Management-Report

August 2002 flood in the watercourses of the Osterzgebirge mountains Event Analysis

Freistaat Sachsen

Sächsisches Landesamt für Umwelt und Geologie

WSL

In August 2002, Saxony was hit by a region-wide flood disaster. The Elbe and Mulde rivers and the tributary streams in the Osterzgebirge mountains were worst hit by the flooding. Torrential rain on 12 and 13 August 2002 caused flash floods in the mountains. The consequences were devastating: valleys were flooded and filled with mud and boulders; houses, roads and cultural heritage were destroyed.
The damage caused by flooding, estimated at over 1 billion euros* alone in the area surrounding the streams in the Osterzgebirge mountains, once again demonstrated the vulnerability of our living environment.
Immediately after the flood, the Saxon State Office for Environment and Geology began an event analysis of the streams in the Osterzgebirge mountains, which had been particularly badly affected by the flood. Right from the beginning, the State Office co-operated closely with the Swiss Federal Institute for Forest, Snow and Landscape Research. The project received financial support from the Swiss Agency for Development and Co-operation (SDC).
The extent of the catastrophe was such that a thorough review of the flood control scheme in Saxony was initiated. The analysis of the flood included a thorough examination and documentation of the event. This documentation was used to draw a series of conclusions, which subsequently formed the basis for developing a sustainable flood control scheme in Saxony. The purpose of such a scheme is to prevent floods like that in August 2002 with catastrophic consequences for the state and its people. This management report summarises the most important findings and conclusions of this event analysis.

* Please note that billion means thousand million in this brochure.

Hydro-meteorological and geomorphologic processes

In the first half of August 2002, large parts of Central Europe were hit by torrential rain. The Free State of Saxony, and in particular the catchment areas of the streams in the Osterzgebirge mountains, bore the brunt of the precipitation and were therefore badly affected by the flooding.

The usually gentle streams of Biela, Gottleuba, Müglitz, Lockwitzbach, Weißeritz, Wilde Sau, Triebisch and Ketzerbach were transformed into torrential rivers, causing more than €1 billion worth of damage in about 8.5 per cent of the flooded areas in Saxony–some 15 per cent of the total damage recorded in the Free State. Sadly, 12 people lost their lives in the area under investigation.

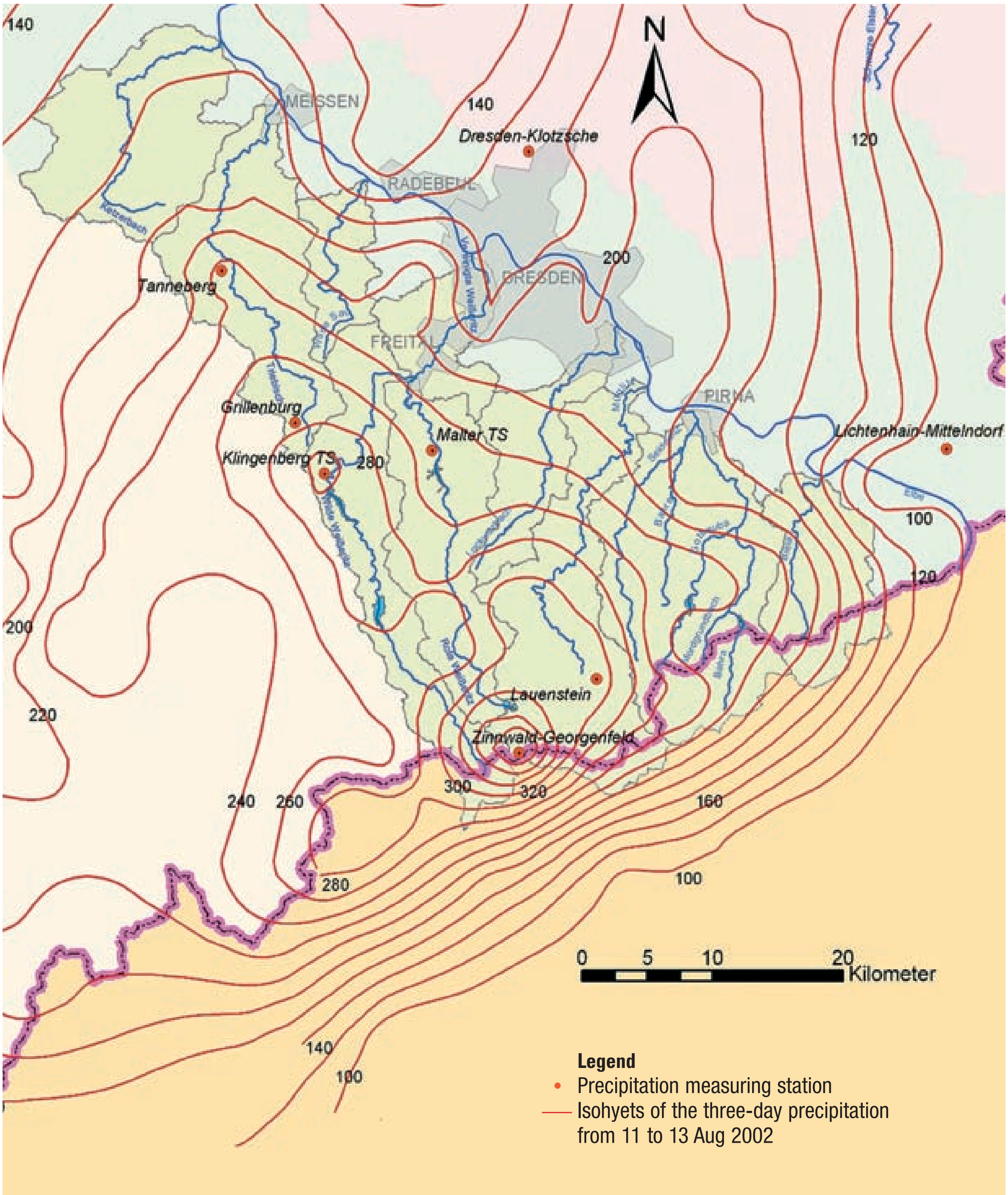

Fig. 1: Area under investigation–the left bank tributaries of the Upper Elbe in Saxony and precipitation in mm from 11 to 13 August 2002 (Source: DWD [German Meteorological Office])

