International Commission
for the Protection of the Rhin

Non Structural Flood Plain Management

Measures and their Effectiveness

Internationale Kommission zum Schutz des Rheins

Commission Internationale pour la Protection du Rhin

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Imprint

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Germany (Partial report A2 / A3): Schadenanalyse und Schadenminderung im Siedlungsbereich.
Technische Universität Hamburg-Harburg, Prof. Erik Pasche, Timm Ruben Geissler
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France and Belgium (Partial report A4): Etude d'efficacité. Section A4 France et Belgique. Cemagref, Lyon, Dr. Jean-Francois Perrin, Dr. Nicolas Gendreau
Switzerland (Partial report A5): Wirksamkeitsstudie. Beitrag der Schweiz. Professur für Hydrologie und Wasserwirtschaft der ETH, Zürich und Geographisches Institut der Universität, Bern, Prof. Paolo Burlando, Wolfgang Ruf Andreas Kipfer

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Non Structural Flood Plain Management

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2 Foreword

The Action Plan on Floods
The Action Plan on Floods sets out the following targets for action:

1. Reduce damage risks
2. Reduce flood levels
3. Increase flood awareness
4. Improve the flood announcement system

On 22 January 1998 the 12th Conference of Rhine Ministers decided on the implementation of the Action Plan on Floods. This plan targets at protecting man and his assets against flooding and at ecologically improving the Rhine and its flood plains.

Implementation is scheduled to be achieved by 2020 with the help of performance targets (see margin) fixed by the International Commission for the Protection of the Rhine (ICPR) within the Action Plan on Floods and the Programme on the sustainable development of the Rhine, "Rhine 2020".

With a view to raising public awareness for this issue, the ICPR has drafted a report to be considered as a catalogue of potential measures aimed at reducing damage risks posed by different flood events. The report is based on the findings of different Dutch, German, French and Swiss studies. The measures listed are applicable to all flood prone areas, not only to the Rhine basin.

The responsibility for implementing the measures listed partly resides with the authorities, partly with the population affected. The measures applied in each individual case depend on the kind of risk and the probability of occurrence. It is also up to the authorities in charge to check on the existing risk and to conduct required vulnerability studies if necessary. The report in hand cannot replace such studies integrating the different parameters to take into account, such as probability of occurrence, flood generation, surface water elevation, flood duration, potential damage or defences, as many of the measures considered are particularly adapted to areas with a low level of defence. It must be pointed out that appropriate maintenance of public defences (e.g. embankments) is required to grant safety.

Each flood event has its own particularities and each reduction of damage bases on the close interaction of local factors and a variety of actions, so that it is not possible to assign an effect to a determined measure. Nevertheless, focal points of effect and orders of magnitude of damage reduction can be made out. Therefore, the findings of the report are not to be applied numerically, but their logic may be applied to any case in question. Understandings must constantly be updated and adapted against the backdrop of new social developments.

"Only the different actors' determination to co-operate allows for damage reduction in the public interest. Non structural flood plain management concerns every one of us."

The report at hand presents general potential measures and assesses them with the aim of reducing flood damage hazards in different situations. It presents current means of reducing potential flood damage. It can however not replace detailed vulnerability analysis and its findings as to whether and which additional measures must be taken.

Prerequisites for non structural flood plain management measures

Knowing about the danger, including all important parameters, such as probability, kind and extent of impact is a prerequisite. This knowledge must be imparted convincingly on all actors.
Flood hazard maps point out areas at risk and are necessary for planning. Flood marks placed in the landscape remind the public of the danger.
Information and education must keep alive flood awareness.
Priority and dimension of measures are determined by the **extent of potential damage**. No measures without damage potential.

Forecasts

High-quality forecasts enable a higher valent use of areas at risk.
Even in cases of short warning lead times forecasts are particularly effective in protection for persons.
They do not develop their full effect unless in connection with planned measures and corresponding exercises.

Protection for persons

Losses of life and limb are in particular due to wrong conduct. It must be possible to quickly reach safe refuges. It is indispensable to repeatedly inform about the risks and the possibilities of escape.
With today's technical means and if there is sufficient time, **the rescuing of persons** is possible even in very difficult cases.

Land use control

On the long run, **spatial planning instructions keeping areas open** will avoid an increase in damage potential and give sufficient room to the river in order to reduce or avoid the flooding of settlement areas.
Building codes and zoning ordinances in spatial planning or development master plans are a means of having proprietors accept appropriate ways of construction. They are necessary for protecting persons and in order to prevent environmental damage or damage to third persons. They have long-term effects.

The damage risk
Generally, damage risk is understood to be a linking of damage probability and extent of damage.

Influencing damage risk
Since the 19th century, the risk of flooding is almost exclusively influenced by reducing the probability of an event by means of hydrological defences.

Understanding of measures limiting the extent of damage by appropriate use or construction was lost or repressed. The report at hand aims at pointing out possibilities of limiting flood damage under present day conditions.

Choice of measures
The choice of measures is mainly determined by the impact, that is flood depth. Its socio-economic justification is a result of flood probability, expenditures for measures and prevented damage.

3 Executive summary

Flood proofing constructions

Appropriate construction combined with different temporary measures in property protection is the only means of reducing the existing damage potential in settlement areas without basically changing their use.
Flood proofing of property is designed to reduce or prevent damage to individual property. If water is kept out by removing property at risk to higher areas or by local flood walls, effectiveness may reach 100 %. 50 – 75 % effectiveness are reached if the building is sealed and 10 – 30 % if interior fittings are not sensitive to the impact of water. Such measures may be taken during restoration subsequent to a flood, large-scale re-arrangements or in new buildings.

Oil heatings represent a particular risk. If these are protected, damage to buildings may be reduced by 50 to 65 %.
Damage to industrial and trade buildings is about double as high as that to housing. Sealing and shielding are particularly effective as both measures also contribute to limiting disruption to business. Damage caused by disruption to businesses may exceed direct damage.
From a **flood depth of two metres** on, measures of flood proofing property are effective in few cases only.

Flood preparedness

The **planning of potential actions** adapted to warning lead time is a prerequisite for correct conduct in case of floods.
All depending on the warning lead time, **removing or moving furniture** from or in housing estate may reduce damage to furniture and equipment by 20 to 80 %. The warning lead time should at least cover 4 hours.
The removal of equipment in industry and trade requires a well co-ordinated organisation which is particularly effective due to the great assets concerned, short periods of disruption to business and avoided supply shortages.

Emergency planning

If flooding may be avoided by implementing **emergency measures**, the cost-benefit ration will be very favourable.
In case of extreme flooding, **emergency spillways** permit to flood surfaces with a lesser damage potential. They must be part of disaster control plans.
The individual's **financial prevention** comes in the first place, state contributions to secure the individual's economic position come in the last place. Between these two positions the state may set up an insurance system. Insurance spreads the damage to a risk community so that it remains within the individual's means. Recommendations and appropriate insurance coverage may encourage damage prevention. However, the rate of premium and the enforcement of damage prevention depend on the peripheral conditions of the insurance system.

Furtherance of implementation

Information and recommendations do not pose any legal problems. Their success depends on experience and – where there is none – on the persuasiveness of arguments. Experience, be it one's own or that made in adjacent areas, must not be lost.

Appropriate insurance benefit or subsidies may provide **financial incentives.**

Regulations are required if persons are at risk or if there is a risk of damage to the environment or to third parties. Often, ill-funded regulations have no effect.

Targets of the study of effectiveness

Use of the study of effectiveness
The study of effectiveness gives an overview of measures aimed at limiting the extent of damage in flood prone areas. The real effectiveness of measures depends on the local situation. If warning lead time is short, little can be done in case of flooding. In case of great flood depth (beyond 2 m) there is only a limited number of measures at hand. If personal experience may be drawn upon, particularly in areas with frequent flooding and limited surface water elevation, damage may be reduced decisively. Therefore, every region is requested to evaluate those measures presented in the study at hand which have proved to be efficient.

The Action Plan on Floods provides for a 10 % reduction of damage risks by the year 2005 and a 25 % reduction by the year 2020. This quantitative standard for the reduction of risks presupposes a quantitative assessment of the effectiveness of measures in the fields of spatial planning, urban development, flood proofing of property, emergency planning, increased protection of core areas, forecasting, warning lead time and information of the population. The assessment of the effectiveness of the above mentioned measures is the main question of the study of effectiveness and may be put as follows:

"Which measures may reduce flood related damage risks under which peripheral conditions and by how much?"

Approach

Work on the study of effectiveness is structured as follows:

- Analysis of the present situation with respect to natural land, legal sphere and socio-economic peripheral conditions
- Analysis of current development tendencies with respect to measures related to flood plain management and spatial planning
- Analysis of damage events with respect to risks posed to individuals and material damage with a view to assessing the possibilities of taking influence on these factors
- Point out possibilities of limiting damage with the help of case studies, individual measures or a combination of both.

