding we conclude that the appropriateness depends largely on the purpose of the participatory process. Defining the purpose is hence an important matter that should ideally be clarified at the beginning of any participatory process. In a general sense we propose to distinguish in a rather *substantive* and a rather *instrumental* rational. If a participatory process follows a *substantive* rationale it aims at increasing the breadth and depth of knowledge contributing to the final product as attempts to include more contextualised forms of knowledge that cannot simply be reproduced by modelling exercises. The *instrumental* rationale aims at building trust between actors from the public and administrative sphere. It may also attempt of contribute to raising people’s awareness and motivation for taking actions to mitigate the impacts of hazards. In this sense, is the answer to the question “What should be achieved by the participatory process?” decisive as it has implications for the choice of actors to be involved during the process, the intensity of the process as well as the outcome of the entire process. More specific recommendations are provided in section 10.3.”

12.1.3 Harmonisation

How did you balance the trade-off between harmonisation of flood risk management within the EU and in-depth analysis of case studies?

By employing participative approaches (interviews, workshops, experimental graphic semiology) in the case studies, it was one of our aims to find out which demands on contents and visualisation of risk maps are ubiquitary and which are highly context specific. This led finally to case study specific recommendations (see sections 4 to 8) as well as common recommendations which we found out to be of overall relevance. It was further aim of RISK MAP to develop tools and frameworks (like the multicriteria risk assessment tool, experimental graphic semiology and a participation framework) which provide a consistent methodological approach on the one hand but on the other hand allow for the inclusion of local knowledge and preferences.

What structures on a regional / basin scale are needed to improve flood event management on a local scale?

Our recommendations for participation (see section 10.3) show which kind of participation processes can be used on the regional level in order to include relevant local knowledge and verifying contents (substantive aim) or to raise awareness and to build trust (instrumental aim). In Section 2.1 we furthermore suggest that “the establishment of the “water fora”, “round tables” etc. as already occurred in the context of the implementation of the WFD would be a step towards a good governance approach for considering stakeholder preferences and knowledge. The inclusion of flood management issues into the application area of these councils would be the easiest way to go beyond “formal consultation” approaches for participation. This way would also promote the aspired coordination between the WFD and the FD.

12.1.4 Restrictions

To what extent is the generalisation of the results restricted by

- a) social / political / economic characteristics,
- b) the flood type and
- c) uncertainties?

How did you handle these restrictions?

We are not entirely sure about the intention of these questions as all flood events as well as flood risk management attempts are embedded in a specific social-socio-cultural-historical-institutional-political-economic context, dependent of flood types and different patterns of awareness and uncertainties. However, by following a similar research design in all case-studies we pay close attention to this question (cf. also “harmonisation” above). We therefore tried to develop case-study specific recommendations (and some of them might not be applicable to other regions) as well as overall recommendation, i.e. recommendations which can be generalised.

12.1.5 Enhancement of resilience

How has your project contributed to the different aspects of resilience?

- a) resistance,
- b) recovery
- c) adaptive capacity/creativity/...?

RISK MAP was mostly concerned with the third aspect of resilience and contributed to the development of an adaptive capacity and this, above all, in a twofold sense: First, we contributed to a strengthening of the networking capacity of various stakeholders by offering them through the two workshops a forum for

exchanging ideas, experiences, needs and interests. Secondly, RISK MAP offered them an opportunity to think beyond their established daily professional routines – an occasion that was explicitly acknowledged by our participants. They had the opportunity to engage creatively with an object, flood maps, in a manner that allowed them to explore learn new aspects both with regard to the content but also with regard to the visualisation of flood maps.

12.2 Maps and EGS diagrams / further results

12.2.1 Maps



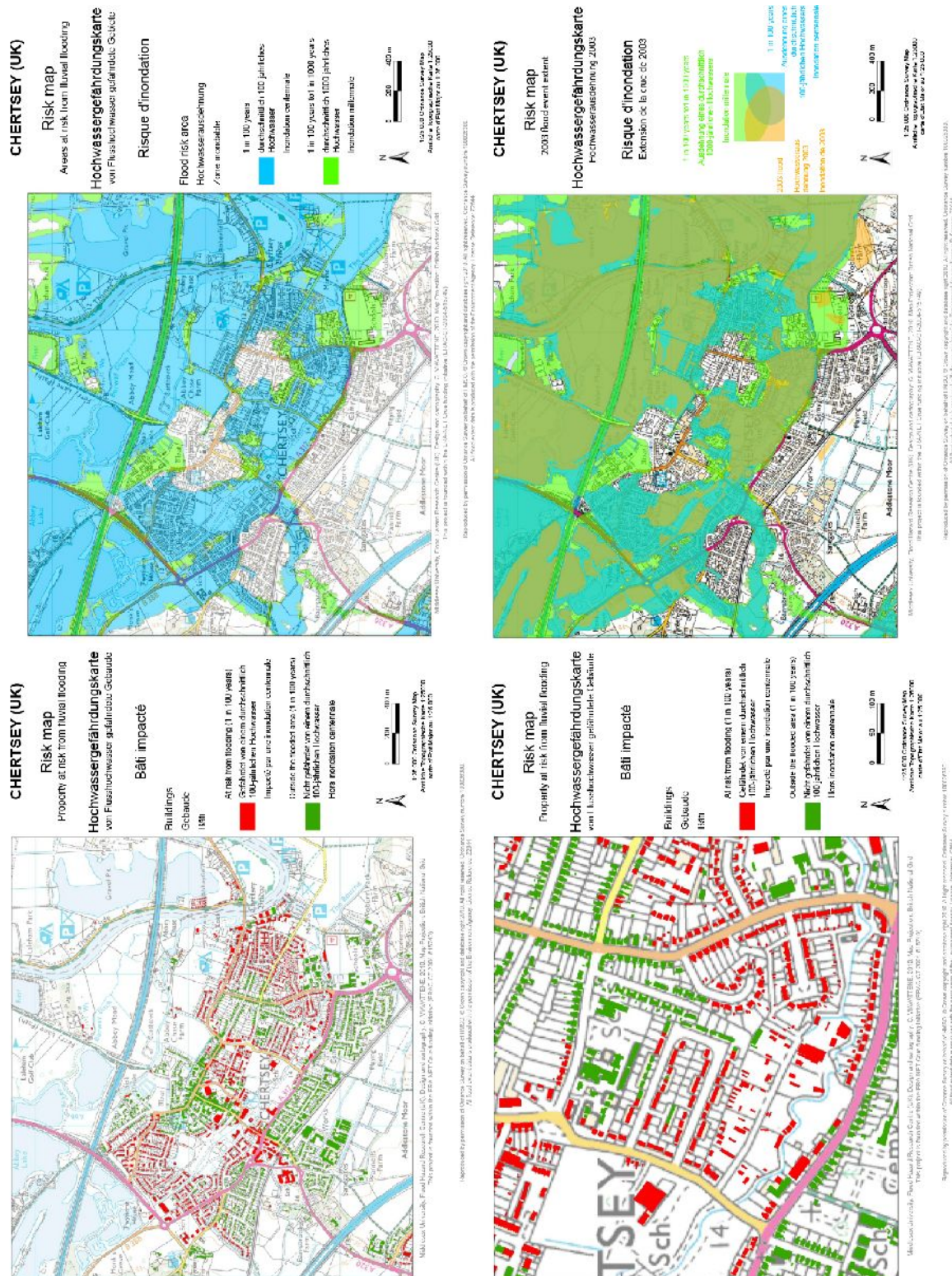


Figure 12.2: Maps of the test site CHERTSEY (UK)