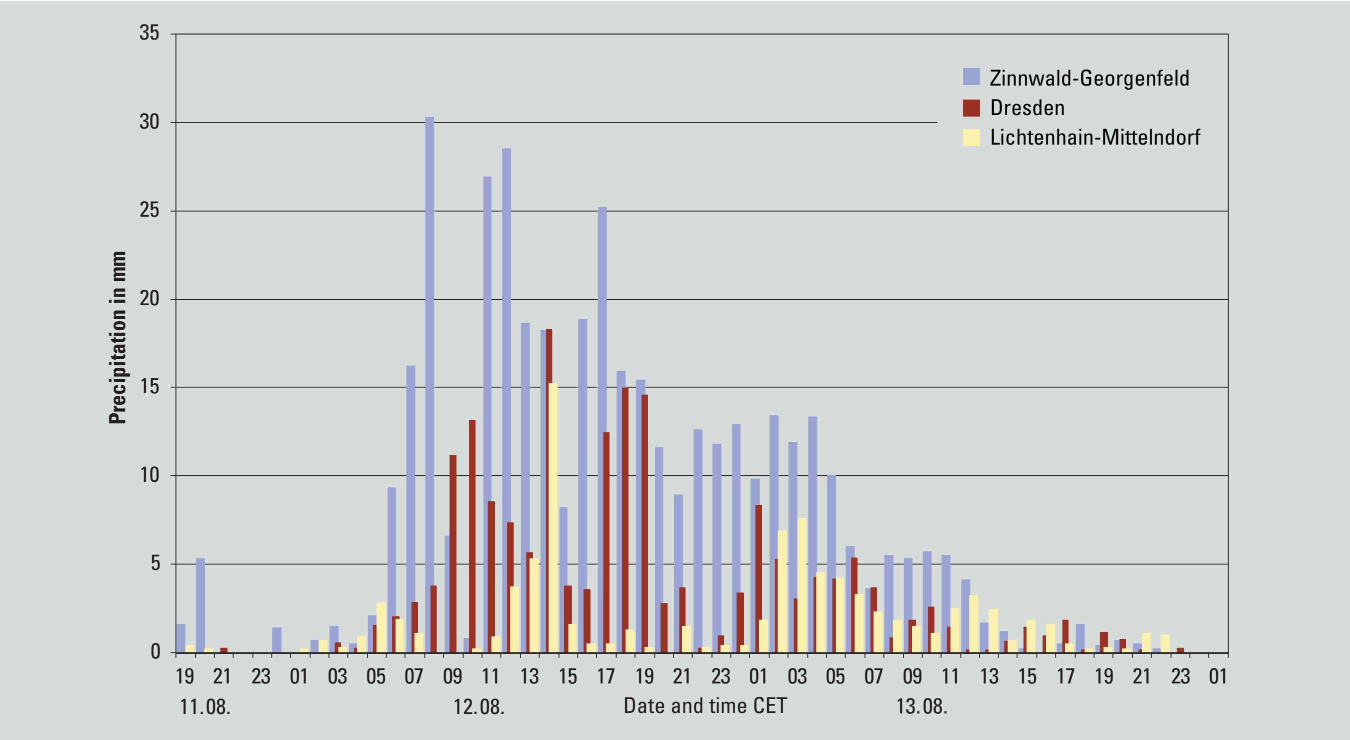

Fig. 2:
Hourly precipitation values measured in the Zinnwald-Georgenfeld, Dresden, and Lichtenhain-Mittelndorf stations between 7 p.m. CET on 11 August 2002 and 11 p.m. CET on 13 August 2002 (Source: DWD [German Meteorological Office])

The flood was caused by rainfall which was exceptional in terms of intensity, duration and areal distribution. More than 200 mm of rain fell in large parts of the Osterzgebirge mountains in just three days: that's between two and three times as much as the average rainfall for the entire month of August. However, the one-day values for rainfall in the peak precipitation area, which was rather small, were very close to the physically possible maximum (see Fig. 2).

Because of its geological condition and the moisture it already contained, the soil was incapable of absorbing much water and was quickly saturated. As a result, it could neither hold water, nor delay discharge in any significant way. Consequently, 60 to 90 per cent of the precipitation ran off in many areas in a very short space of time. This led to discharge rates far beyond any known values in almost all of the investigated watercourses (see Fig. 3).