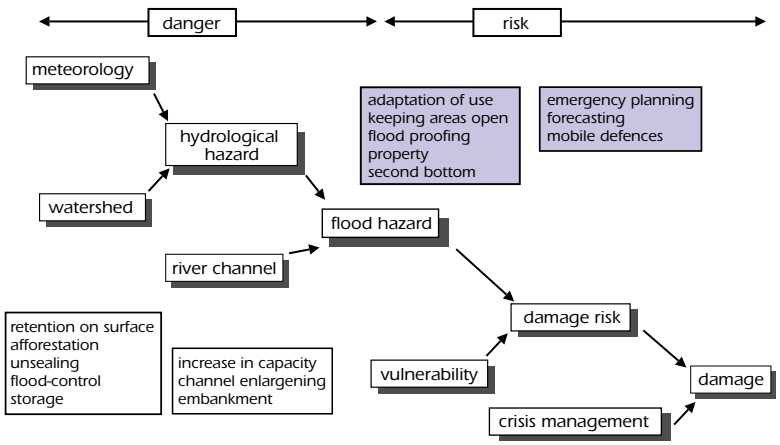
Processing

The summarising report in hand lists the most important findings on the possibilities of limiting damage. It is based on the reports listed in the imprint drafted between 1999 and 2001 and thus summarises experience made in the Netherlands, Germany, France, Belgium and Switzerland.

Classification

Flood damages may be influenced by a number of measures. Classical flood protection comprises measures taken in the watershed and along the main stream and thus reduces the probability of flooding. Additionally, flood preparedness comprises measures aimed at reducing the damage potential due to appropriate use and emergency planning.

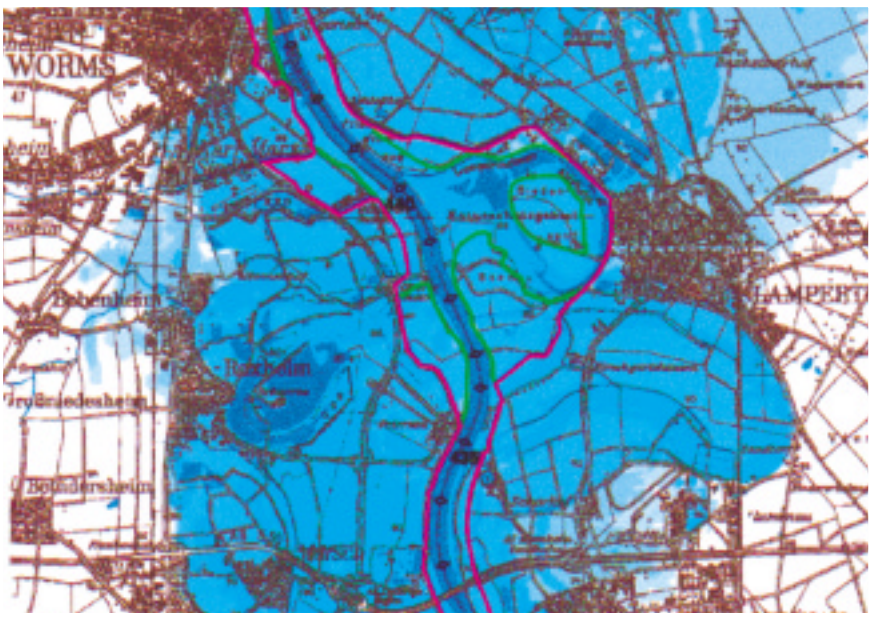
The diagram illustrates the chain of damage generation. The report at hand is limited to those measures aimed at reducing damage risks which are represented in the diagram.



"Hazard recognised is half the hazard."

Hazard understanding

Often, existing flood hazard is hard to make out. This problem is all the more critical in cases of technical flood defences simulating completely effective protection. Furthermore, as a result of today's mobility, inhabitants have no longer experienced the threat posed by water bodies and do not know how to cope with it.
Where flood experience exists, knowledge about the hazard often does not reach all persons at risk in the area. The flood hazard maps pass on this knowledge and include historic as well as potential future events. Flood hazard maps are at the basis of considerations and determinations in land use control, flood proofing of constructions and flood preparedness. As far as flood fighting and disaster control are concerned, results for different scenarios and different time scales for the propagation of flooding should be available. The duration of flooding and warning lead times are of interest for measures of preventive construction and conduct.



ICPR flood hazard maps

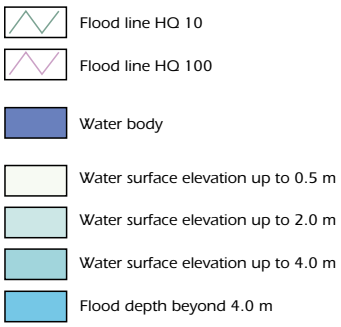
The ICPR flood hazard maps illustrate the envelope of a flooding of different probability and the water surface elevation of very rare events. With today's possibilities of computer modelling it is possible to draft large scale flood hazard maps. Formerly, it was only possible to estimate the hazard due to evident marks in the terrain or receded flooding. Today's calculation programmes help to determine surfaces hit and flood depth. Locally, flood velocity and flood direction may be determined for any location and any time of flooding. Model calculations are verified against historical considerations and show that every flooding has its very own development.

Danger assessments determine the potential risk. Flood hazard maps spatially represent this hazard. They are meant to inform all actors involved and are at the basis of measures of spatial planning.

Hazard understanding
Hazard understanding is knowing about the factual existing hazard.

Flood hazard maps
Actors are made aware of the hazard by means of flood hazard maps. These maps pinpoint the type of hazard and its degree.

Legend of the ICPR map



Specialised maps
Specialised maps at a larger scale are of basic importance for designing measures. The intensity of flooding may be represented for different return periods by degrees of shades. With the help of this information optimised protection concepts may be developed, integrating all elements of flood protection and weighing them up.

Understanding with the help of computer simulation

“Live with flooding.“

Hazard awareness

Hazard awareness
To be aware of a risk means to have recognised it, to know about it, not to forget or to repress it and to take it into account appropriately when acting.

People must recognise flooding as part of their environment. Inhabitants must be aware of being at risk. If they themselves have not yet experienced flooding, knowledge about the risk must be passed on with the help of the flood hazard maps. Locally, flood marks on buildings and signs have proved to be very helpful.
If there is no hazard awareness, incentives will not be of any help.

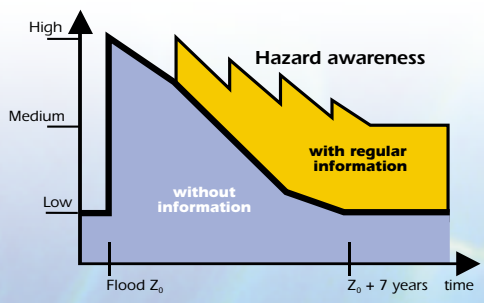
In Basel, building insurance companies and authorities in charge of civil defence offered people living in the at risk areas to secure oil tanks free of charge. Hardly anybody accepted the first offer. On the other hand, mobile defences put up solely upon the initiative of the inhabitants of the village of Boll (CH) after the flooding in 1986 and 1987 were still in a good condition and ready for operation in 2001.

It is particularly hard to keep alive flood awareness behind dikes.

On the long run only great disasters – like that of 1953 in the Netherlands – are remembered. Using mobile flood walls at least partly instead of embankments, as is the case in Cologne, keeps alive flood awareness.

If nothing points towards a flood risk, flood awareness is reduced to a minimum within 7 years after a flood event. The population at risk will again be unprepared for and thus surprised by the next flooding.

Shortly after a flooding, persons hit are highly aware of the risk. Without flooding, awareness of the latent hazard diminishes. Regular information may keep alive acute hazard awareness.



It is above all the individual’s flood experience which raises hazard awareness. If there is no individual experience or if this dates back too long, flood marks, flood signs or regular information must remind of the risk.

"Take account of the forces of water."

Impact parameters

Types of hazard

Static flooding is characterised by low flow velocity (below 1 m/s). Its impact is a result of hydrostatic pressure rising with increasing flood depth.

Dynamic flooding is characterised by medium to high flow velocity (above 1 m/s). The impacts to be taken into account are the hydrostatic as well as the hydrodynamic force of flowing water.

River bank erosion is due to relocation of the water course or to slipping of terrain. It poses a threat to buildings because of direct aggression by flow velocity or by loss of stability.

A **rise of ground water** poses a threat to buildings due to static flooding. It is a result of flooding, even if water does not break the banks.

Impact parameters

Flood depth determines the vertical zone of influence above ground level. Normally, flood depth rises continuously, reaching its maximum during or shortly after the flood crest. If the flood event is comparable to the development of a flood wave in the mountains, in case of dike breaches or flood waves, the maximum flood depth is reached on the onset of the flooding.

The **duration of flooding** begins with moistening and ends with the drying up. Along the Upper Rhine it varies between some hours and several days. In the Rhine delta, flooding may last for weeks.

In steeper terrain (5 – 10 %), **flow velocity** lies between 3 and 5 m/s if flood depth exceeds 0.5 m. Such high velocities also occur along canalised stretches (streets). In more flat terrain (less than 2 %) flow velocity is generally reduced to less than 2 m/s. In case of dike breaches, very high flow velocity is reached near the breach itself.

Velocity of water rise describes how fast water rises during a flood. This parameter determines the threat posed to persons in and outside of buildings. A high velocity of water rise may particularly be expected during flooding caused by debris damming (flume blocking and the following local flooding) or following a dike breach.

The type of threat posed by a flooding and its quantitative impact must be known in order to be able to take measures.