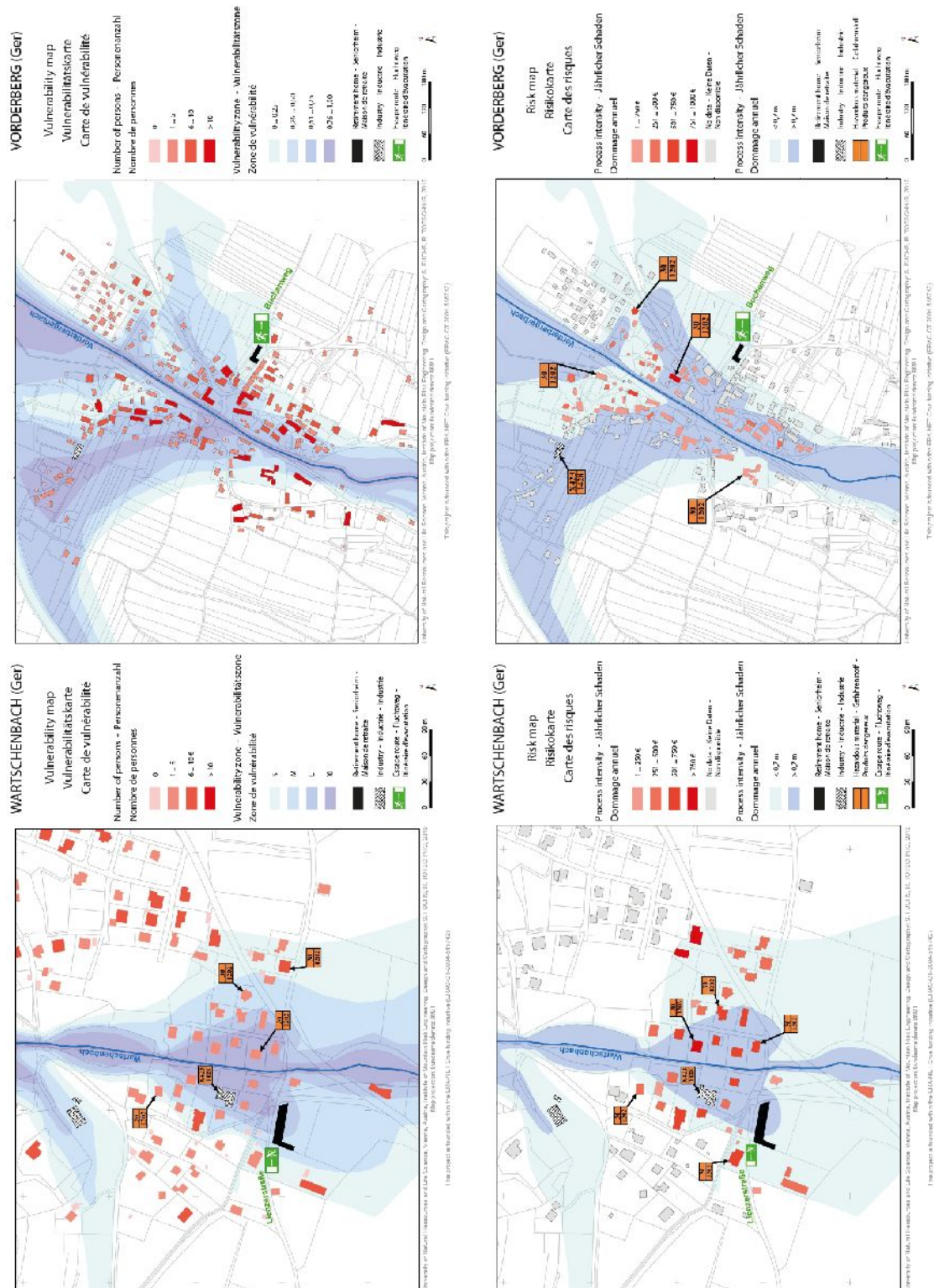


Figure 12.3: Maps of the test site VORDERBERG / WARTSCHENBACH (AUS)





12.2.2 Participants

Table 12.1: Participants EGS test

Volunteer code	Country	Date	Level of education	Activity
0111HI	AL DEG	08-oct.	Dipl Géographie	Other
1803CH	AL DEG	08-oct.		Researcher, teacher or student
1109RO	AL DEG	08-oct.	Bachelor	Researcher, teacher or student
2002MO	AL DEG	08-oct.	Promotion	Researcher, teacher or student
2102BA	AL DEG	08-oct.	Uni-Abschule	Other
1811EL	AN	14-oct.	Master	Population
3012CA	AN	14-oct.	PhD	Population
2805JA	AN	14-oct.	Master	Researcher, teacher or student
0412JA	AN	14-oct.	PhD	Researcher, teacher or student
2305DO	AN	14-oct.	style learning	Population
0412DA	AN	14-oct.	Degree + Qualification	Population
1805PA	AN	14-oct.	City +Guilds	Population
2105MA	AN	14-oct.	HND	Population
0608LA	AN	14-oct.	City +Guilds	Population
2607AN	AU	22-oct.	Studium/dipl	Population
2409IN	AU	22-oct.	HTBL	flood risk management actor
1412MA	AU	22-oct.	Master	flood risk management actor
1912HE	AU	22-oct.	AHS BHS	flood risk management actor
1810VI	AU	22-oct.	Universität	Researcher, teacher or student
1306RE	AU	22-oct.	Universität	Researcher, teacher or student
0502AN	AU	22-oct.	Universität	Researcher, teacher or student
1404MA	AU	22-oct.	Studium/dipl	Researcher, teacher or student
0406MA	AU	22-oct.	Geographie	Researcher, teacher or student
2806CH	AL MUL	29-oct.	Realschule	Flood risk management actor
0207AN	AL MUL	29-oct.		Researcher, teacher or student
0911EL	AL MUL	29-oct.	Fachschule	Other
2608SI	AL MUL	29-oct.	Master	Researcher, teacher or student
3112UR	AL MUL	29-oct.	PhD	Researcher, teacher or student
2208AN	AL MUL	29-oct.	hochschule	Flood risk management actor
2107HE	AL MUL	29-oct.	diplom	Researcher, teacher or student
2208AM	AL MUL	29-oct.		Researcher, teacher or student
2604AN	FR	08-oct.	B+5	Researcher, teacher or student
1603FR	FR	19-nov.	B+5	Other
1710MA	FR	09-nov.	B+2	Flood risk management actor
1407NA	FR	09-nov.	B+3	Flood risk management actor
2312MA	FR	22-nov.	B+5	Flood risk management actor
2506AN	FR	26-nov.		Flood risk management actor
1610CA	FR	17-déc.		Flood risk management actor
1306AU	FR	07-janv.		Policy maker
2310MI	FR	13-janv.		Policy maker
2107JO	FR	13-janv.		Policy maker

* Frequency:	** Realisation:	*** Use:
1 : less than once a year	1 : Generally realized by you	1 : an illustration
2 : once a year	2 : Generally realized by your team or service	2 : a tool of research
3 : once a month	4 : Generally realized by external units	4 : a tool of decision
4 : once a week	8 : Only from external sources	8 : others
5 : more than once a week	16 : Others	3 = 1+2 ;
	3 = 1+2 ;	5 = 1+5 ;
	5 = 1+4	6 = 2+4 ;
		7 = 1+2+4 ;
		12 = 4+8 ;
		13 = 1+4+8 ;
		14 = 2+4+8

12.3 Photo collections Austrian case studies

12.3.1 The Wartschenbach test site

(Copyright Austrian Torrent and Avalanche Control Service)



Settlement of Wartschenbach torrent fan in 1972



06.08.1995, retention basin filled



„Korber“ building with carport,
06.08.1995



„Bachlechner“ building, 06.08.1995



„Stolzlechner“ building, 06.08.1995



„Stolzlechner“ and „Singer“ building,
16.08.1997



„Bachlechner“ (right) and „Bacher“
(middle) building, 16.08.1997



„Bachlechner“ commercial building,
06.09.1997

12.3.2 The Vorderbergerbach test site

(Copyright Austrian Torrent and Avalanche Control Service)



Large amounts of debris retained
by technical structures (event of 23
August 2003)



Aerial photography of the 2003 event (23 August 2003)



Detail of 2003 damage.

12.4 Appendix French case study

Table 12.2: Overview⁶¹

Name of the case study	Loire Basin (France)
Size (km ²)	40 000 km ²
Catchment	Valleys of Tours and Luynes
Rivers :	Loire and Cher
Size (km ²)	4 600 km ² (over a length of approx. 26 km)
Subcatchment	Tours urban area
Rivers :	Loire and Cher
Size (km ²)	?
Flood data (river flood)	
Val de Tours	Val de Tours
Return period :	Discharge rate (m ³ /s, HYDRA model)
50 years	HQ50 : 4200 m ³ /s at the Bec de l'Allier reduced by the Villerest dam
	HQ70 : 5000 m ³ /s
70	HQ100 : 6000 m ³ /s
100	HQ170 : 6500 m ³ /s
170	HQ200 : 7000 m ³ /s
200	HQ500 : 8500 m ³ /s
500	

Table 12.3: Historical Flood Data (Loire & Cher rivers), city of Tours. The Val de Tours⁶² is diked along its entire length⁶³ and has been subject to many floods, the most serious of which occurred in the 19th century.