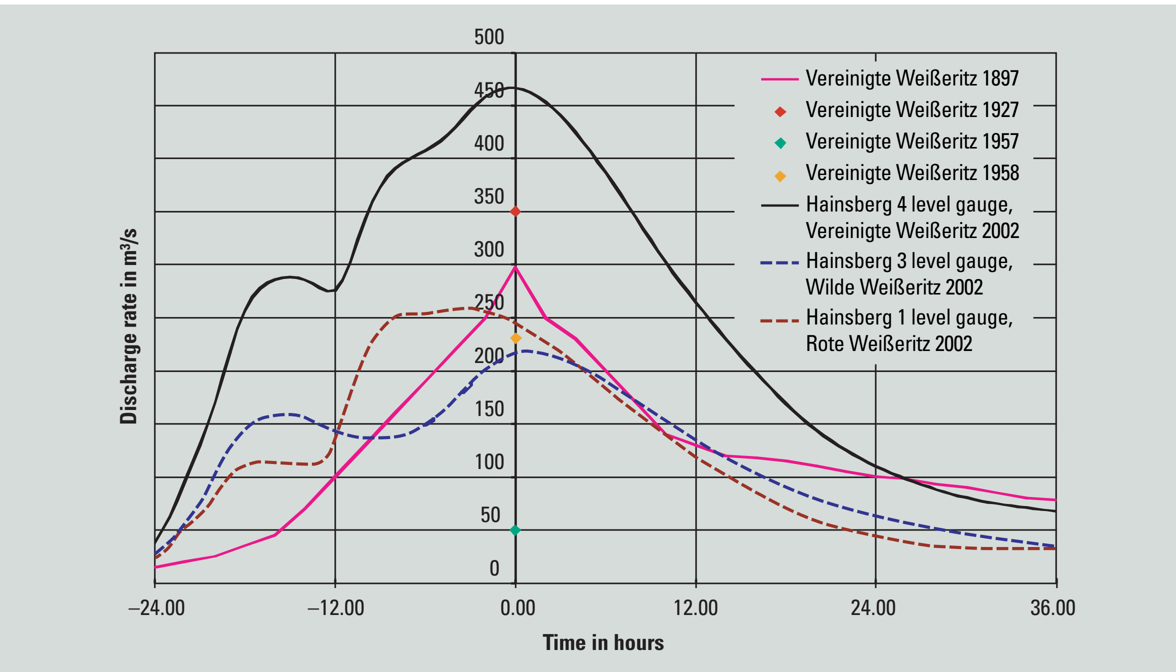

Fig. 3:
Historical hydrograph curve and peak discharge rates for the river Weißeritz compared with the flood on 13 August 2002

Several hundred thousand cubic metres of sediment were moved in the most heavily affected streams, the Weißeritz and the Müglitz. The main sources of material included collapsing revetment walls and their backfill, road and railroad embankments, as well as artificial and semi-natural reinforcements made of unconsolidated material. The material was mostly transported over short distances and deposited either in shallow sections with little transport capacity or in front of obstructions such as bridges. Transport processes considerably modified the river beds, even entire channels were displaced. The flow capacities of river cross-sections and at bridges were exceeded almost across the entire region. As a result, large areas, and in particular villages and towns, were flooded.

Fig. 4: Complete erosion of the railroad embankment in the valley of the river Müglitz. The exposed old retaining wall, which used to give the stream a much wider bed, is noteworthy (photo: LTV [State Dam Management Office], 2002).

Fig. 5: Choked and damaged bridge in the valley of the river Müglitz– temporary bridge in Schlottwitz, upstream from the confluent Trebnitzbach stream (photo: LTV, 2002).

In terms of its areal extension, intensity of discharge, and solid material displacement, the August flood must be classified as an extreme event.

Fig. 6: Lauenstein railway station after the flooding of the river Müglitz in 1927 (photo: taken from POHL, 2003)

Similar damage as a result of sediment and drift wood etc. are documented for all major historic floods in the Osterzgebirge mountains. However, solid material processes only become relevant when the flow rate exceeds a certain limit, which leads to massive overbank flow. In such cases, damage increases drastically.

Damage

Total damage for the area under investigation amounted to over 1 billion euros. The Weißeritz and Müglitz valleys were more affected than any other. Accounting for 60 per cent of the total damage, municipalities and private property were worst hit by the flooding. The traffic arteries, which often run alongside the watercourses, were also badly affected.

Although the region flooded by these watercourses only represents 8.5 per cent of all flooded areas in Saxony, it accounts for 15 per cent of the financial loss and 60 per cent of the casualties in the area. This was due not only to the region's vicinity of the peak precipitation area, but also to the characteristics of the processes in the mountain streams investigated for this report.

The affected communities suffered an average property loss of ten per cent of the total assets in the flooded area. This figure rises as high as 20 per cent for the communities in the valleys of the Müglitz and Weißeritz rivers. Almost half of the flooded areas were settlement areas. This illustrates the great pressure in the valleys to utilise available space for settlements. The great proportion of damaged property to total assets clearly demonstrates that there are conflicts between human use and the spatial requirements of the watercourses.

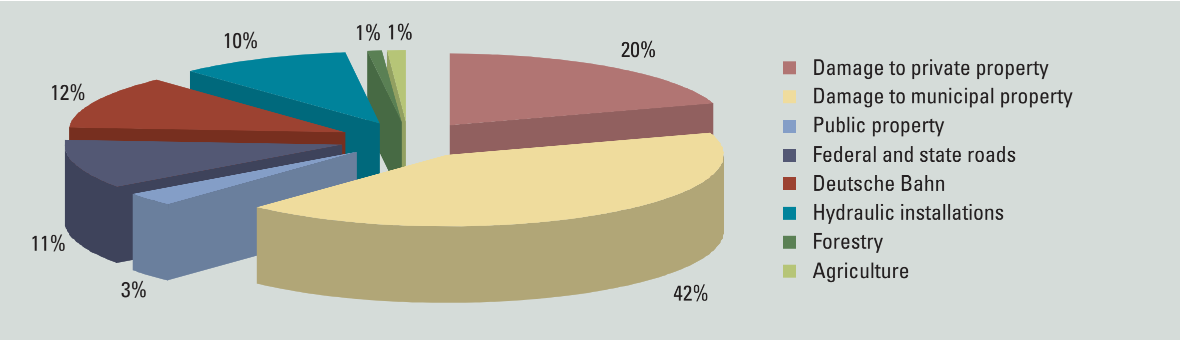

Fig. 7: Flood damage distribution by damage class in the area under investigation

Fig. 8: Destroyed building and channel displacement of the Rote Weißeritz in Schmiedeberg (photo: GOTTFRIED HEROLD, 2002)

Fig. 9:
Removal of debris in Tharandt on 18 August 2002 (photo: RAINER ELZE, 2002)

Catchment area	Loss in million euros	Proportion in %
Biela	24	2
Gottleuba	89	8
Müglitz	201	17
Lockwitzbach	87	7
Rote Weißeritz	181	15
Wilde Weißeritz	93	8
Vereinigte Weißeritz	366	31
Wilde Sau	10	1
Triebisch	103	9
Ketzerbach	22	2
Total:	**1176**	**100**

Table 1:
Total damage by catchment area

Fig. 10:
The river Müglitz downstream from Weesenstein castle (photo: STEFAN HÄSSLER, 2002)

Total damage for the area under investigation amounts to over 1 billion euros. Almost half of the flooded areas were settlement areas. This explains why the damage in the municipal and private sectors was particularly high. This flood highlighted the conflicts between human use of the valleys and the spatial requirements of the watercourses.