Types of hazard
Measures must be adapted to the type of hazard and the individual impacts.

Static flooding

Dynamic flooding

River bank erosion

Rise of groundwater

"Man's life is at risk if he is surprised by the event, if he believes to be in a secure place or if he is unable to reach a place of refuge in time."

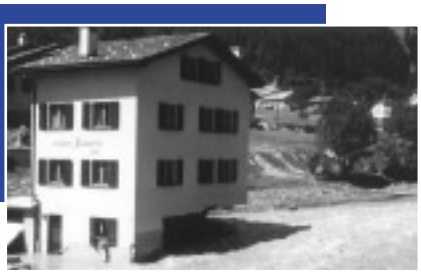
Vulnerability

Danger to life
The threat posed to the life of people depends on the intensity of impact, the location and the conduct of people during a flood event.

Threat posed to people in the open air

Threat posed to people due to flooding of buildings

Threat posed to people in the basement of buildings



Threat posed to people due to the collapsing of buildings

Influence of the impact

The **quicker water levels rise,** the less time there is for seeking refuge in a safe place. High **water surface elevation** reduces the number of safe refuges. High **flow velocity** makes it more difficult or even impossible to cross already flooded areas. Pressure of the current and underwashing of foundations may make buildings collapse.

Great flood disasters comparable to that of 1953 in the Netherlands (1800 casualties) or that of 1962 in Hamburg (315 casualties) are caused by widespread floods at great depth, when houses completely disappear below water or are destroyed and safe refuges are too far away.

In Switzerland, where widespread floods at great depth have not been experienced, large numbers of casualties result from the destruction of buildings following the impact of considerable dynamic forces (e.g. October 2000, 15 casualties).

Influence of conditions of exposure

In the **open air,** people are exposed to the impacting forces without any protection. Darkness and cold reduce the possibilities of orientation and of keeping above water for a longer time. With lacking experience, the impact of flow velocity is mostly underestimated.

On **camp sites,** people are protected as little as in the open air. To aggravate the situation, in a tent, a caravan or any comparable provisional accommodation the hazard is not recognised as such and at night people may be taken by surprise.

Staying in a vehicle may turn out to be mortal, as buoyancy is underestimated and a car may already be carried away at a flood depth of 50 cm.

A **building** is a safe refuge if it has accessible storeys above the maximum flood depth and if it remains stable. Often, people staying in basements (e.g. underground garages, storerooms, salesrooms) cannot recognise the hazard and escape towards other storeys is blocked by water entering the building.

24 casualties were deplored following the heavy floods of November 1999 in southern France. 10 of the persons affected died in cars, 9 in buildings and 3 were pedestrians. 8 out of the 9 casualties in buildings were senior citizens.

There is danger to life when buildings no longer protect and people are taken by surprise in the open air or in vehicles or if they misjudge the hazard or their own vulnerability.

"Know about safe refuges – hold rescue exercises."

Self protection/assistance

Self protection

Recognising the hazard and adequate conduct are the best measures of self protection in case of imminent flooding.
When staying in buildings, the following should be avoided shortly before or during floods:

- Senior or handicapped citizens should not stay in parts of the building lying below the maximum flood depth (southern France 1999, 10 casualties)
- The use of rooms without any possibility of escaping to higher floors (Brig CH 1993, 2 casualties)
- Use of basements and underground garages (Boll, CH 1987, 1 casualty)
- Use of elevators (Augsburg D 1999, divers rescued 1 person)

When staying in the open air, it should be avoided:

- to stay on bridges and embankments during a flood
- to camp in the course of flood water discharge (Savoie 1987, 23 casualties)
- to drive on flooded roads (Switzerland, 1987, 3 casualties, southern France, 1999, 10 out of 24 casualties)
- flood tourism

In Switzerland, misconduct played an important role in 40 % of the 67 casualties due to floods registered between 1972 and 2001.

Protection for persons
Protection for persons is based on information about the actual flood situation and required preventive measures of conduct of people at risk.

Evacuation plan for Hamburg

Continuation: Self protection/assistance

Assistance

Assistance

Effective assistance begins before the onset of flooding and is accomplished upon the onset of flooding. In the regions where the source of the water body is located warning lead times are very short and assistance may partly begin after the onset of the flooding, so that its effectiveness is much more uncertain.

In the Netherlands, the evacuation of 200'000 persons showed that

- citizens may only be convinced of the necessity of evacuation by means of clear and uniform information policy to be co-ordinated between the different regional decision making bodies and with the media.
- preparations must begin in good time before the onset of the flood event and that local organisation plays an important part.
- some people are hard to convince of the necessity of leaving their homes.
- everybody must be evacuated and it must be demonstrated that protection of material assets against theft and vandalism is granted.
- a large number of persons gains the indicated refuges on their own or have their own organisation.
- most assistance is required for handicapped people, people in need of help and children.
- returning to the homes hardly requires any particular organisation.

If warning lead times are short, refuges must be found in the vicinity of the people at risk. On the basis of the corresponding information they must be able to reach these refuges on their own (e.g. evacuation plan for Hamburg). In cases of longer warning lead times, large scale evacuations of people and livestock may be prepared (e.g. Netherlands).

"Wetting or dirt cause the damage."

Vulnerability of uses

Type of use

Vulnerability with respect to material damage caused by the impact of flooding continually rises in the following order: agriculture, settlement, trade, industry. There are direct and indirect damages to use:

Direct damage

Damage is caused by the direct impact of water and the substances it transports. Wetting and dirt induce partial to complete depreciation of building structures (floors, walls, ceiling), installations and goods kept in the buildings. In individual cases, even its statics may be affected (buoyancy, erosion, etc.). Increased duration of flooding leads to dissemination of humidity above the maximum flood depth. This must in particular be considered in cases of longer flood duration. The odorous substances transported by water contaminated by oil or faeces may lead to total losses of buildings. Solid particles penetrating electric or mechanic machines generate breakdowns and may often not be eliminated at a reasonable price. In particular computers and computer controlled installations are at risk.

Indirect damage

Indirect economic damage comprises disruption to businesses and infrastructure (supply and cleaning up), expenditure for temporary arrangements and market losses suffered. In particular in trade and industry it is liable to exceed direct damage.

Direct and indirect damage to different categories of use may be summarised as follows:

	Direct damage	Indirect damage
Crafts, trade, industry	Loss of material, tools, stock Loss of furniture and archives	Expenditure for cleaning up Expenditure for moving Loss of exploitation
Farms	Damage to annexes Loss of material, tools, stock Loss of livestock and harvest	Loss of exploitation Loss of production
Individual housing	Damage to real estate Loss of furniture and assets	Expenditure for rehousing Expenditure for cleaning up
Public services and network	Loss of real estate Loss of equipment	Expenditure for cleaning up Expenditure for organising rescue and substituting services
Cultural heritage, environment	Damage to cultural heritage (incomplete evaluation)	Expenditure for restoration work
Local economy		Drop of finances, future income, value of real estate

Damage due to wetting

Damage due to dirt

Damage due to disruption to business

Damage results from the conflict between nature made flooding and human usage. The type and extent of damage continuously changes with development in society.

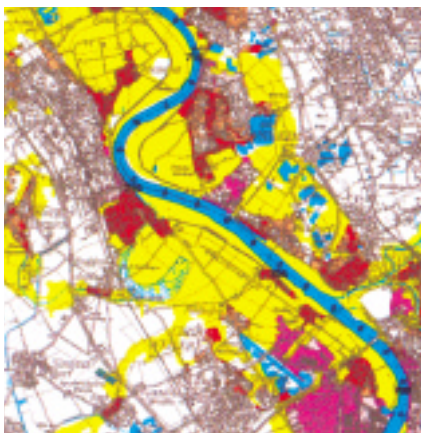
"If there is no potential damage, there is no need for action."

Potential damage

Potential damage
The potential damage is the sum of possibly damaged assets in the area at risk. It is to be distinguished from the damage caused by a flood event covering the real damage and taking into account the real strain as well as the implemented measures.

Damage functions
Damage functions describe the relationship between the intensity of flooding and the damage. The damage functions applied in the different countries are represented in annex. They may differ by a factor of 2 to 5.

Potential damage due to extreme flood events: ICPR atlas



Legend

- Flood damage to infrastructure and traffic up to 25 000 €/1000 m²
- Flood damage to infrastructure and traffic above 25 000 €/1000 m²
- Flood damage to settlement up to 5000 €/100m² housing
- Flood damage to settlement above 5000 €/100m² housing
- Flood damage to agriculture

Cost/benefit comparisons
On the basis of on-site property analysis and detailed maps of flood hazard, sound cost/benefit comparisons may be made for preventive measures.