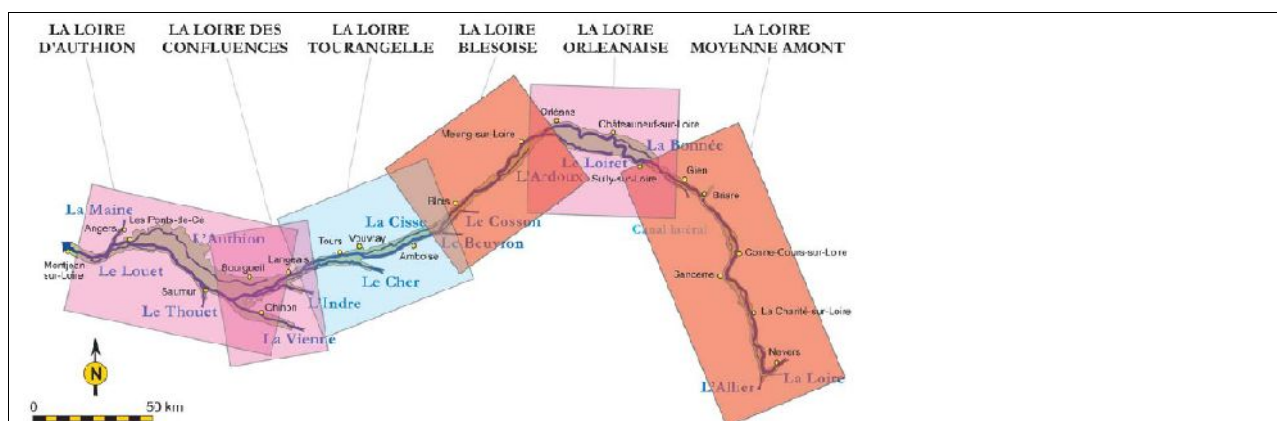
Date	Height (m)	Flow m ³ /s
October 1846	7,15 m (Wilson bridge level) (Z0 = 44,60 m NGF)	5900 m ³ /s
May-June 1856	7,52 m (Wilson bridge level - Loire) 6,25 m (Sanitas bridge level – Cher)	6800 m ³ /s (Wilson bridge level)
September 1966	6,59 m (Wilson bridge level)	6200 m ³ /s (Wilson bridge level)
October 1907	5,61 m (Wilson bridge level)	
January 1982	3,82 m (Wilson bridge level) 4,07 m (Sanitas bridge level)	3400 m ³ /s (Wilson bridge level)
December 2003	3,40 m (Wilson bridge level)	3000 m ³ /s (Wilson bridge level)

⁶¹ "Étude de la propagation des crues et des risques d'inondation en Loire moyenne. Crues Loire moyenne. Résultats des crues fortes et très fortes simulées en Loire moyenne dans la situation des référence 1998". Pluridisciplinary team working on the *Plan Loire Grandeur Nature*, April 2004.

⁶² This valley is located between the Loire and Cher rivers over a length of 26 kms with an approximate surface area of 4600 km².

⁶³ According to the *Service Interministériel de Défense et de Protection Civile* (SIDPC) from the Préfecture of the Indre et Loire department, the worst scenario would be the collapsing of a dike. A flood due to the banks bursting can be foreseen roughly 48 hours ahead and the *Plan de Secours Spécialisé* details measures to be taken for evacuating and protecting people and property. Yet the Plan depends entirely on the dikes' resisting. Damage caused by the banks bursting is completely unforeseeable.

2ND CRUE FUNDING INITIATIVE ON FLOOD RESILIENT COMMUNITIES
 RISK MAP



Middle Loire: map of the Vals of Tours and Luynes (blue rectangle)
 (Source: "Etude Loire moyenne, équipe pluridisciplinaire plan Loire grandeur nature", 2004. Modified by K. Serhini, 2010)

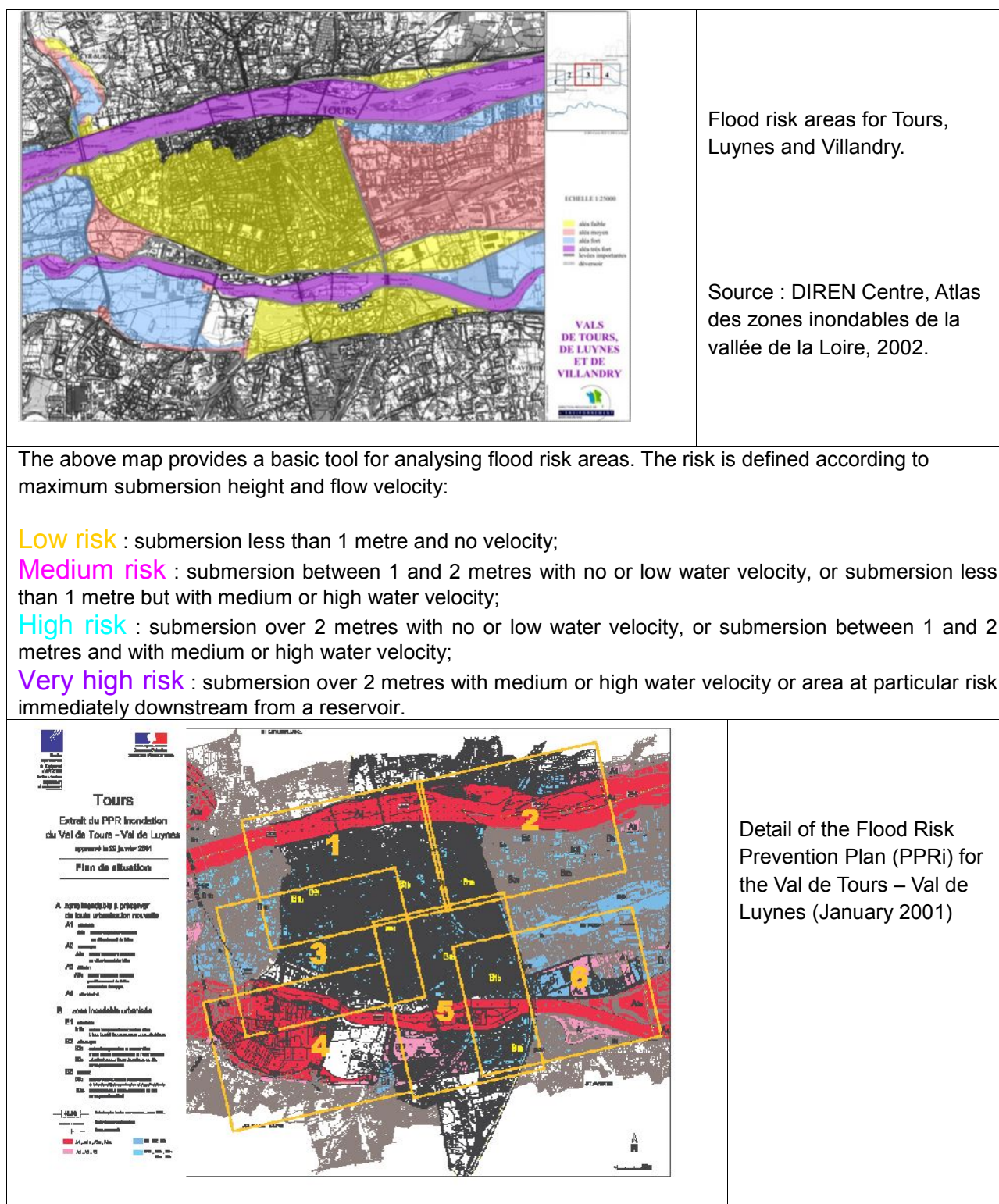
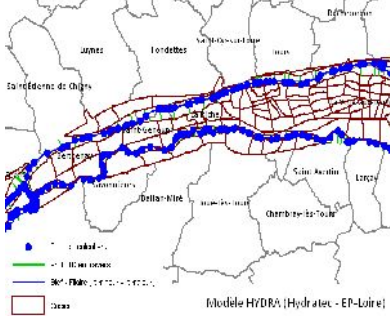


Figure 12.6: Flood Plain Maps

**Table 12.4: Flood risk management in France: a top down and multilevel organization
Major actors at different levels (national, regional, departmental, local municipalities):**

Level	Actor	Role	Intervention	Geographical location
Loire river basin (pink color)	Water board Loire Authority (EP-Loire)	Statutory Public (EP-Information, research)	SDAGE, SAGE Survey (diagnosis of companies' vulnerability)	
Region (Centre)	DREAL (ex DIREN)	Information, prevention, forecasting...	Monitoring, data bases, advisory...	
Department (Indre-et-Loire, 37)	Prefect (local representative of Head of State, in command of the Police force) DDT (ex DDE)	Crisis management Knowledge	DDRM, PPRI	
Commune (City of Tours)	Mayor	Management, information	PCS, DICRIM	

Table 12.5: Case study (Tours and surrounding area) description

Socio-economic data	
The Tours urban area includes 19 boroughs, 5 of which have populations of over 100 000 habitants (INSEE census, 1999) ⁶⁴ : Tours, Saint-Pierre-des-Corps, Saint-Cyr-sur-Loire and Joué-lès-Tours. The Val de Tours is equipped with dikes along all its length.	
Flood extent	
Two towns, Tours and Saint-Pierre-des-Corps, are regarded as the most vulnerable. 54% of the population in Tours and 100% in Saint-Pierre live in flood areas.	
The least affected towns are the ones located along the cliff areas to the north and (Saint-Cyr sur Loire, Saint-Avertin and also Joué-lès-Tours).	
Geomorphology	
BRGM.	
History of urban development and land use	
Flood history	
See historic floods, page 2 above.	
Hydrology: HYDRA Model	
The flood scenarios (HQ50 70, 100, etc.) on page 1 were obtained using the HYDRA model with the Val de Tours being modeled in 74 boxes (polygons). The Loire and Cher rivers are shown in thread form (main and lesser beds) with 35 cross-sections for the Loire and 44 for the Cher.	
	