Classification of events

In the Biela catchment and in the neighbouring eastern part of the Gottleuba catchment the August flood is classified as a 1:50 or 1:100 year event. In the western part of the Gottleuba catchment and in the adjoining Lockwitzbach catchment, the August flood is classified as an event that only recurs every 100 to 200 years. The recurrence periods of the August flood are generally longer in the lower reaches of the streams than in their upper reaches. Whereas the 2002 flood in the Weißeritz catchment is classified as a 1:100 year event in the upper reaches, the recurrence period is increased noticeably downstream, where it is characterised as an event that recurs about every 500 years max. Also in the lower reaches of the Triebisch catchment, which borders the western part of the Weißeritz catchment, the August flood is given a relatively large recurrence period of 200 to 500 years. The recurrence periods for the catchments of the Wilde Sau and Ketzerbach streams are smaller again, namely 50 to 100 years.

The analysis showed that the flood of the left bank tributaries of the Upper Elbe in 2002 cannot be classified as a 1:10,000 year event or even a maximum possible flood (see Fig. 11).

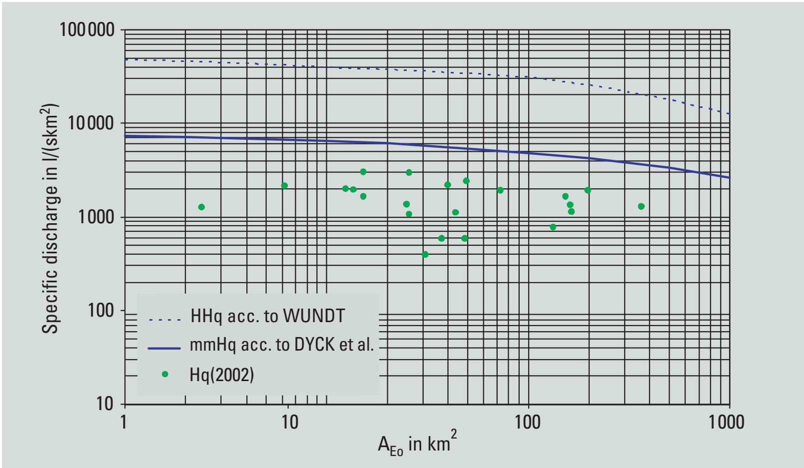

Fig. 11: Comparison of the specific discharge during the August flood Hq (2002) and the envelope curves of maximum known discharge volumes world-wide (according to WUNDT) and in southern Saxony and Thuringia (according to DYCK)

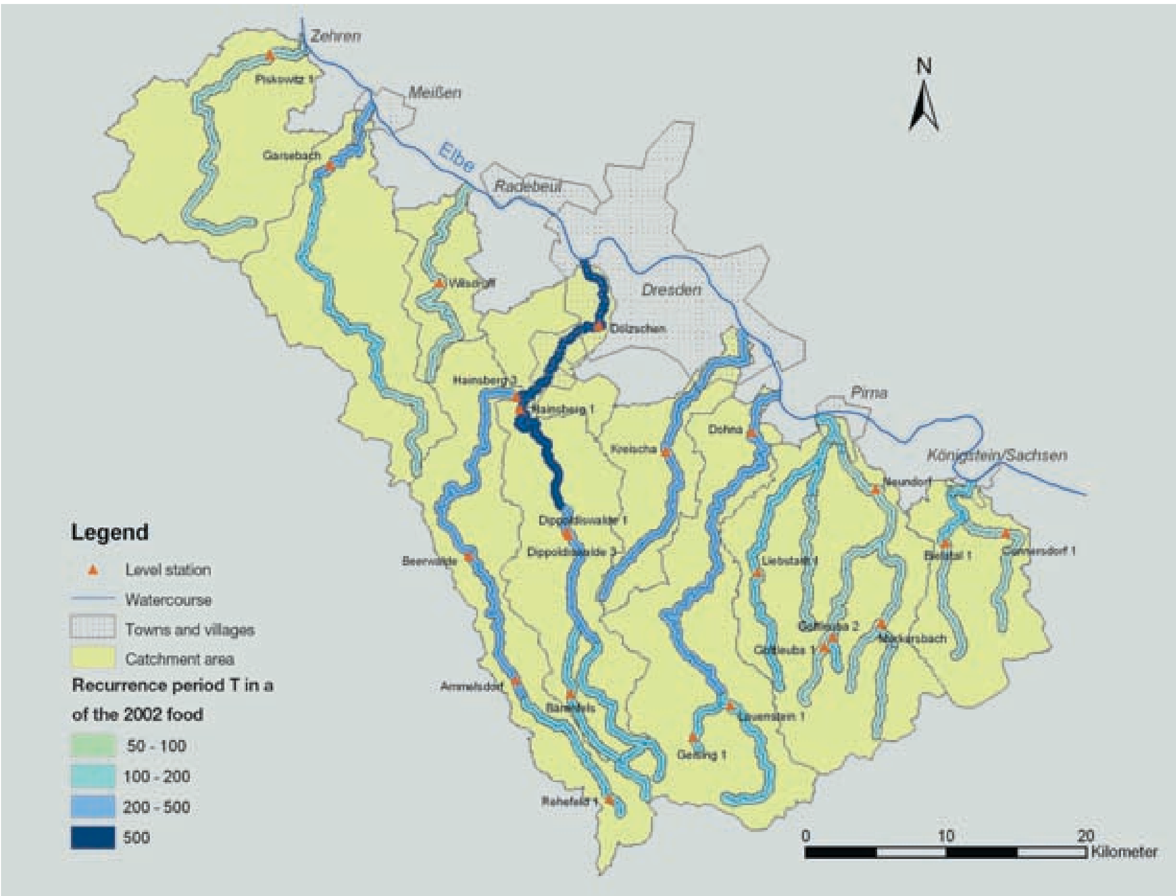

Fig. 12: Statistical classification of the flood in August 2002

A comparison of historical floods before systematic measurements were initiated shows that similar events have occurred in all of the catchment areas under investigation in the past. However, in most cases, only some of the streams were affected simultaneously. What made the flood of August 2002 so exceptional was not so much its severe impact on each of the catchment areas, but the fact that all areas were hit simultaneously.