Determination of the existing potential damage

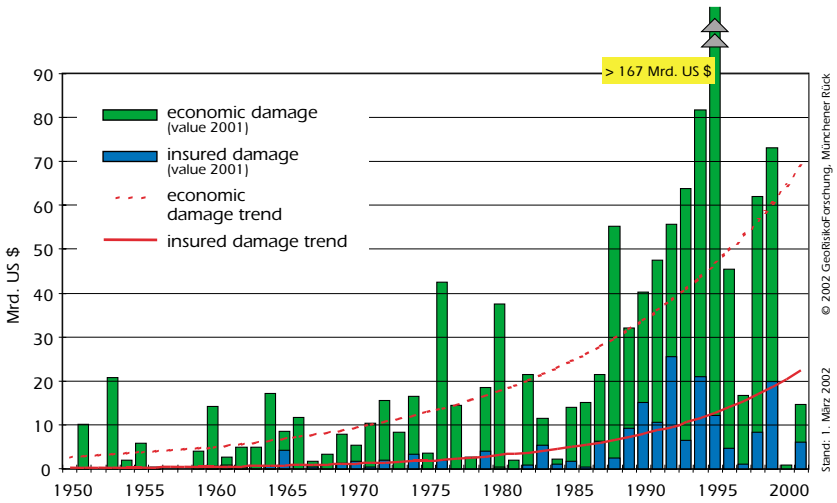
Potential damage must be determined in order to assess the necessity and effectiveness of measures to be implemented.

Large-scale determination:
For different types of use per surface unit or type of building average values and a degree of damage (damage function) depending on flood depth are determined and summed up for the surface at risk.

Focal points of action for supra-regional considerations are determined on the basis of large-scale maps of damage potential.

Small scale determination:
On a small scale, damage potential is determined by applying damage functions and by an on-site analysis of buildings. The advantage is that water levels at which damage begins (damage threshold) are recognised and that the real damage to the storeys of buildings is estimated. Small scale determinations are useful for in-detail planning, in particular with respect to preventive construction measures.

Development of damage potential
Great natural disasters between 1950 and 2001



Insurance companies report of constantly rising damage sums. This development is caused by a constant rise in value added and increased building density. Additionally, increasing vulnerability raises the extent of damage as people rely on increased security due to flood defences, and do not adapt constructions and usage to the existing risk.

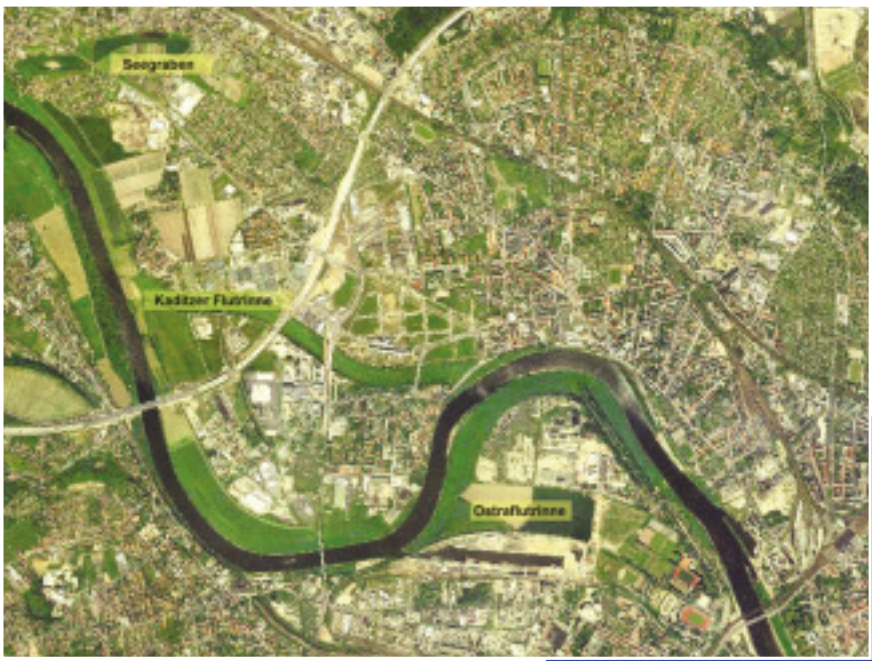
Effectiveness of preventive measures
In this report, the effectiveness of damage limitation always refers to a starting point without any preventive measures. Long-term measures, such as keeping surfaces clear are described with respect to their qualitative effect. If necessary, effectiveness is indicated as depending on relevant factors of influence.

"Give more room to the river – without damage potential no damage."

Keep areas open

The most efficient measure aimed at limiting potential danger is to avoid development. If built-up areas steadily increase in flood risk areas, the extent of damage will continue to rise, even if new constructions are adapted to the risk. Besides avoiding damage, keeping areas open aims at

- storing flood water
- evacuating flood water.



The example of Dresden gives an impressive example of how the strategy of keeping the flood plains open gives the required room to the R. Elbe. Due to population density throughout Europe, it is so far rare that settlements in the vicinity of rivers are re-located at a later date.

Following the great floods of the Mississippi in 1993, population transfer was subsidised by the state.

Keeping areas open must not necessarily mean that they are kept out of any kind of use. All depending on the frequency of flooding, they may be used for agricultural or recreational purposes. In cases of disaster, areas with low damage potential are useful for draining off and short-time storage of waters in excess.

Effectiveness
Keeping areas open avoids increased development in flood prone zones. There is thus no further increase in potential damage. Efficiency is greatest in areas with high probability of flooding.

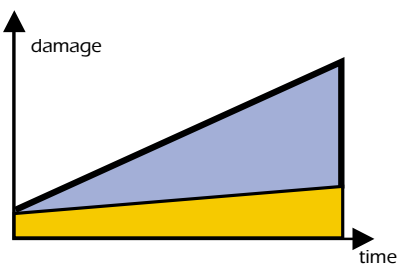
Land use control
Land use control is at the basis of all measures aimed at managing damage potential. It may guide the extent and type of development. If consequently applied, the effectiveness of this tool develops over a longer period.

Example Dresden
Consequently keeping the flood plains of the Elbe free from development over the centuries

Use of the open areas
Open areas may be used for recreational purposes or temporary leisure-time activities.

Hydraulic pressure on open areas
The hydraulic pressure on open areas used in settlement areas should not exceed the following threshold values:
- 1 m flood depth in gardens
- 0,3 m flood depth on parking areas
- 0.2 m flood depth and 2 m/s on roads
- 0.2 m depth and 1.5 m/s on squares

Reduction of damage potential by keeping areas open
If areas are kept open (yellow), the increase of damage is marginal; in developed areas it increases considerably.

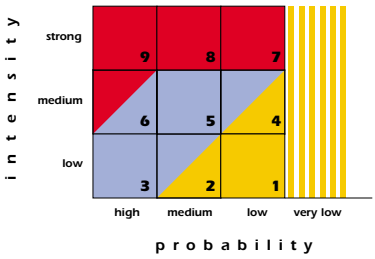


"Building projects and projects of zoning must be adapted to the risk."

Building codes and zoning ordinances

Levels of danger
In France and Switzerland building regulations are issued according to levels of danger. The level of danger is defined as a function of intensity and probability.

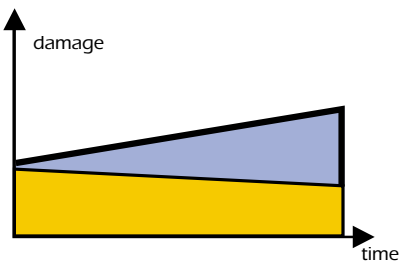
Swiss levels of danger
Red: high level of danger
Blue: average level of danger
Yellow: low level of danger



Zoning ordinances
Zoning ordinances are common in cases of risks posed to persons or to third parties and the environment.

Building codes – Codes concerning the level of entrances

Reducing an increase in damage potential by building codes and zoning ordinances
On the long term, building codes and zoning ordinances entail a reduction of damage (yellow) compared to uninfluenced growth.



Building codes and zoning ordinances demand that planned constructions be adapted to the existing risk. The target is to limit damages to third parties, to the environment and the extent of damage in case of flooding.
The extent of the regulations depends on the degree (level) of danger and required protection of the construction. Authorities may fix more or less strict regulations all depending on the level and frequency of danger as well as on the need to protect the constructions.
In different countries, the following levels of danger have proved to be useful:

- **Low risk:** There are no restrictions to the use of constructions requiring normal protection. The limited risk is pointed out and protection measures are recommended. Measures aimed at property protection must be taken for buildings presenting an increased need of protection.
- **Average risk:** the necessary measures of property protection must be taken for all new and renovated constructions.
- **High risk:** New development is prohibited. Existing constructions may be maintained and kept up to date. Authorities reserve the right to oblige the owners to take necessary flood proofing measures.

The risk of flooding is not always as plain to the building client or developer as illustrated by the photo below.

Effectiveness
New or renovated constructions are adapted to the existing risk of flooding. Increased damage is only a result of increased development in potential flooding areas. If, due to flood proofing measures taken later on, a damage reduction of 25 to 50 % may be achieved per building and presuming replacements or renovations every 30 to 50 years, it is possible to reckon with an annual reduction in the progression of damage potential of one to two per cent, even in developed areas.

"Combined with appropriate use and equipment the controlled flooding of buildings is a measure aimed at limiting damage."

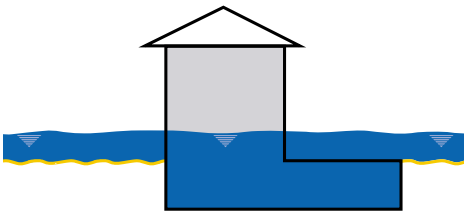
Flood proofing homes – wet flood proofing

If not influenced by preventive measures, flood damage in settlements holds about equal shares in damage to equipment and to buildings. 40 % of damage to equipment concern furniture and fixtures, the remaining 20 % are shared by doors and electrical equipment. 36 % of damage to buildings concern walls, ceilings and their panelling, followed by damage to floors and floor coverings and damage to heating systems with 27 % each. The remaining 10 % of damage concern electric installations and windows. The following illustration points out the effectiveness of wet flood proofing.