Inhabitants:	
284 885 inhabitants (Tours urban area)	
+ 3% between 1999 and 2007 (INSEE census)	
The population of this conurbation makes up over 47% of the whole of the Indre-et-Loire department (37) and is the largest urban area in the Centre Region (http://www.agglo-tours.fr/).	

Abbreviations

DDRM: Departmental Report for Major Risks *Dossier Départementale des Risques Majeurs* □
Preventive information & knowledge for all types of risk at departmental level

DREAL: Regional Environmental, Development and Housing Authority *Direction Régionale de l'Environnement, de l'Aménagement et du Logement* (DIREN + DRE + DRIRE). In charge of the CRISTAL network (monitoring system for the Loire and its tributaries). <http://www.centre.developpement-durable.gouv.fr/>

PPRi : Plan for Flood Risk Prevention *Plan de Prévention du Risque Inondation*:

- Statutory plan implemented by Law 95-101 dated 1995
- National approach (Ministry Guide for PPRi)
- Realized at an urban area level (agglomeration)
- Based on PHEC (Highest Level of Known Flooding: *Plus Hautes Eaux Connues*) or HQ100

SAGE: Documents for Water Planning and Management *Schémas d'Aménagement et de Gestion des Eaux*

SDAGE: Directives for Water Planning and Management *Schémas Directeurs d'Aménagement et de Gestion des Eaux*

⁶⁴ INSEE Centre Info, n°145, September 2007.

12.5 Fact sheets

12.5.1 Project fact sheet

	<i>Integrate, Consolidate and Disseminate</i> European Flood Risk Management Research	
	2nd ERA-Net CRUE Research Funding Initiative Joint research project fact sheet	
RISK MAP Improving Flood Risk Maps as a Means to Foster Public Participation and Raising Flood Risk Awareness: Toward Flood Resilient Communities		
UFZ - Helmholtz Centre for Environmental Research BOKU - University of Natural Resources and Applied Life Sciences FHRC - Flood Hazard Research Centre FHD - University of Applied Sciences Deggendorf Université François-Rabelais, École Polytechnique	Volker Meyer, Christian Kuhlicke (Co-ord.) Sven Fuchs Sally Priest, Sue Tapsell Wolfgang Dörner Kamal Serrhini	
Executive summary RISK MAP aims at improving flood risk maps as a means to foster public participation and raising flood risk awareness. For achieving this, RISK MAP (1) develops rules for appropriate stakeholder participation enabling the incorporation of local knowledge and preferences; (2) improves the content of risk maps by considering social, economic and environmental risks applying a deliberative multicriteria risk mapping tool; (3) improves the visualisation of flood risks in order to produce user-friendly risk maps; and (4) provides quantitative information related to the content of risk maps through the application of experimental graphic semiology methods, particularly the eye-tracking approach. During the first phase, RISK MAP will investigate the status quo in risk mapping with special regard to participation activities. Then, rules for stakeholder inclusion will be developed and at least 2 stakeholder workshops per case study. Participants of the 1st workshop series will identify important risk criteria as well as limitations of existing risk maps. Based on this, new risk maps will be compiled considering new risk criteria and improved visualisation. These improved risk maps will be tested by selected stakeholders for comprehensibility. During a 2nd workshop series the results will be discussed with stakeholders. Their preferences for the different risk criteria will be incorporated in a multicriteria risk mapping tool in order to produce final aggregated risk maps.		
Intended outcome The major results of RISK MAP will be (1) exemplary, improved and aggregated flood risk maps and (2) recommendations on how to actually organise participation in risk mapping and on how to improve the visualisation of flood risks and the content of risk and hazard maps. Specifics in context and geographical area also form an integral part of the results.	Project duration 01/09/2009 - 31/08/2011 (24 months)	
Dissemination and implementation actions (1) Direct communication with stakeholders on the local and regional level by interviews and workshops, (2) the final report contains recommendations for good practices of risk mapping addressing all member states, (3) conference presentations and scientific journal papers and (4) broader dissemination via website and stakeholder-database.	Project costs [€] € 387,012; requested funding 98%	
Methods and data to be intended to use The research will be initially based on reviews of current legal frameworks, administrative practices and existing flood risk and hazard maps in five case studies. It is further conducted by means of expert interviews, stakeholder workshops, multicriteria risk assessment and mapping approaches and methods of experimental graphic semiology.	Funded by Austria, England, France and Germany	
Geographical focus of research (test sites) Joint Mulde River, Saxony; Vils and Rott Rivers, Bavaria, Germany Wartschenbach and Vorderbergerbach Rivers, Austria Lower Thames River, London, England; France (in general)	Contact details christian.kuhlicke@ufz.de volker.meyer@ufz.de (Co-ordinators) sven.fuchs@boku.ac.at s.priest@mdx.ac.uk wolfgang.dorner@fhd.edu kamal.serrhini@univ-tours.fr	
CRUE Co-ordinator: John Goudie (Defra) Project Contract No: ERAC-CT-2004-515742 Project website: www.crue-eranet.net		



12.5.2 Case study factsheet Saxony



*Integrate, Consolidate
and Disseminate
European Flood Risk*

Vereinigte Mulde River Case Study, Saxony (Germany)

Main Characteristics

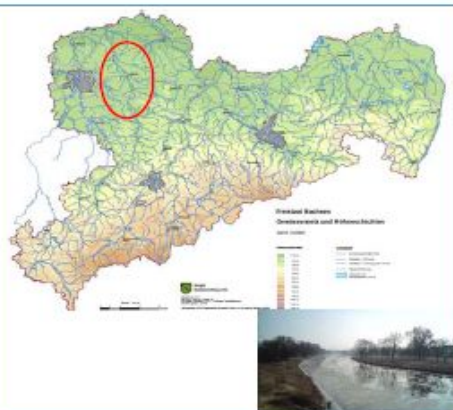
Major Type of Flood: fluvial

Size of Catchment Area: until gauge Golzern 1 (upstream of the city of Wurzen): 5,442 km², overall catchment size: 7,400 km² (64 m³/s)

Past flood events: e.g. 1954; August 2002

Environmental Setting: The Mulde River is a non-navigable river in Saxony and Saxony-Anhalt, Germany. It is one of the main tributaries of the Elbe River. The 124 km long course of the Vereinigte Mulde is formed by a western branch, the Zwickauer Mulde (128 km), and an eastern branch, the Freiburger Mulde (124 km). Both rivers originate in the upper Ore Mountains (ca. 1,000 m). In terms of flood risk, the Mulde River system represents both flood source areas in the uplands with high discharge dynamics including flash floods and receptor areas in the lowlands.

Socio-economic Setting: The valleys as traditional areas of medium-sized industries are densely populated and potentially vulnerable. This industry was based on the century long mining in the area, which has left a considerable amount of contaminated sites. The study site around the cities of Wurzen and Bennewitz has approx. 22,000 inhabitants.



Level of Stakeholder Involvement

Almost all public bodies responsible for flood risk management in Saxony – from the state level throughout the regional and district levels down to the local level are involved. Representatives were interviewed as project-external experts only. The organised and the general or (potentially) affected public were not in the focus.

- Stakeholder 1: LfULG – State Office for the Environment, Agriculture and Geology, also representing the Saxon Flood Centre
- Stakeholder 2: LTV – State Dam Administration of the Free State Saxony
- Stakeholder 3: State Directorate Leipzig
- Stakeholder 4 & 5: Districts of Leipzig and Northern Saxony
- Stakeholder 6 & 7: City of Wurzen and Community of Bennewitz

CRUE Activities

In August 2002, an extreme flood caused severe damage along many Czech and East German rivers. Discharge reached approximately 21,500 m³/s. Since, a lot of experience with innovative flood risk management is being made. Key words include: literature review on flood mapping & participation, stakeholder analysis, expert interviews, workshops, participatory mapping, eye-tracking tests, structuring of local knowledge in a knowledge database

Specific Outcomes

- Outcome 1: Recommendations for innovative and/or enhanced flood risk maps and their production, use and updating
- Outcome 2: Exemplary maps for the case study area
- Outcome 3: A knowledge structuring and decision support tool (FloodCalc)

Lessons Learned

Expectations of and requirements for flood maps are highly actor and user dependent. Contents as called for by the Floods Directive are more relevant for strategic planning, whereas disaster managers need much more and more detailed information.

CRUE Project

RISK MAP – Improving Flood Risk Maps as a Means to Foster Public Participation and Raise Flood Risk Awareness: Toward Flood Resilient Communities.

Funded from 09/2009 to 09/2011 within the 2nd CRUE Funding initiative "Flood resilient Communities".