The watercourses in the Osterzgebirge region–the Gottleuba, the Müglitz and the Weißeritz–have seen at least three comparable flood events since the late 19th century.

Fig. 13: Damaged wing of the Löbtau town hall after the flooding of the river Weißeritz in 1897 (photo: LfUG [State Office for Environment and Geology])

Fig. 14: Town of Berggießhübel in the valley of the river Gottleuba: on the first Sunday after the 1927 flood (photo: taken from MARSCHNER, 1927)

Fig. 15: Town of Pirna after the river Gottleuba flooded in 1957 (photo: LTV)

Although the flood of August 2002 has a statistical recurrence period of 100 to 500 years in the individual catchment areas, a diachronic analysis shows that similar events must be expected in all of the investigated watercourses at any time. The analysis of the flood shows that the August flood was not an event of the magnitude of a greatest possible event.

Flood events that are as severe as or even worse than the one in August 2002 cannot therefore be ruled out in the future.

Effectiveness of flood control measures

The watercourses in the region under investigation are almost completely channelled and the banks consolidated in the settlement areas, and partly so outside the settlement areas.

Dams, bridges and other structures along the channels reduce the discharge capacity considerably in places. Bottlenecks, i.e. places where the available discharge profile was completely incapable of coping with the volume of water, have been identified in almost all affected settlements. For example, some one-third of all bridges in the settlement areas are too small to cope with a hundred-year flood (HQ[100]). Quite apart from the consideration of the above-mentioned bottlenecks, the current development of the river beds in several places is not enough to discharge anything more than a HQ(20).

Fig. 16: Road bridge over the Triebisch stream in Meißen, max. flow rate with no freeboard approx. HQ(50) (photo: LUKAS HUNZINGER, 2003)

Fig. 17: Spillway of the Malter dam on 13 August 2002 (photo: LTV, 2002)

The catchments of the Gottleuba, the Lockwitzbach and the Weißeritz have one or several flood retention reservoirs and dams with flood control function. Even though their limit capacity was exceeded, and water ran over the spillways, these facilities considerably delayed the discharge. For this reason and because the areas below the dams and reservoirs were also hit by heavy rain, the flood control facilities were unable to prevent widespread major damage.

A large part of the flow profiles and embankments proved to be too small to be able to cope with the loads exerted on them by the August 2002 event. Many of them were badly damaged, some were destroyed.

Requirements for future flood control

The scope of damage seen during the August 2002 flood must be drastically reduced in possible future events of like dimension. In particularly, it must have highest priority to save lives. A complete prevention of any financial loss, however, is neither feasible in technical nor in economical terms. The amount of the remaining financial risks which must be borne can be derived from a cost-benefit analysis of the required flood control measures. The required measures target both the reduction of exposure and the decrease of the potential scope of damage.

- The aforementioned flood control concepts and the hazard maps enclosed therein form the technical basis for planning and implementing the above-mentioned measures. This is already taken into account in the current amendment of the Saxon Water Act. The hazard analysis must, where possible, include all relevant processes and should not be restricted solely to the water discharge. A framework of landscape planning and statutory provisions would significantly boost the implementation of the proposed concepts. Hazards in the form of high stream velocities, even outside the riverbed, must also be taken into consideration. A protection concept that is based on water levels and water discharge alone is insufficient.

- Adequate space must be provided for watercourses. In addition to discharge rates, hazards in the form of erosion, sedimentation and flotsam must be taken into account when planning protective measures and defining polder areas.