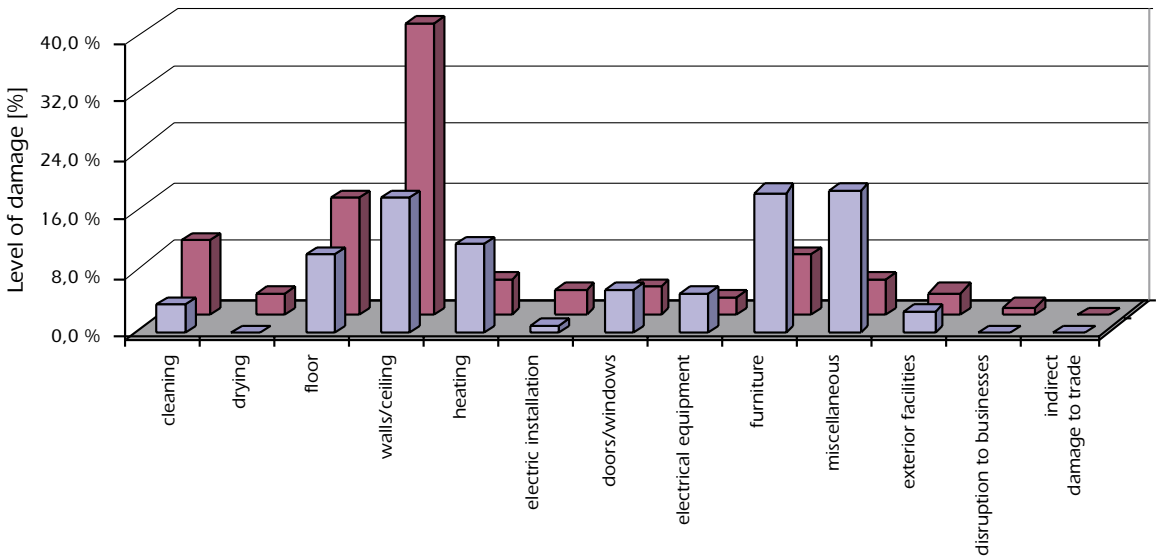
About 40 % of the total damage caused by the Kraiburg flooding concerned furniture, heatings and further installations while the example of Braubach (appropriate use and equipment) shows a reduction of this category of damage to 15 %.

Flood proofing constructions
Measures of flood proofing constructions aim at minimising damages by means of appropriate use and equipment of buildings (wet flood proofing) or by means of sealing, reinforcement and shielding (dry flood proofing).

Wet flood proofing



Focal points of damage
RED: Prepared and partly appropriate (Braubach 1988)
BLUE: Unprepared (Kraiburg 1985)



Continuation: Flood proofing homes – wet flood proofing

Elevated gas supply installation

Appropriate use

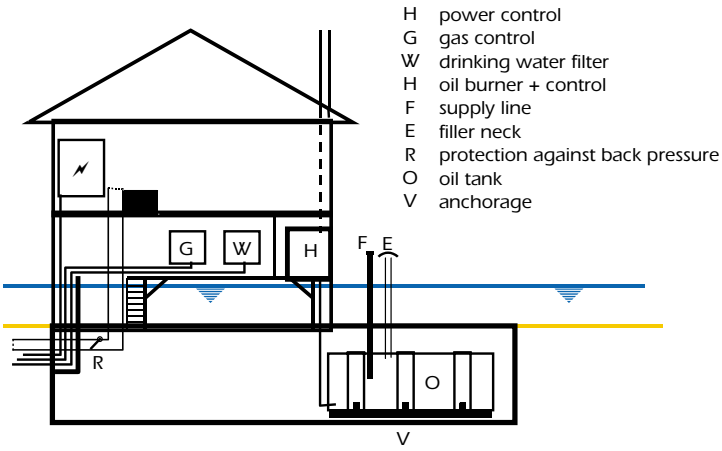
In existing buildings, reduction of damage is achieved by refraining from vulnerable uses of rooms located below flood depth. In new constructions, damage is reduced to a minimum if the building's concept of use thoroughly takes into account the risk of flooding. The following measures may be taken:

- Renouncing to cellars or basement storeys may reduce the average total damage by 3000 to 6000 €.
- A flood-proof equipment of the oil tank or choosing a gas heating instead of an oil heating may reduce subsequent damage by up to 50 % or more.
- Mounting master switches and distributors above flood depth allows to use upper floors even during floods.

Appropriate equipment

Ideally, the use of as water repelling or resistant material as possible will only lead to expenditures for cleaning and drying up amounting to 1.500 to 3.000 €. In winter time, expenditure for drying up elder buildings may amount to the 3 to 5fold of the indicated sum.

Concept for supply facilities



Reducing damage potential by appropriate use

0-25%	25-50%	50-75%	75-100%

Reducing damage potential by appropriate equipment

0-25%	25-50%	50-75%	75-100%

Effectiveness

The appropriate use of rooms at risk of flooding may reduce the damage potential by 30 to 40 %. The use of water resistant materials for buildings and their installations may reduce the damage potential by 15 to 35 %.

**"As long as the building resists to the water pressure,
the sealing of buildings figures among the most efficient measures."**

Protection of housing – Sealing

Sealing measures

The effect of completely sealing buildings is that their interior is protected against the impact of water. Damage is limited to a dirty and wet shell.

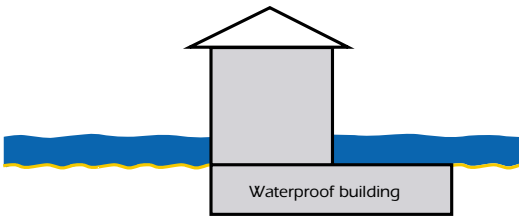
Existing buildings:
If the shell and the cellar are waterproof, sealing only concerns the openings of the building. In this case, waterproof doors and windows may be installed and, in case of sufficient warning lead time, mobile stop logs and emergency measures (sand bags, foil, etc.) may be taken.
If the shell of the building is not waterproof, it may be sealed by using stop logs or a foil. The additional permanent sealing of buildings whose cellar is not waterproof brings about considerable expenditure and effort, as the entire building must be uncovered.
Should the cellar not be sealed, smaller quantities of water may be pumped out permanently so that only wet walls and a wet cellar floor must be dried and cleaned. If the cellar proves not to be protected against buoyancy it must be partly or entirely flooded with clean water so as to secure stability.

At all events, sufficient attention must be paid to the risk of buoyancy and back pressure from sewerage.

New constructions:
New constructions may be waterproofed by tanking. Either waterproof concrete tanking with concrete tanked slab and waterproof interstices or constructions with a waterproof skin (bitumen sealing) are used.

Example of the business premises of the "Seehof" in Luzern, Switzerland
The business premises of the Seehof in Luzern consists of four basement storeys and 4 upper floors. All technical installations of the house (distribution of electricity, ventilation system, water and sewerage as well as the oil heating and its tank) are located in the basement storeys. A flooding of these storeys would cause a several months disruption to businesses in the entire group of buildings. When the premises were built, sealing measures took account of the risk of flooding. In case of flooding, the lower lying entrances (access to the underground garage, etc.) are protected by mobile defences. Investment in property protection measures amounted to some 0.15 million €. Thanks to these defences, a potential damage equivalent to some 9 million € was avoided during the flooding in 1999.

Dry flood proofing: sealing



Sealing the shell of buildings (mobile)

Continuation: Protection of housing – Sealing

Sealing openings (mobile)

Sealing openings (permanently) by water resistant walls

Reducing the damage potential by sealing

0-25%	25-50%	50-75%	75-100%

Effectiveness
A waterproof cellar reduces total damage by about 75 to 85 %. If the cellar must be flooded, effectiveness lies between 10 and 40 %. If penetrating waters are pumped, damage reduction amounts to 50 to 60 % as long as only the cellar is concerned, and to 60 to 70 % if the cellar and the ground floor are concerned. In areas with great flood depth this measure may only be applied to a very limited extent.

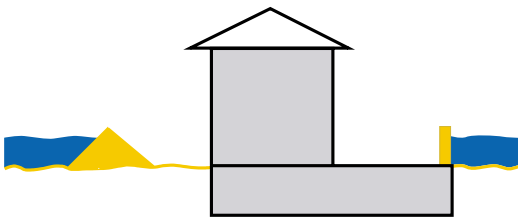
"As long as flood depth may be controlled, shielding of buildings achieves the most far reaching damage reduction among the measures aimed at protecting housing."

Protection of housing – Shielding

Shielding

Shielding keeps water away from the building and may influence the spreading and intensity of flooding. Shielding must not increase risk posed to properties in the vicinity.

Dry flood proofing: shielding



Elevation

Elevation is a very efficient and cheap possibility of protecting new buildings. The following possibilities may be envisaged:

- **Mounting on supports:** leaves vast possibilities for creative development and the space under the building may be used as parking area.
- **Mounting on walls:** extends the building's possibilities of use.
- **Mounting on dams:** is particularly cheap in cases of slopes nearby and makes sense if groundwater levels are high.