Partners

Helmholtz Centre for Environmental Research – UFZ, Germany
University of Natural Resources and Life Sciences – BOKU, Austria
Flood Hazard Research Centre – FHRC, Middlesex University, United Kingdom
University of Applied Sciences Deggendorf – FHD, Germany
University François-Rabelais Tours, France

Funders

BMLFUW (Austria), DEFRA (England), MEEEDM (France), BMBF (Germany)

12.5.3 Case study factsheet Bavaria

 <i>Integrate, Consolidate and Disseminate European Flood Risk</i>	
Rott River Case Study, Bavaria (Germany)	
Main Characteristics Major Type of Flood: fluvial Size of Catchment Area: 1,200 km² Past Flood Events: flooding of agricultural areas, roads and buildings in 1991, 1996, 2005, 2006, March 2009 and January 2011. Environmental Setting: the river is situated in the tertiary hill landscape of Southern Germany with a length of 110 km and a height of 350 and 550 m a.s.l., the soils are alluvial origin, diluvia origin on top. Extreme slope hills, fertile loess soils and maize cultivation cause erosion and pollution. Socio-economic Setting: Rural settlements, scattered buildings and intensive agricultural use	
Level of Stakeholder Involvement The stakeholders in this Case Study were members of disaster management and emergency services. Representatives involved were: • fire brigades • relief organisations (Malteser) • district offices (Deggendorf and Freyung-Grafenau) and • federal armed forces CRUE Activities The test site represented a valley of intensive agricultural use and immense anthropogenic alterations in the lower part with numerous issues of flood risk management in lowland communities. <u>Key words:</u> literature review on flood mapping & participation, cognitive survey including expert interviews and workshops, eye-tracking tests Specific Outcomes • intervention maps should be used to prepare for emergency situations; • risk maps (including social, economic and ecologic aspects) should be used in order to chose the most appropriate and cost-efficient mitigation alternative Lessons Learned Early stage involvement of different stakeholder-> increases the acceptance of flood maps (hazard and risk) and flood mapping procedure; Adjusted symbols-> self-explaining symbols/ strategic symbols instead of planar risk information.	CRUE Project RISK MAP – Improving Flood Risk Maps as a Meansto Foster Public Participation and Raise Flood Risk Awareness Toward Flood Resilient Communities. Funded from 09/2009 to 09/2011 within the 2nd CRUE Funding Initiative "Flood resilient Communities". Partners Helmholtz Centre for Environmental Research – UFZ, Germany University of Natural Resources and Life Sciences – BOKU, Austria Flood Hazard Research Centre – FHRG, Middlesex University, United Kingdom University of Applied Sciences Deggendorf – FHD, Germany University François-Rabelais Tours, France Funders BMLFUW (Austria), DEFRA (England), MEEDDM (France), BMBF (Germany)
Contact: Wolfgang Dorner, University of Applied Sciences Deggendorf Wolfgang.Dorner@fh-deggendorf.de Project website: www.risk-map.org	

12.5.4 Case study factsheet Austria 1



*Integrate, Consolidate
and Disseminate
European Flood Risk*

Vorderbergerbach (Austria)

Main Characteristics

Major Type of Flood: fluvial sediment transport

Size of Catchment Area: 20 km²

Past Flood Events: 50,000 m³-80,000 m³ bedload
(120 m³/s, 23. August 2003)

Environmental Setting: Situated in the eastern Alps between 690 m and 1,560 m a.s.l., the test site is dominated by limestone and Ordovician shale, and covered by deposits from the Würmian glaciation. Therefore, the catchment is susceptible to erosion processes, in particular fluvial sediment transport.

Socio-economic Setting: Approximately 120 buildings are located in endangered areas in 2010.



Level of Stakeholder Involvement

Apart from residents, stakeholders from spatial planning, authorities responsible for local hazard assessment, for emergency planning and for planning technical protection measures were involved during the entire project. With respect to the Austrian test site, specific collaboration was done with

- the Austrian Torrent and Avalanche Control Service
- the members of the Task Force responsible for the implementation of the European Floods Directive (hosted at Umweltbundesamt GmbH)

CRUE Activities

The test site was chosen to include the issues of risk mapping applied in mountain catchments in the project. The aim was to compare specific needs in risk visualisation of mountain communities with requirements of lowland river communities.

Specific Outcomes

Risk maps have to be compiled stakeholder-oriented with respect to different needs of different target groups. Therefore, by using the same meta-information on hazard and risk,

- intervention maps should be used to prepare for emergency situations;
- risk maps (people at risk, economic risk) should be used in order to choose the most appropriate and cost-efficient mitigation alternative.

Lessons Learned

The involvement of different stakeholder groups at an early stage of risk mapping increases the acceptance of such measures and allows for the consideration of site-specific characteristics.

CRUE Project

RISK MAP – Improving Flood Risk Maps as a Means to Foster Public Participation and Raise Flood Risk Awareness: Toward Flood Resilient Communities.

Funded from 09/2009 to 09/2011 within the 2nd CRUE Funding initiative "Flood resilient Communities".

Partners

Helmholtz Centre for Environmental Research – UFZ, Germany

University of Natural Resources and Life Sciences – BOKU, Austria

Flood Hazard Research Centre – FHRC, Middlesex University, United Kingdom

University of Applied Sciences Deggendorf – FHD, Germany

University François-Rabelais Tours, France

Funders

BMLFUW (Austria), DEFRA (England), MEEDDM (France), BMBF (Germany)

12.5.5 Case study factsheet Austria 2

 <i>Integrate, Consolidate and Disseminate European Flood Risk</i>	
Wartschenbach (Austria)	
Main Characteristics Major Type of Flood: torrential Size of Catchment Area: 2.5 km² Past Flood Events: 2,000 m³-7,500 m³ bedload (1996 and 1998), 35,000 m³-50,000 m³ bedload (1995, 1997 [2x], and 1999, 2000: 20,000 m³) Environmental Setting: Situated in the eastern Alps between 670 m and 2,113 m a.s.l., the test site is dominated by para-gneiss and mica schist, and covered by glacial deposits. Therefore, the catchment is susceptible to erosion processes, in particular debris flows. Socio-economic Setting: Approximately 40 buildings are located in endangered areas in 2010.	
Level of Stakeholder Involvement Apart from residents, stakeholders from spatial planning, authorities responsible for local hazard assessment, for emergency planning and for planning technical protection measures were involved during the entire project. With respect to the Austrian test site, specific collaboration was done with - the Austrian Torrent and Avalanche Control Service - the members of the Task Force responsible for the implementation of the European Floods Directive (hosted at Umweltbundesamt GmbH)	CRUE Project RISK MAP – Improving Flood Risk Maps as a Means to Foster Public Participation and Raise Flood Risk Awareness: Toward Flood Resilient Communities. Funded from 09/2009 to 09/2011 within the 2nd CRUE Funding initiative "Flood resilient Communities".
CRUE Activities The test site was chosen to include the issues of risk mapping applied in mountain catchments in the project. The aim was to compare specific needs in risk visualisation of mountain communities with requirements of lowland river communities.	Partners Helmholtz Centre for Environmental Research – UFZ, Germany University of Natural Resources and Life Sciences – BOKU, Austria Flood Hazard Research Centre – FHRC, Middlesex University, United Kingdom University of Applied Sciences Deggendorf – FHD, Germany University François-Rabelais Tours, France
Specific Outcomes Risk maps have to be compiled stakeholder-oriented with respect to different needs of different target groups. Therefore, by using the same meta-information on hazard and risk, - intervention maps should be used to prepare for emergency situations; - risk maps (people at risk, economic risk) should be used in order to choose the most appropriate and cost-efficient mitigation alternative.	Funders BMLFUW (Austria), DEFRA (England), MEEDDM (France), BMBF (Germany)
Lessons Learned The involvement of different stakeholder groups at an early stage of risk mapping increases the acceptance of such measures and allows for the consideration of site-specific characteristics.	
Contact: Sven Fuchs, University of Natural Resources and Life Sciences, Vienna, Austria, sven.fuchs@boku.ac.at Project website: www.risk-map.org 	

12.5.6 Case study factsheet England



*Integrate, Consolidate
and Disseminate
European Flood Risk*

Lower Thames Case Study, Chertsey (UK)

Main Characteristics

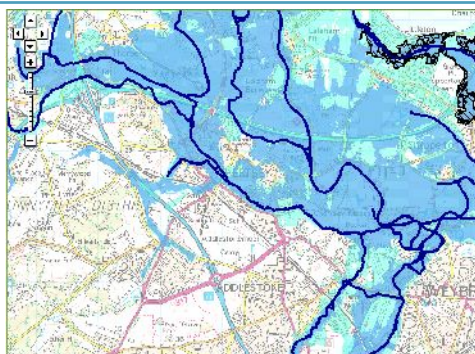
Major Type of Flood: groundwater and fluvial

Size of Catchment Area: The Thames River: 8120.0km². The Chertsey Bourne (main source of flooding): 90.1km².

Past flood events: Major events: 1894, 1947, 2003

Environmental Setting: The Bourne catchment is located in largely permeable Bagshot Beds. The Thames catchment consists of scarp and vale topography. The Borough encompassing Chertsey (Runnymede Borough) comprises the 'Thames Basin Lowland' and is located on the urban fringe of London. 68% of the land is protected from urban development, designated as 'Greenbelt land'.