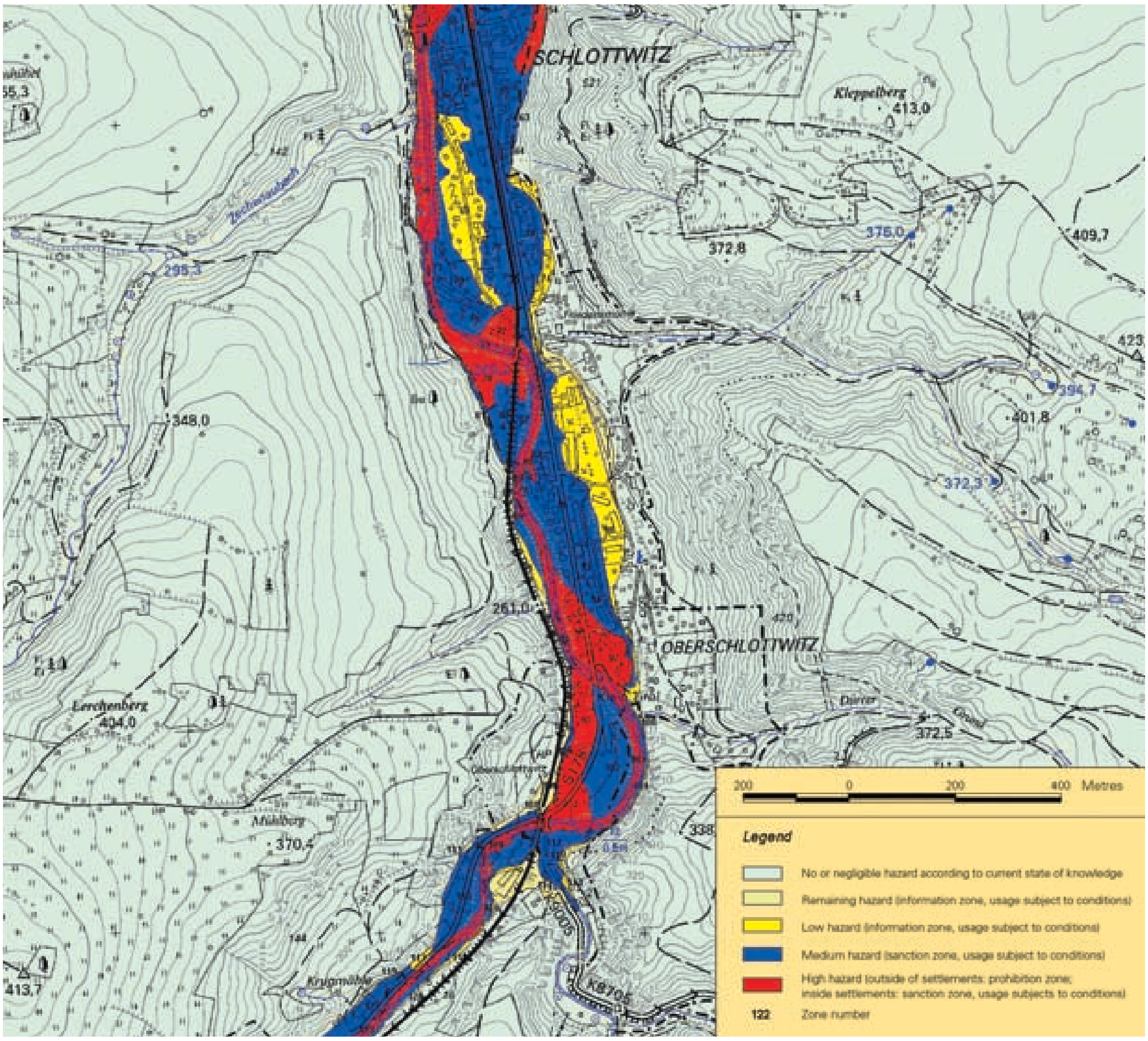

Fig. 18: Detail of the hazard map of the Schlottwitz municipality

- The damage potential must be minimised; at the very least, the observed trend towards developing property in hazard areas must be stopped. These stipulations obviously lead to land use conflicts, which need to be debated in public in the context of flood control. In order to be able to face future flood hazards, landscape planning and land use must be adapted and differentiated, and building regulations complied with.

- Ample cross-sections must be created, and areas for the deposition of sediment and flotsam must be provided at suitable locations. The dimensions of hydraulic structures must be such that they are capable of withstanding major floods and do not have an adverse effect on hydraulic processes.

- Hazards can only be controlled to a certain degree. More importance must be attached to the decentralised retention of discharge volumes, in particular by purposefully influencing the land use in the catchment areas.

- Flood retention reservoirs will need to be constructed at several locations in order to ensure sufficient protection. However, as regards the existing settlements in the Müglitz and Rote Weißeritz valleys in particular, it would appear that justifiable expenditure will not be enough to provide effective protection against a HQ(100) in the municipalities themselves.

- In the event of a catastrophe, good emergency planning is imperative for operative flood protection. Every municipality must therefore have detailed flood alert plans ready, and ensure that their fire brigades are prepared and ready for action. Flood forecasts and their rapid and reliable dissemination are other important aspects when it comes to launching such defence measures.

Fig. 19: Destroyed revetment of the Müglitz stream in Glashütte, 2002 (photo: LTV, 2002)

Fig. 20: Same revetment of the Müglitz stream in Glashütte, 2004 (photo: LTV, 2004)

Flooding hazards are indicated in hazard maps. The hazard analysis must include any relevant processes and should not be restricted to the water discharge alone.

The stated hazardous processes shall be taken into account in landscaping by providing adequate flood plains with usage restrictions.

Ample cross-sections must be created, and areas for the deposition of sediment and flotsam must be developed.

Conclusions for the flood information service

Several weaknesses in the flood information and reporting system were revealed during the August flood, some of them caused by a widely ramified reporting structure. There were numerous instances of delays and interruptions in the flow of information. Fire brigades, other rescue institutions, and civil protection offices were not always given sufficient notice to plan and implement more effective flood control measures in time. In addition to a breakdown of several measuring stations, the situation was compounded by the fact that some of the actual discharge rates vastly exceeded the reference values for alert phase 4. Standard routines, which focused mainly on more frequent, smaller floods, were not able to cope with this situation. The way in which the flood co-ordination office and local offices dealt with the August 2002 flood was further complicated by the lack of experience with a flood of that size. The redevelopment of the flood information service concept aims to provide better information about impending flood situations and the development of an existing flood situation. The future flood reporting and information chain is illustrated in Fig. 21.

- The improvement of the flood information service in Saxony will be based on the improved operational reliability of the water level recorders, redundant data transmission routes, and optimised organisational structures. The intention is to forward all information directly to the individual municipalities.
- The incorporation of additional data, such as information about precipitation and damage recorded in the catchment areas, will improve the quality of flood alert messages.
- The newly established shift system in the co-ordination office takes into account the short response times in the catchment areas under investigation. The operators receive warnings of heavy rain and such information is immediately assessed in the context of the current water levels in the State Flood Control Office (LHWZ). In the small catchments of the Upper Elbe tributaries, it takes only a few hours for heavy rain to affect the discharge rates in the streams (see Fig. 23).