Permanent or mobile flood walls

The construction of an embankment or a wall is a permanent measure. Access may be granted by a ramp or a waterproof gate.
Constructions which may be lifted or tipped up figure among the possible temporary measures. In case of longer warning lead times, mobile systems using stop logs, embankments consisting of sand bags or a combination thereof may be applied.
In all cases of flood wall shielding, damages caused by **groundwater** occur, as long as no particular measures against this type of risk are taken.

Elevating light constructions

The example of the flooding of 1999 in the canton of Bern points out the differences between a flooding and damage caused by groundwater.

Type of danger	Number	Damage in CHF		Degree of damage in %	
		Mean value	Median	Mean value	Median
Flooding	214	62'000	39'000	10.1	6.9
Groundwater	837	19'000	9'000	3.3	1.4

Constructing protection dams

At all events, the danger of buoyancy and back flow from the sewerage system, from return seepage and groundwater must be sufficiently considered when flood barriers and flood walls are used.

Continuation: Protection of housing – Shielding

Example Cologne Rodenkirchen
During the flood of 1999, mobile flood walls consisting of aluminium supports, pallets and foil protected the district of Rodenkirchen from flooding. Within 5 hours the construction was put up by 18 persons along a stretch of 500 m. Due to its flexibility, manageability and lightness this system may also be used in settlement areas.

Raising protection barriers (mobile)

Reducing the damage potential by shielding

0-25%	25-50%	50-75%	75-100%

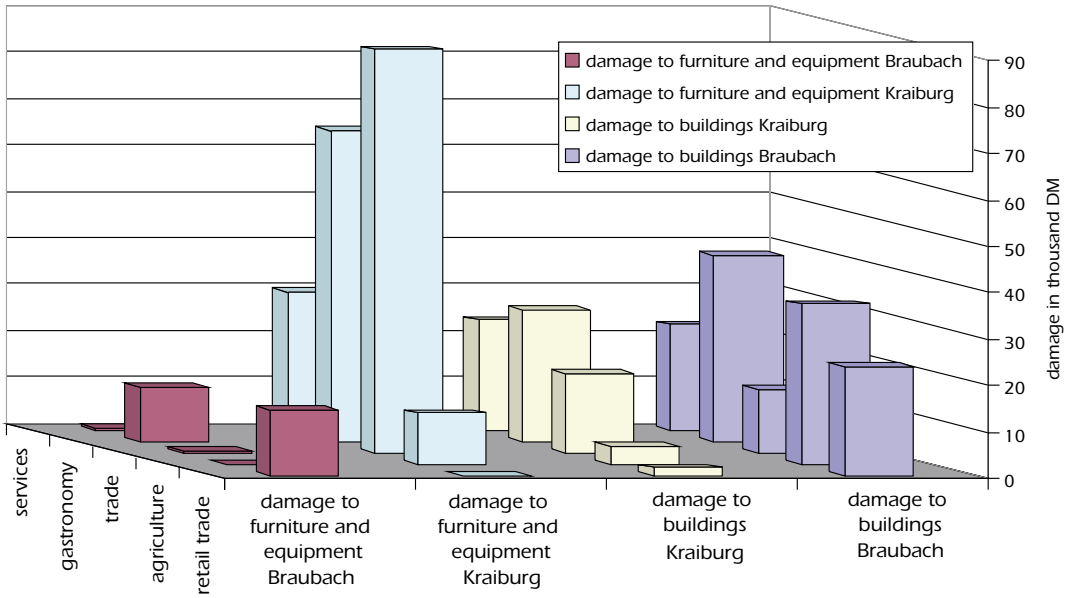
Effectiveness
Shielding may reduce damage by 60 to 80 %. The remaining damage and thus the total degree of effectiveness largely depends on the damage potential in cellars. If these are sealed, effectiveness almost obtains 100 %. This measure may only be used to a very restricted extent in areas with high water surface elevation.

"Damage to trade and industry is considerably higher than that to settlements and influences the running of the business or even its survival."

Flood proofing property in trade/industry

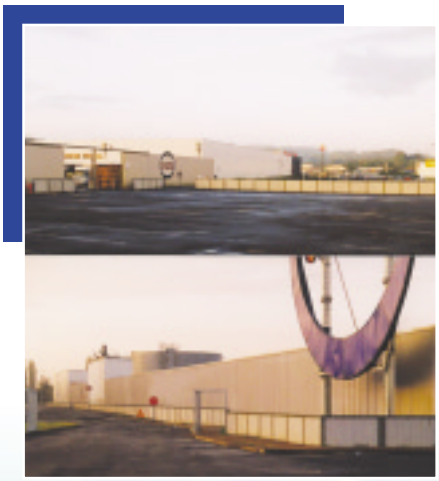
Flood proofing of buildings in industrial estates and areas

Normally, in trade, damage to furniture and equipment as well as damage caused by disruption to business outstrips damage to buildings. The effect of preventive measures is particularly visible in case of damage to furniture and equipment. In Braubach (prepared for flooding) damage to buildings was comparable to Kraiburg (unprepared), but damage to furniture and equipment was considerably higher in Kraiburg.



However, differences in the level of damage in trade and industry are great – even with respect to damage to buildings. The comparably great damage suffered by gastronomy is striking.

In trade and industry measures of flood proofing constructions are very varied and differ according to the sector or line of business concerned. Damage caused by disruption to businesses may be shortened by effective preventive measures, but it may hardly be avoided. In certain cases it may make sense to provide for a temporary relocation of production or to manage stocks thus that an eventual disruption to production is calculated with.



Flood wall shielding (Meuse, F)

Continuation: Flood proofing property in trade/industry

Protected petrol station in Vallendar

Protection of a petrol station in Vallendar
During the flooding of 1993 and 1995, flood depth in the petrol station was measured at 1.3 m for a fortnight. As a consequence, the operator reconstructed the entire installation.

- Mobile defences protect the shop.
- The number of discharge points of supply lines on the premises of the petrol station was reduced
- Separator settling tanks for petrol and fluid liquids proof to water pressure were installed
- Water resistant construction material easy to clean was used for the building
- Flood pumps were installed in the outside area
- The heating was installed at an elevated level.

These measures will help to reduce future damage by 80 % compared to the damage caused in 1993.

Protection of energy supply (installation in upper storeys)

Reducing the damage potential by flood proofing property in trade/industry

0-25%	25-50%	50-75%	75-100%

Effectiveness
In trade and industry measures of flood proofing constructions achieve a damage reduction of 25 – 100 %. The choice of measure largely varies according to the building and the equipment and furniture at risk.

"Safe storage of oil and of substances hazardous to the environment reduces the extent of damage by half and avoids damage to the environment."

Hazardous substances

Housing: Damage caused by leaking heating oil

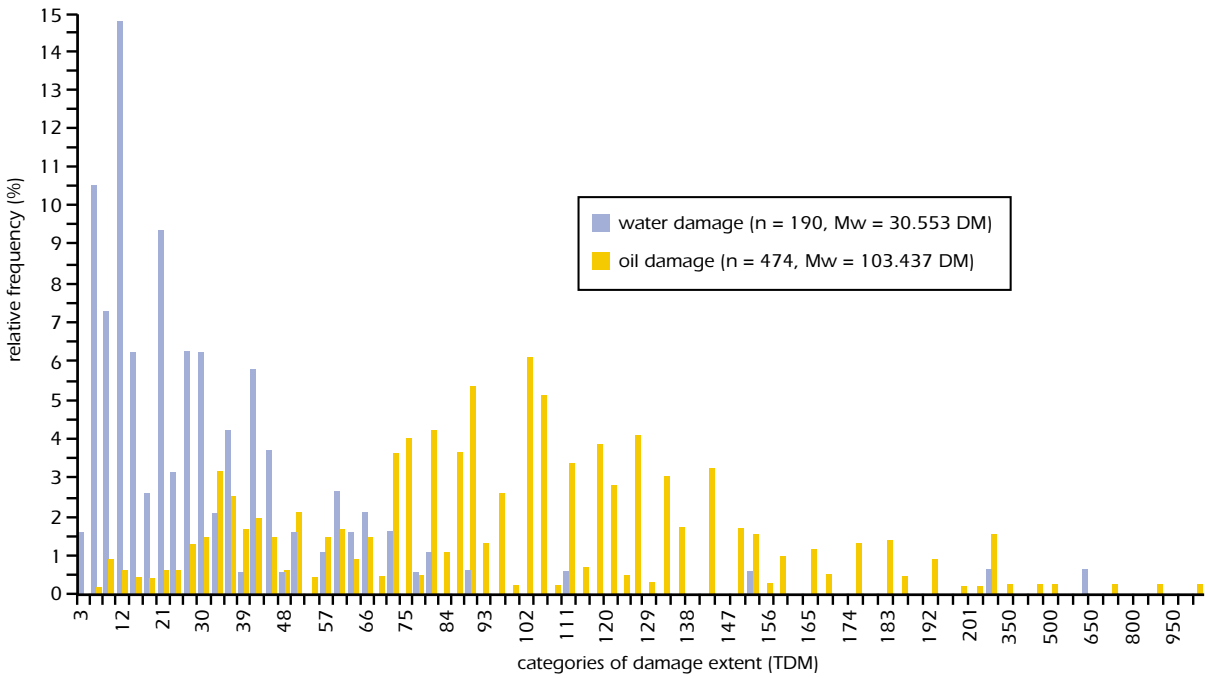
If water residence time is prolonged, leaking heating oil doubles to triples the damage extent.