Socio-economic Setting: Chertsey is located on the fringe of London with good connections to the city, making it a popular area for commuters. There are approximately 12,000 inhabitants. Chertsey is part of Surrey County Council which has the highest GDP compared to all other counties in England.



Environment Agency website

Level of Stakeholder Involvement

The focus of this case study was on public participants. Participants were drawn from the local community with an emphasis on residents living in the flood risk area, as determined by Environment Agency flood maps. The participants can be broadly categorised into two groups:

- Experienced: Those who have experienced flooding in their property
- At-Risk: Those who have not experienced flooding but live within the flood risk zone.

CRUE Activities

The site was selected as a community in the lower Thames basin area which has recently (2003) experienced flood risk. Attention had to be paid to ensure that the study area was not already engaged as part of the Lower Thames Strategy so as to be able to test an approach to using mapping to facilitate participation. The area was selected as approximately 350 properties had been flooded in 2003, providing a good base from which to recruit experienced participants.

Specific Outcomes

- To develop a mapping approach to facilitate public participation
- To provide recommendations for improved visualisation and contents of flood maps

Lessons Learned

Maps are a useful tool for facilitating public participation and enhancing awareness and understanding of flood risk. The involvement of the public, as end-users, enhances the trust and understanding of flood maps and mapping processes.

CRUE Project

RISK MAP – Improving Flood Risk Maps as a Means to Foster Public Participation and Raise Flood Risk

Awareness: Toward Flood Resilient Communities.

Funded from 09/2009 to 09/2011 within the 2nd CRUE Funding Initiative "Flood resilient Communities".

Partners

Helmholtz Centre for Environmental Research – UFZ, Germany

University of Natural Resources and Life Sciences – BOKU, Austria

Flood Hazard Research Centre – FHRC, Middlesex University, United Kingdom

University of Applied Sciences Deggendorf – FHD, Germany

University François-Rabelais Tours, France

Funders

BMLFUW (Austria), DEFRA (England), MEEDDM (France), BMBF (Germany)

12.5.7 Case study factsheet France



*Integrate, Consolidate
and Disseminate
European Flood Risk*

Test site of Tours (France)

Main Characteristics

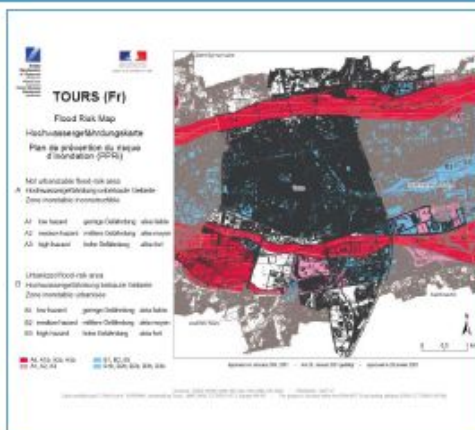
Major Type of Flood: fluvial

Size of Catchment Area: 4,600 km²

Past Flood Events: December 2003, January 1982,
October 1907 September 1966, May-June 1956,
October 1846

Environmental Setting: The Val de Tours is
equipped with dikes along all its length.

Socio-economic Setting: The Tours urban area
includes 19 boroughs, 5 of which have populations
of over 100,000 inhabitants: Tours, Saint-Pierre-
des-Corps, Saint-Cyr-sur-Loire and Joué-lès-Tours.



Level of Stakeholder Involvement

- Dreal Centre, Civil security of Tours (37000), "Etablissement Public Loire" manager (EP-Loire) – institutional stakeholder
- Mayors of Berthenay (37510) and Artannes-sur-Indre (37260), local manager of the agglomeration of Tours
- Hospital security manager, fire brigade force (SDIS37)
- University researchers

CRUE Activities

The site of Tours was chosen because the population of this agglomeration makes up over 47% of the whole of the Indre-et-Loire department (37) and is the largest urban area in the Region Centre.

Key words: Experimental Graphic Semiology; models of visual strategy; preferences of map readers; eye-tracking; cognitive survey; cartographic puzzle

Specific Outcomes

- EGS in Tours for the 5 test sites (visual strategy, survey, puzzle)
- Guide/recommendations to improve flood risk maps of the 5 sites

Lessons Learned

It is necessary to take into account the readers in the production of the maps of risk because their expectations and preferences are very different (scale, pictograms, colours, etc.). We could also go further in the analysis by seeking the influence / importance of the volunteers' gender, their culture and nationality as well as their knowledge of the site.

CRUE Project

RISK MAP – Improving Flood Risk Maps as a Means to Foster Public Participation and Raise Flood Risk Awareness: Toward Flood Resilient Communities.
Funded from 09/2009 to 09/2011 within the 2nd CRUE Funding initiative "Flood resilient Communities".

Partners

Helmholtz Centre for Environmental Research – UFZ, Germany
University of Natural Resources and Life Sciences – BOKU, Austria
Flood Hazard Research Centre – FHRC, Middlesex University, United Kingdom
University of Applied Sciences Deggendorf – FHD, Germany
University François-Rabelais Tours, France

Funders

BMLFUW (Austria), DEFRA (England), MEEDDM (France), BMBF (Germany)

12.6 List of figures

Figure 1.1:	Structure of RISK MAP and associated sections in this report.....	15
Figure 3.1:	Arnstein's ladder of participation	26
Figure 3.2:	Process of participation in hazard mapping	29
Figure 3.3:	Process of participation in hazard mapping	33
Figure 3.4:	Process for designing a participatory approach.....	34
Figure 3.5:	Workshop framework	40
Figure 3.6:	Multicriteria risk assessment methodology implemented in the FloodCalc tool following Chen et al., (2001), Malczewski (1999) and Smith & Petley (2009).	46
Figure 3.7:	Suggestions for the compilation of risk maps in order to allow for an efficient and target-oriented risk communication (Fuchs et al., 2009b).	54
Figure 3.8:	Experimental graphic semiology (from RISK CATCH to RISK MAP, see Serrhini et al., 2008 and Fuchs et al. 2009b)	56
Figure 3.9:	Evolution of risk maps during the preparation for the test in Tours (example from Pocking test site, Germany).....	57
Figure 3.10:	Logigram used for each individual set of risk maps (example from Chertsey test site, UK).	58
Figure 3.11:	Average number of fixations for each map.	59
Figure 3.12:	Example of the most attractive elements in a map (example of Pocking, Germany).	60
Figure 3.13:	Examples of visual strategies developed during the map reading, top: example of Bennewitz, Germany, bottom: example of Chertsey, UK.	60
Figure 3.14:	Correlations between the five criteria tested.....	61
Figure 3.15:	Preference graph for local population. Code Numbers and coloured lines represent the answers of individual test persons to the questions of the survey.....	62
Figure 3.16:	Preference graph for flood risk management actors. Code Numbers and coloured lines represent the answers of individual test persons to the questions of the survey.....	63
Figure 4.1:	Structure of the planning system related to flood hazards in Austria (Holub (2009), modified from ÖROK (2005)).	71
Figure 4.2:	Test sites for the Austrian case study	76
Figure 4.3:	Final results of the hazard modelling for the Austrian case studies (top: Wartschenbach, bottom: Vorderbergerbach).....	77
Figure 4.4:	Risk maps for the Wartschenbach test site.	82
Figure 4.5:	Risk maps for the Vorderbergerbach test site.	83
Figure 5.1:	Developers and users of the Environment Agency flood map.....	89
Figure 5.2:	Example of the outline indicative flood map: Zones 3 (dark blue) and Zone 2 (light blue) (Environment Agency, 2010; 6)	91
Figure 5.3:	National Flood Risk Assessment showing significant (red), moderate (orange) and low (blue) likelihood of flooding (Environment Agency, 2010; 6).....	92