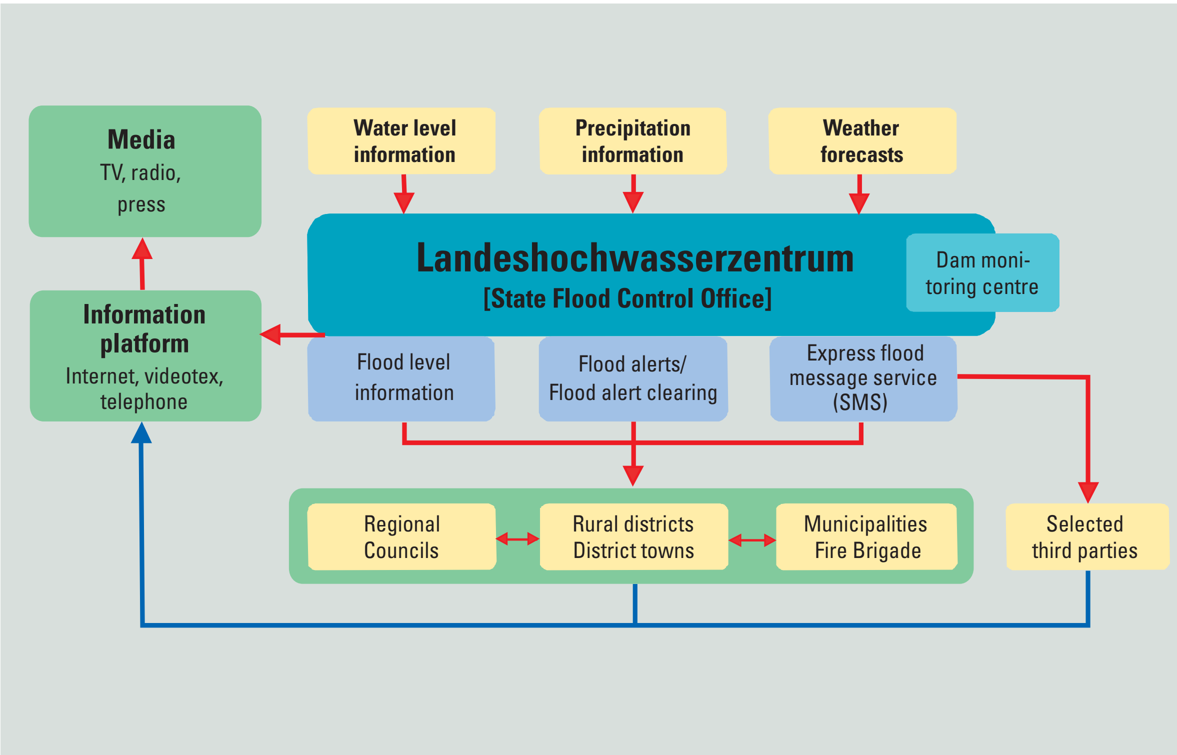

Fig. 21: Future reporting and information chain for flood-related messages in the Free State of Saxony

Flood projections with a long forecast horizon for these regions are mainly based on precipitation forecasts. They cannot, therefore, be more accurate than the precipitation forecasts. The German Meteorological Office (DWD) and other institutions are conducting extensive research into the improvement of local forecasts. Catchment-specific flood alerts will only become possible once improved precipitation forecasts are available.

- Precise precipitation values, which are due to be available from May 2005, will make short-term forecasts more accurate and will allow for speedier dissemination. Together with all measured actual values and other data from the information platform that is currently being developed, the municipalities in the small catchment areas of the Upper Elbe tributaries will have the best possible information at their disposal when making flood control decisions.

- The municipalities must combine this information with local information about blockages and sediment depositions to independently implement concrete flood protection measures. Prepared and regularly reviewed flood alert plans will be the most important basis for this work. At the same time, the municipalities must consider how the local observations can be integrated into the information platform and thereby be made available to a restricted group of bodies, e.g. the downstream municipalities, the local flood control offices, and the State Flood Control Office.

Fig. 22: Saxon State Flood Control Office

Based on a reliable and up-to-date emergency plan, the fast and reliable dissemination of flood forecasts is a vital part of triggering flood protection measures. Naturally, saving lives has the highest priority when it comes to exceptional events.

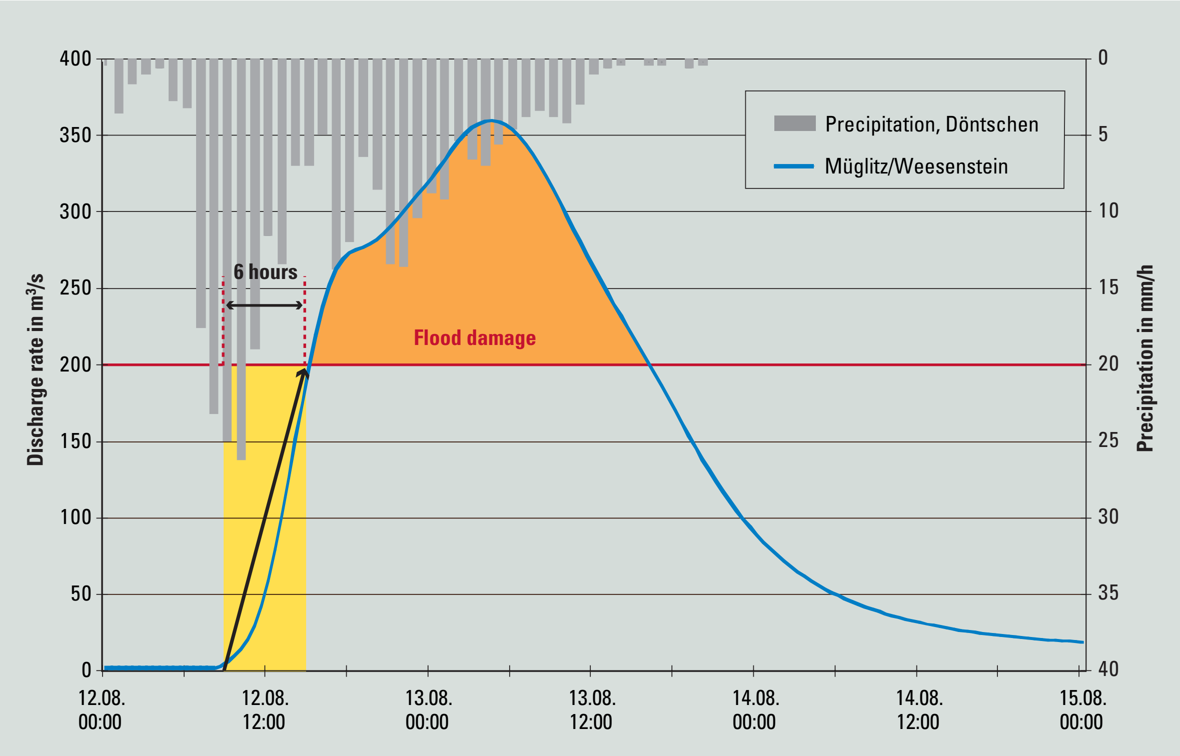

Fig. 23: Hydrograph curve of the river Müglitz in the Weesenstein area and the delay until flood damage occurred

Flood control in Saxony: a summary

In terms of its areal extension, intensity of discharge, and solid material displacement, the August flooding of the watercourses in the Osterzgebirge mountains must be classified as an extreme event. A large part of the cross-sections and embankments proved to be too small to cope with the loads exerted on them. Many of them were badly damaged or destroyed. Similar damage as a result of sediment and flotsam in these rivers has been documented for all major historic floods in the Osterzgebirge mountains. The historical analysis shows that events like those in August 2002 can be expected on all rivers. However, the analysis of the flood also demonstrates that the August flood was not an event of the magnitude of a greatest possible flood. This is why flood events in that area as severe or even worse than that in August 2002 cannot be ruled out in the future. The total damage in the area under investigation amounts to more than 1 billion euros. This once more demonstrates the vulnerability of our living environment in the event of a flood like the one in August 2002, and highlights the conflicts between human use and the spatial requirements of the watercourses. In those places where settlements, transport routes and other developed spaces overlap with hazard areas, natural processes can cause extreme damage. Knowledge about the hazards in the area under investigation is a prerequisite for a purposeful and efficient implementation of protective measures.