Lessons learned during the flooding of Kelheim in 1999:
About 70 % of the total damage to constructions resulted from leaking oil.
The following measures are particularly due to damage caused by leaking oil:

- Renewal of ceilings, screed, tiles, painting and plaster
- Replacement of walls (brickwork, wood)

Leaking oil increased the extent of damage, as oil may also adhere to parts of the building resistant to water, such as tiles and thus cause vast need for remedial work.

Leaking oil in Neustadt / Donau (Kelheim district) 1999



Damage statistics Kelheim

Damage caused by the impact of oil was made out after all flood events, but never to the extent as in Kelheim. Lacking experience in an area protected by embankments and the long duration of high flood depth are the main reasons for the high damage. In case of short-time flooding, less oil penetrates the walls and in most cases few parts of the building will be concerned so that the impact of oil damage will not become as clear among the large number of damage statistics.

Continuation: Hazardous substances

Replacing brickwork following oil pollution in Neustadt / Donau (Kelheim district) 1999

Trade and industry

Generally speaking, stocked goods must be judged by their toxicity, their inflammability and explosiveness as well as their ecotoxicity. During a flooding, environmentally hazardous substances are not only released in trade and industry areas, but also in housing areas (oil, sewerage) and in agriculture (pesticides, fertilisers). Thus, as far as substances hazardous to water are concerned, preventive measures must not only be taken for financial reasons, but also for reasons of environmental protection.
The best precautionary measure is to stock hazardous substances outside the flood risk area or to elevate stocking areas. All depending on the type and amount of substances concerned and the conditions of operation, individual solutions must be sought for.

Oil tank protection against buoyancy (Basel)

Storage of fixed tanks

Reducing damage potential due to appropriate storage of hazardous substances

0-25%	25-50%	50-75%	75-100%

Effectiveness
Stocking outside the flood plain reduces the extent of damage by 100 %. Measures aimed at elevation and flood-proof stocking attain an effectiveness of 50 % to 75 %.

"Preparations must begin long before the onset of the flooding."

Preparation

Information / Education

Information is at the basis of flood preparedness:

- Targeted information and education must raise awareness of the possibilities of limiting damage long before the onset of an event. This knowledge must regularly be passed on to the different actors.
- When floods rise, flood warnings and flood forecasting leave sufficient time to implement the preventive measures chosen.

When conceiving preventive measures, the warning lead time is of decisive importance. It varies from a few minutes in mountainous regions to several days in the Rhine delta.

Who needs what information?

Authorities:
Authorities require information about the flood risk, the current situation, alert and emergency plans. Co-operation between the different technical services must be co-ordinated.

Population affected:
Information starts off with the description of the potential danger. The population affected must be aware of the risk and of the warning lead time. Measures aimed at reducing damage to buildings, furniture and equipment must be known. Addresses where to get further details and information must be published. The population at risk must know about the kind of alert and the measures recommended in each individual case.

Civil protection and disaster control (emergency services):
Emergency services must know about the spatial distribution of risk and all measures required. These measures must be fixed in disaster control plans.

Preparation

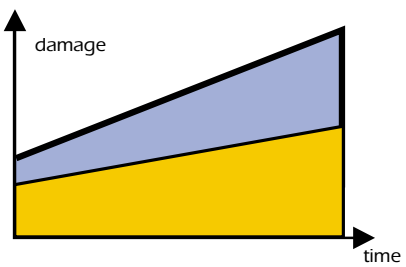
Flood preparedness is planned by representatives of emergency services as well as individuals. The result is an **individual emergency plan** listing the sequence of preventive emergency measures and the addresses and telephone numbers of emergency services or workmen.

Effectiveness
Information, education and preparedness are prerequisites for flood preparedness. Their effect is to raise awareness of the pending risk and to make the individual recognise his possibilities of action. This is the sole means of reducing an increase of damage.

Flood preparedness
Information, education and preparedness are prerequisites for appropriate conduct liable to reduce damage in an emergency.

Information event aimed at raising the population's awareness in Cologne

Reducing damage potential due to flood preparedness
blue: damage potential avoided
yellow: remainig damage potential



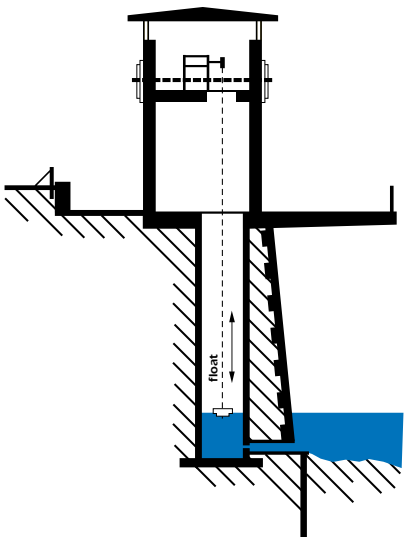
"Reliable forecasting is at the basis of flood preparedness."

Forecasting and warning

Warning
Forecasting and warning are prerequisites for a timely implementation of planned emergency measures

Forecasting announces the expected water levels and their development in time.
Warning indicates that the expected water levels may rise above the threshold values.
Alert implies the call for concrete action to secure life and limb as well as material assets.

Water level gauge



Flood warning centre Cologne

Timely and reliable flood warning and forecasting are at the basis of effective flood preparedness. All depending on the location of the sub-basin within the watershed, lead times for warning and forecasting may vary, beginning with some minutes for mountainous brooks up to several days for the Rhine delta. Clearance of houses must only be planned if a forecasting period of 4 hours is given. In the Rhine delta, warning lead times of at least 72 hours are required for the evacuation of several hundreds of thousands of people.
In the Rhine basin, the regional flood announcement services publish up-to-date flood information for the entire region. The smaller the watershed is, the more the reliability of flood forecasting depends on the quality of meteorological forecasting. During the past years, the existing flood forecasting systems largely contributed towards reducing flood damage. The quality of information and forecasting is steadily improved.

The consequence of a false alarm is always a loss of confidence and the significance of an alert must be plain, as otherwise all measures of flood preparedness lose their effect.

In January 1995, the flooding of the Meuse in Charlesville topped the record value of 1993 by 52 cm. The mounted flood walls were overtopped and damage was nearly twice as high as in 1993. On principle, the forecasting of the flood wave was correct, but it arrived later than predicted so that the population no longer believed in the alert. On the one hand this was due to the fact that forecasting went beyond experience made so far, on the other hand observations at the time of alert (unchanging water levels) did not correspond to forecasting (rapidly rising water level).

In 1995, the dikes in the Netherlands were not overtopped as feared. Experts fear that this will make it considerably more difficult to motivate the population at risk to agree to the next evacuation measures. However, according to new polls, the many floods of the past years have increased the population's flood awareness, and such preventive measures are understood.

Warning may be issued through: hoarding, local radio stations, vehicle mounted loudhailers, patrols, automatic information systems (pager, etc.), sirens, internet and free of charge telephone.

The internet addresses for flood warning and forecasting in the Rhine basin are available on the survey map under www.iksr.org.

Effectiveness
Just as information and preparation, warning is a prerequisite of flood preparedness. The more precise and reliable a warning is, the higher effectiveness of emergency measures will be.

"Avoid nearly half the damage by simple means!"

Emergency measures in housing

Emergency measures in housing

Removing furniture:
The simplest and most evident measure mostly applied by the population at risk without any preliminary warning in case of unexpected flooding is the removing of movable equipment. According to the warning lead time distinction is made between:

- Simple removal: small objects
- Intensive removal: big objects
- Complete removal: removal of fitted furniture.

At all events, removal activities in cellars and safeguarding of assets must be stopped before the onset of a flooding.

Besides the warning lead time, flood preparedness and thus the available flood-safe room is the limiting factor for the effectiveness of clearing measures. In case of low flood depth it will often be sufficient to elevate goods.

In 1999, when it was recognised in Kelheim that flooding was inevitable, recommendation was issued to remove as many goods as possible to higher floors. When these too were flooded in the most hard hit quarters, the population complained about the first recommendation issued, which had later on proved to be useless. It was generally believed that time might have been used more sensibly.

The flooding of the Dutch Meuse gives an impressive example of how to reduce damage to furniture. In 1995, damage to furniture was reduced by 80 % compared to the damage suffered during the 1993 flooding only by appropriate removal of goods. In both cases flood depth and warning lead time were about comparable.

The damage reduction of the flood event in 1995 compared to 1993 in households in Rodenkirchen (Cologne district) is of a comparable order of magnitude:

Households	Average damage per household		Damage reduction per household
	1993	1995	-
All	20'500 €	6'100 €	14'400 €
No experience with flooding	**27'600 €**	**8'100 €**	**20'000 €**
Recent experience with flooding	2'500 €	1'900 €	600 €

Emergency measures
Emergency measures are those which limit the extent of damage shortly before, during and after a flood event.