Figure 5.4:	NaFRA 'learn more' information as presented on the Environment Agency website (Environment Agency website, Accessed 20.04.11).	94
Figure 5.5:	An example of the current Environment Agency flood map as presented on the Environment Agency website (assessed 05/09/2011).....	95
Figure 5.6:	Map showing the example of background graphics provided on the current EA flood map until Early 2011 – background detail is that commonly viewed on maps of scale 1: 25 000.	96
Figure 5.7:	Map showing the example of background graphics provided on the current EA flood map from 2011 – background detail is that commonly viewed on maps of scale 1: 25,000.	97
Figure 5.8:	Example of an Area susceptible to surface water flood map.....	100
Figure 5.9:	Example of the areas at risk from reservoir flooding in Chertsey (Environment Agency website; accessed 11/05/11).	101
Figure 5.10:	River level information as presented on the Environment Agency website.....	102
Figure 5.11:	Map illustrating the location of Chertsey (photo courtesy of Kevin Burgess	106
Figure 5.12:	Chertsey flood map and the Isles of Cerotus.....	107
Figure 5.13:	Environment Agency map showing flood zones 2 and 3 for Chertsey	109
Figure 5.14:	Surrey Council Wetspot Map of Chertsey. Wet spots are highlighted in blue.	110
Figure 5.15:	Task 1 WSA Roads and Rail map	118
Figure 5.16:	Task 1 Workshop A Rivers map	118
Figure 5.17:	Task 1 Workshop B Rivers map	119
Figure 5.18:	Task 1 Workshop B Roads Rail and Rivers map.....	119
Figure 5.19:	Chertsey maps tested during the experimental graphic semiology and their revisions post-testing which were presented in the Findings workshop (continued)	137
Figure 5.20:	Other maps presented at the Findings workshop that were not tested during the experimental graphic semiology workshop outcomes and evaluation.....	139
Figure 6.1:	Overview map of Saxony with the case study area of the Vereinigte Mulde River near the City of Wurzen and the Municipality of Bennetwitz.....	151
Figure 6.2:	Detail of a topographic map 1:50,000 showing the City of Wurzen and the Municipality of Bennetwitz.....	152
Figure 6.3:	The Landkreis Leipzig (district, dark red) within the Direktionsbezirk Leipzig (light red) and their location in Saxony (left); location of the City of Wurzen (centre); location of the Municipality of Bennetwitz (right)	154
Figure 6.4:	The reporting and information chain for flood related messages in Saxony	159
Figure 6.5:	Example of the map showing the flooded areas in August 2002 for the area of Wurzen/Bennetwitz	162
Figure 6.6:	Example of the Intensity map HQ100 for the area of Wurzen/Bennetwitz	163
Figure 6.7:	Example of the flood hazard maps for residential areas for the area of Wurzen/Bennetwitz.	164
Figure 6.8:	Example of the flood inundation map as part of the Atlas of Flood Hazards in Saxony for the area of Wurzen/Bennetwitz.....	165

Figure 6.9:	Example of the damage potential map as part of the Atlas of Flood Hazards in Saxony for the area of Wurzen/Bennewitz.	166
Figure 6.10:	Example of the map showing Legally binding flood-prone areas (according to the Saxon Water Act) for the area of Wurzen/Bennewitz.	167
Figure 6.11:	Example of priority and reserved areas for flood protection (according to the Regional Planning Act) for the area of Wurzen/Bennewitz.	168
Figure 6.12:	Examples of a municipal flood information map (left) and a municipal hazard zone map (right) for an area in the City of Glauchau.	169
Figure 6.13:	Part of a flood hazard map for the City of Plauen (Saxony, Germany) on the upper Weiße Elster River according to the Saxon conception within LABEL (left) and the same river in Plauen (right).	171
Figure 6.14:	Integrated assessment of economic, ecological and social risks (FLOODsite).	172
Figure 6.15:	A screen shot from the INGE information software	173
Figure 6.16:	A screen shot from the DISMA decision support system.	174
Figure 6.17:	Research and participation process in the case study	180
Figure 6.18:	1 st workshop: blank maps (left) and group work with GIS layers (right)	182
Figure 6.19:	fictional map with GIS layers.	183
Figure 6.20:	Set of maps for the case study Bennewitz/Wurzen tested by means of experimental graphic semiology.	189
Figure 6.21:	Examples for the eye movement of two test persons. Yellow circle show points with longer fixations, the number indicate the chronology of these fixations.	191
Figure 6.22:	Main areas of interest in map 3. The left Figure shows the temporal concentration of all test persons within the first 9 seconds of the test. Bright red colours indicate the areas where the gaze of test persons spent the most time, i.e. which attracted the eyes of test persons most. Based on these the main areas of interest are highlighted in the right Figure (black: core zone, red: extended zone)	191
Figure 6.23:	Set of improved maps discussed with stakeholders in the 2 nd workshop	193
Figure 6.24:	Evaluation of the new maps by stakeholders (n=6) during the 2nd workshop. For “complexity” and “information density” 50 is the best score. For the other three criteria 100 would be the best score. Map 4 was not included in this survey.	195
Figure 6.25:	Map for emergency managers, updated after the 2 nd workshop	202
Figure 7.1:	01 – Catchment area of the river Rott and the project area; 02 – River Rott and its catchment area in Bavaria; 03 – Case study area and the main area of interest: Pocking and Ruhstorf a. d. R.	205
Figure 7.2:	Pocking and Ruhstorf – Area of interest and content of flood hazard and flood risk maps	206
Figure 7.3:	Industrial and Commercial parks of Pocking	207
Figure 7.4:	Exemplary picture: 1954 flood	208
Figure 7.5:	Exemplary picture of the 2011	
Figure 7.6:	The organisation of the flood information and alarm service.	213
Figure 7.7:	Establishment of flood risk management plans	215
Figure 7.8:	IÜG – Standard version, showing Pocking and provisionally secured flood areas	218
Figure 7.9:	IÜG – Expert version, showing Pocking and water sensitive areas.	219

Figure 7.10:	Flood hazard and flood risk maps, designed for the EGS tests in Tours, France	224
Figure 7.11:	Application of flood maps	227
Figure 7.12:	Evaluation of the rate of use of flood maps	227
Figure 7.13:	Evaluation of the experiences with flood maps.....	228
Figure 7.14:	Intensity Map HQ100	228
Figure 7.15:	Flood Hazard Maps for Sites	229
Figure 7.16:	Hazard Map.....	229
Figure 7.17:	Flood Inundation Map	229
Figure 7.18:	Mapping preferences	230
Figure 7.19:	Relevance of Risk Information	230
Figure 7.20:	Usability of different Map Types.....	231
Figure 7.21:	Remodelled maps from the EGS-test in Tours, France, presented at the 2 nd workshop	232
Figure 8.1:	Highest known flood levels	237
Figure 8.2:	Cartorisque.....	243
Figure 8.3:	Cartorisque for Tours	244
Figure 8.4:	Economic, social, ecological and special risks (critical infrastructure)	245
Figure 9.1:	Potential barriers of maps as devices for communicating flood risk.....	247
Figure 9.2:	Historical flood outline for the 1987 flood event (Environment Agency data).....	254
Figure 9.3:	Current online Environment Agency flood map at 1:6,000 scale.....	255
Figure 9.4:	Current online Environment Agency flood map at 1:10,000 scale.....	256
Figure 9.5:	The flood mapping cycle	259
Figure 9.6:	Timing of participatory approaches in the risk mapping cycle	261
Figure 9.7:	Participation framework	265
Figure 9.8:	Graphical illustration of the semantic network describing the notion of a hazardous event as applied in FloodCalc and the respective flood risk assessment ontology. This notion follows Cardona (2004), after which any hazard can be defined using its intensity and recurrence interval or probability of occurrence, respectively. Hence, the ontology captures this expert knowledge by several object properties (associating the relevant concepts as illustrated above) and a data type property as a means to store the respective recurrence interval. Flood events are defined as a subclass of hazardous events, which is indicated by the use of a taxonomic constructor.	268
Figure 9.9:	Intensity measures defined in the flood risk assessment ontology. Each measure is a subclass of the <i>IntensityMeasure</i> superclass. A value constraint is imposed on the requires BaseUnit object property, which associates each intensity measure with its base unit. These units are defined in the units ontology being part of the SWEET upper-level ontologies. This is indicated by the <i>units</i> -prefix in the relevant labels. See Figure 9.8for an explanation of symbols.	269
Figure 9.10:	Graphical representation of the notion of elements at risk in the flood risk assessment ontology as a union of material infrastructure, population (comprising either the total population or distinct cohorts) as well as environmental components to account for all dimensions of flood risk.	270

Figure 9.11:	Semantic network of the infrastructure and population class. Infrastructure includes both institutional infrastructure and material infrastructure, which in turn poses on set of elements at risk. Table 9.6 lists the considered material infrastructure in more detail. Another set of elements at risk is the affected population, which includes the total population or the cohorts as shown in this Figure. Although numeric value restrictions apply for the depicted age cohorts (children: 0-10 years of age; elderly: >65 years; all other age cohorts: 10-65 years of age), these restrictions cannot be imposed on the different classes, since the current version of OWL does not allow for such a numeric value constraints. See Figure 9.8 for an explanation of symbols.....	272
Figure 9.12:	Global logigram for the visual variables studied, in blue variables related to the hazard, in yellow related to the vulnerability and in red related to the summarising risk information (Serrhini 2011).	278
Figure 9.13:	Different patterns in the visual strategy of map reading.	278
Figure 9.14:	Original risk maps (left) and improved maps according to the findings of visualisation and experimental graphic semiology. Top: risk map pair from Vorderbergerbach, Austria: Improvements included the scale of the central graphic element, the toponymy, and more specific information on people at risk and evacuation possibilities. Bottom: risk map pair from Bennewitz/Wurzen, Germany: Improvements included the hue, the depiction of areas at risk including population at risk, and strategic pictograms highlighting risk hot spots and evacuation pathways.	279
Figure 10.1:	Exemplary map for emergency management (case study Saxony): Map contents include important emergency management information (coordination centre, assembly points, evacuation routes), critical infrastructure, inundation depth and affected population. However, stakeholders criticised that information on exact number of affected people, building information can still be improved.....	291
Figure 10.2:	Idealised map for strategic planning	294
Figure 10.3:	Idealised map for emergency management	295
Figure 10.4:	Idealised map for the general public.....	296
Figure 12.1:	Maps of the test site POCKING / SCWAIBACH (GER).....	313
Figure 12.2:	Maps of the test site CHERTSEY (UK).....	314
Figure 12.3:	Maps of the test site VORDERBERG / WARTSCHENBACH (AUS).....	315
Figure 12.4:	Maps of the test site BENNEWITZ / WURZEN (GER)	316
Figure 12.5:	Maps of the test site TOURS (FR).....	317
Figure 12.6:	Flood Plain Maps	326