Flooding hazards are indicated in hazard maps. The hazard analysis required for these maps must include all relevant processes and should not be restricted solely to the water discharge. The stated hazardous processes must be taken into account in landscaping by providing adequate flood plains with usage restrictions. The planning of operative flood protection can also be based on these hazard maps. Smaller and medium-sized floods can be reduced and their effects minimised by improving natural retention in the catchment areas and, where necessary, by implementing technical flood control measures. In the event of an extraordinary flood like the one that occurred in August 2002, the top priority is to save lives with the help of quick and targeted flood alerts and consequential flood control measures. Although material damage can be limited by technical flood control measures, compliance with building laws, timely warnings and on-site flood defence, it must be put up with to some extent. Small catchment areas (A_{Eo} < 500 km^2) still remain problematic because of the short response times involved.

Flood protection can be substantially improved in the Free State of Saxony by consistently implementing the above-mentioned concept development, constructional and organisational measures.

It is important to note, however, that even the best flood control scheme cannot prevent a flood, it can only minimise its effects. Any potentially affected people can also make a substantial contribution to diminishing the extent of the damage. This is why it is vital that the Saxon authorities raise awareness of the flooding hazards among the population to ensure that all possibilities of reducing damage are exhausted.

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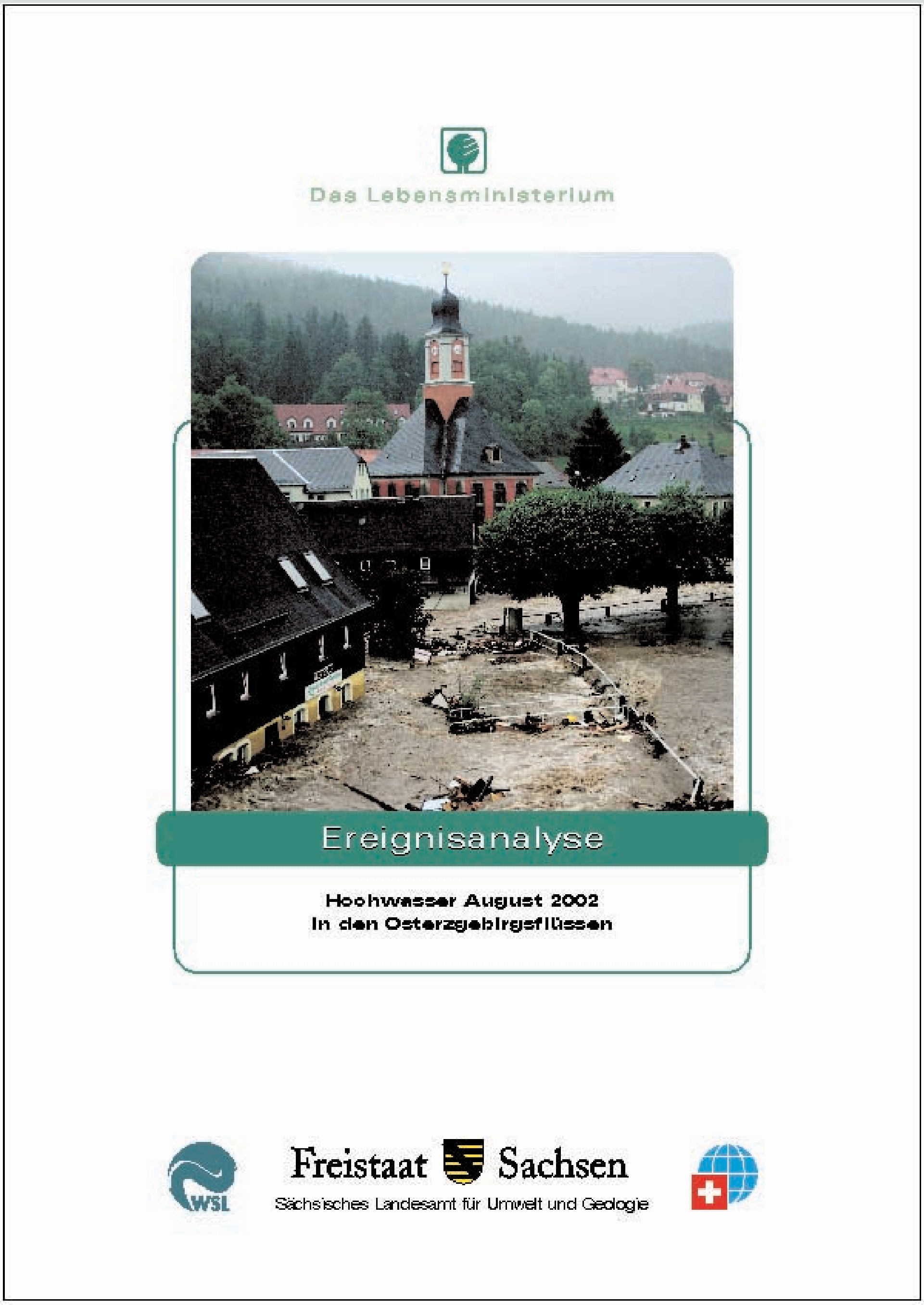
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Ereignisanalyse

Hochwasser August 2002
in den Osterzgebirgsflüssen

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Sächsisches Landesamt für Umwelt und Geologie

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