12.7 List of tables

Table 2.1:	Public participation requirements in flood risk planning according to EC-directives	17
Table 3.1:	Presentation methods for the workshop introductions.....	41
Table 4.1:	Precipitation data Zettersfeld. Source: Hydrographischer Dienst Tirol.....	65

Table 4.2:	Flood record of the Wartschenbach catchment. Source: (Event documentation of the Austrian Torrent and Avalanche Control Service, and Angerer et al., 2000; Hübl et al., 2002).	66
Table 4.3:	Flood record of the Vorderbergerbach catchment. Source: (Event documentation of the Austrian Torrent and Avalanche Control Service, and Hübl et al., 2004)	68
Table 4.4:	Matrix of mitigation measures to mitigate mountain hazards (adapted from ONR, 2009).	70
Table 4.5:	Floor height, number of storeys, and average values per m ³ used during the set of calculation. Modified from Keiler et al. (2006: 122)	79
Table 5.1:	The evolution of flood mapping in England and Wales	87
Table 5.2:	Mapped zones on the outline indicative flood map	93
Table 5.3:	Flood risk zones defined as part of the National Flood Risk Assessment	93
Table 5.4:	Example of Environment Agency webpages and documents relating to the flood map	98
Table 5.5:	Key characteristics of flood hazard and flood risk maps as defined by the Risk Regulations (2009)	103
Table 5.6:	Principles and activities in the EA FCRM risk mapping strategy 2010-2015	104
Table 5.7:	workshop findings	141
Table 6.1:	Peak discharges (Q in m ³ /s) and peak water levels (W in cm) for the City of Wurzen (km 54,654 upstream from the mouth of the Mulde River near the bridge in Grubnitz)	153
Table 6.2:	Alarm stages and corresponding water levels for the local reference gauge at Golzern 1, Vereinigte Mulde River	153
Table 6.3:	Population for the administrative entities of the case study area	154
Table 6.4:	Categorisation of stakeholders according to scale and role	160
Table 6.5:	Derivation of intensity criteria	176
Table 6.6:	Results from the evaluation of the importance of different map components	187
Table 6.7:	Recommendations for contents	200
Table 7.1:	discharge (Ruhstorf)	204
Table 7.2:	water level (Ruhstorf)	204
Table 7.3:	basic information about the catchment of the river Rott	207
Table 7.4:	Flood History and Protection Measures	208
Table 7.5:	water authorities in Bavaria and their specific roles	210
Table 7.6:	Selectable scales and background maps for IÜG	218
Table 8.1:	Historic flood levels in Tours	238
Table 8.2:	Synthesising the actors and documents involved in flood risk	242
Table 8.3:	Current key to flood hazard mapping (Cartographie de l'Aléa d'Inondation or AZI)	246
Table 8.4:	future key for mapping flood hazard, as suggested by DREAL-centre	246
Table 9.1:	Stakeholders in the case studies	248
Table 9.2:	Characteristics of the Saxon case study	249
Table 9.3:	Characteristics of the Bavarian case study	250

Table 9.4:	Characteristics of the Austrian case study.....	251
Table 9.5:	Characteristics of the English case study	252
Table 9.6:	Description of material infrastructure as element at risk.....	271
Table 9.7:	Description of core OWL classes in the flood risk assessment ontology.	274
Table 9.8:	Description of core OWL object properties and datatype properties in the flood risk assessment ontology.	275
Table 10.1:	Recommendations for participatory processes for different aims.....	285
Table 10.2:	Map contents required by different end-user groups	292
Table 12.1:	Participants EGS test.....	318
Table 12.2:	Overview	324
Table 12.3:	Historical Flood Data (Loire & Cher rivers), city of Tours. The Val de Tours is diked along its entire length and has been subject to many floods, the most serious of which occurred in the 19th century.	324
Table 12.4:	Flood risk management in France: a top down and multilevel organization Major actors at different levels (national, regional, departmental, local municipalities):.....	327
Table 12.5:	Case study (Tours and surrounding area) description	328

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12.9 Table of project information

RISK MAP	
Joint project title	Improving Flood Risk Maps as a Means to Foster Public Participation and Raising Flood Risk Awareness: Toward Flood Resilient Communities
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Project website:	http://www.risk-map.org
Objectives	RISK MAP aims at improving flood risk maps as a means to foster public participation and raising flood risk awareness. For achieving this aim RISK MAP (1) develops rules for the appropriate stakeholder participation enabling the incorporation of local knowledge and preferences; (2) improves the content of risk maps by considering social, economic and environmental risks by means of a deliberative multicriteria risk mapping tool (3) improves the visualisation of risk maps in order to produce user-friendly risk maps and (4) provides quantitative information related to the content of risk maps by the application of the experimental graphic semiology method using the eye tracking approach.
Background	Flood maps are considered as an important means of risk communication and a basis for decision making in strategic planning and emergency management. However, risk communication by flood maps is mostly organised in a one-direction top-down manner. I.e. the public is only considered as the receiver of information and is not directly involved in the risk mapping process. Secondly, flood maps are mostly focused on the hazard. If risks are taken into account they are mostly expressed in monetary terms, such as risks to buildings and inventories. Other risk criteria, like social and environmental effects are often neglected so far. Finally, risks maps are often designed and visualised in a way which cannot be easily understood by laypersons and/or not suitable for the respective needs of public authorities in risk and event management.
Research	First, the status quo of flood mapping in the case studies was analysed by means of literature review and explorative interviews, with regard to the current practices and the legal context of flood mapping and participation. After that a first series of stakeholder workshops was carried out in order to discuss existing maps and

	explore stakeholder needs. A multicriteria software tool (FloodCalc) was developed in order to support the integration of local knowledge and preferences in flood maps. New test maps were developed and tested by means of eye-tracking tests. Based on the results of the first workshop and the eye-tracking tests maps were adjusted and then again discussed with stakeholders in each case study in a second workshop. In the final phase slight adjustments of the maps were made and common recommendations have been drawn with regard to i) the participation processes in flood mapping, ii) the contents of flood maps and iii) the visualisation of flood maps, considering the needs of different user groups.
Findings and implications	Different end-users (from strategic planning, emergency management or the public) require different flood maps with regard to content and visualisation. E.g. strategic planners require detailed hazard and risk information, whereas emergency managers require quickly accessible information on hazard extent and depth, number of people to be evacuated, critical infrastructure and additional emergency management information on evacuation routes etc. The public requires simple maps with information on the affectedness of buildings and potential evacuation routes. More detailed recommendations on contents and visualisation are given in chapter 10 of this report. However, regional requirements can be very diverse, so it is recommended to conduct participation processes in order to i) improve and verify maps contents by means of local expert knowledge and ii) to increase the usability of maps and raise risk awareness among the population. More detailed recommendations on participation processes are given also in chapter 10 of this report.
Publications related to the project	• Priest, S.J., Pardoe, J., McCarthy, S.S. and Viavattene, C. (2011) Narrowing the focus: Public understanding of flood maps in the River Thames catchment, Proceedings of Urban Flood Risk Management: Approaches to enhance resilience of communities International Symposium, Graz, Austria, 21st to 23rd September 2011, p 309-314. • Scheuer, S., D. Haase, V. Meyer, J. Luther and C. Kulicke (2011) Enhancing Flood Risk Assessment, Management and Mapping by means of a Risk Assessment Ontology. Proceedings of Urban Flood Risk Management: Approaches to enhance resilience of communities International Symposium, Graz, Austria, 21st to 23rd September 2011. • Seidel, J. and W. Dörner (2011) Flood Risk Maps for Disaster Control. Application and Resulting Requirements. Proceedings of Urban Flood Risk Management: Approaches to enhance resilience of communities International Symposium, Graz, Austria, 21st to 23rd September 2011. • Unnerstall, H. (2010). Legal Framework for Public Participation in Flood Risk Mapping - A comparative study on different European member states and on the requirements of the Flood Management Directive. UFZ Discussion Paper 13/2010. Leipzig. • Unnerstall, H. (2011) Legal Framework for Public Participation in Flood Risk Mapping. Proceedings of Urban Flood Risk Management: Approaches to enhance resilience of communities International Symposium, Graz, Austria, 21st to 23rd September 2011.