Continuation: Emergency measures in housing

After the flood event, reparable goods and total losses must be separated. Attention must be paid to those goods which, once appropriately cleaned, may again function.

Elevating furniture

Elevating electrical equipment

Reduction of damage potential by removing furniture

0-25%	25-50%	50-75%	75-100%

Effectiveness

All depending on expenditure for preventive measures, the total damage may be reduced by 20 to 50 % due to removing furniture and equipment or to elevating it. A prerequisite is that part of the buildings are flood-proof and that warning lead times are sufficient for securing furniture.

“Plan and exercise damage prevention with the staff!“

Emergency measures in trade and industry

Emergency measures in trade and industry

Flood preparedness in trade and industry is manifold and differs from one branch to the next. Measures are determined by the kind of goods at risk, the amounts to be secured and the staff at hand. Safeguarding substances hazardous to water is of greatest importance.

Flood protection by the Bayer AG, Leverkusen

In the aftermath of the last great floods of the Rhine, the state redefined the aims of protection. This encouraged the Bayer AG to extend its flood protection to a one in 200 years event by constructing new fixed as well as mobile flood walls and a flood pumping station. Expenditure amounted to 4 million €. Due to the natural rise of the site, and even without the flood wall, a one in 200 years event would only flood the parts of the site in the direct vicinity of the riverbank. However, water might penetrate the sewerage systems through the heads of canal of carriageway drainage and thus impede normal drainage. The main motivation of the Bayer AG was to avoid disruption to production and voluntary commitment to "act responsibly” with respect to environment and safety. The flood protection measures are part of the organisation of alert and hazard control of the works fire brigade. All depending on water levels, protection scenarios have been defined in a "Plan for alert and hazard control”. Furthermore, a "logistic concept” has been drafted fixing the terms for short term raising of the mobile flood protection wall. Regular exercises grant that trained staff is on the premises of the Bayer AG at any time.

Mobile flood wall Bayer AG, Leverkusen

Continuation: Emergency measures in trade and industry

Conduct of the cement asbestos works "Eternitwerke AG" in Niederurnen, Switzerland during the flooding of 1999:
The cement asbestos works in Niederurnen (cement industry) managed to avoid damage worth millions and a longer lasting disruption to business due to the timely establishment of an emergency plan. The strategy of conduct to adopt is based on a detailed contour map of the site specially drafted for the purpose of planning these emergency measures. The following actions were implemented:

- Assembly of an educated flood defence unit
- Construction of a high-perfomance unit for filling sandbags
- Miscellaneous investigations concerning emergency power supply
- Testing and retrofitting tank installations at risk of buoyancy
- Installation of a gauging station with an alarm for stand-by duty
- Drafting of an emergency plan with all required actions referring to different flood levels.

As a reward for their great efforts, the staff and the particular flood defence unit received special premiums from the works management. The insurance company of the works voluntarily paid 10'000 € to the works in recognition of the performance of the defence unit.

Timely displacement of substances hazardous to the environment

Reducing damage potential due to emergency measures in industry and trade

0-25%	25-50%	50-75%	75-100%

Effectiveness
In large businesses, flood damage quickly goes into millions. On the other hand, expenditure for flood preparedness and exercises only amounts to few thousandth parts or percent of this sum. It is not possible to make general indications of effectiveness. Effectiveness will be limited by high water surface elevation.

"Plan and exercise preparedness for extreme flood events!"

Flood fighting and disaster control

Flood fighting and disaster control

Well structured emergency organisation is vital in order to be able to cope with flood emergencies. Normally, such an organisation is split up in: management, information and warning service, security and order, flood fighting, evacuation and rescue services, protection, care, medical and sanitary services and technical infrastructure.

Experience with flood fighting on the R. Odra in 1997

Along the R. Odra, flood fighting avoided the flooding of some 68'000 ha and 26'000 inhabitants. This corresponds to an avoided damage of some 300 million €. However, this flood fighting caused expenditure of some 292 million €. Expenditure for flood fighting includes damage to embankments and roads caused by heavy lorries. In the flooded areas expenditure caused by flooding amounted to 12 million €.

Example: warning and alert plan of the municipality of Warcq (F):

Phase	Warning	Alert	Evacuation
Gauge (m)	**3.00**	**3.00 - 4.50**	**4.50 - 6.30 (1995)**
Instructions and regulations	▪ mobile: boat, tools, TW … ▪ emergency accommodation ▪ list of human means, designation of person in charge of island ▪ organisation of parking areas	▪ crisis management group (daily) ▪ evacuation ▪ vehicle mounted loudhailers ▪ command post flooding, rescue	▪ stopping traffic ▪ fire brigade and army block the town ▪ evacuation 2 (complete evacuation at 6.30m) Orsec plan

Experience drawn from the flooding of the Meuse in 1995

The 6 700 interventions by 150 fire brigades comprised the following services: precautionary evacuation and assistance to people at risk (42 %), protection of private property and precautionary measures (30 %), pumping out water from houses and annexes (13 %) and other interventions (15 %). These actions were initiated and supervised by 2 500 persons belonging to the police and public services and mainly concerned traffic regulation and the maintenance of public infrastructure.

Effectiveness

Effectiveness of emergency planning may above all be evaluated in terms of quality. Evacuation and rescue services prevent casualties. Flood fighting reduces the probability of damage.
A general quantification of effectiveness with respect to the extent of damage is not possible.
This type of risk prevention is of great importance for areas with great flood depth.

Emergency planning

Emergency planning targets at limiting extent of and expenditure for damages in case of very rare events. In these cases one falls back on flood fighting and emergency services and, if there is no subvention by the state, insurance companies.

Flood fighting:
shielding an embankment

Evacuation of the Rhine floodplain in 1995

The evacuated area comprises some 640 km² and is inhabited by more than 200'000 people.

“Emergency spillways are the airbag of flood prevention.“

Emergency spillways

Emergency spillways
Emergency spillways are exclusively reserved for emergency situations and are therefore part of disaster control plans. They do not present any alternative to structural safety measures, as e.g. the designation of washlands.

Effect
Within hazard preparedness, the second defence line is comparable to a fire wall not preventing the burning of a house, but that of a town.

Emergency spillways

The target of emergency spillways is to let water overtop the banks in areas with a lesser damage potential instead of risking uncontrolled flooding with unforeseeable consequences if the design level is exceeded. This measure is aimed at avoiding casualties and limiting damage. The controlled deviation of water into emergency spillways lowers water levels downstream and makes these areas safe. Emergency spillways are part of disaster control plans.

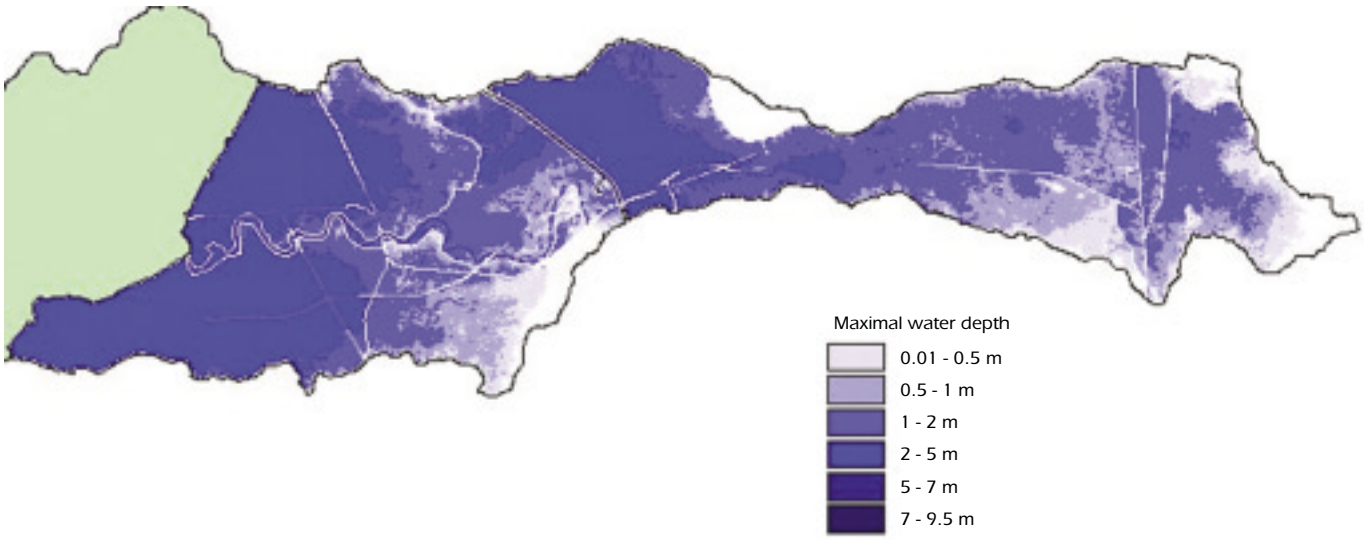
Second line of defence

Existing longitudinal structures, such as roads, old dikes and canals may serve as additional security devices for areas particularly vulnerable to damage in case of failure of the original flood defences.

Examples:

In the Netherlands, great polder surfaces may be subdivided into cells so as to avoid the entire surface being flooded in case of a breach of dikes.

Example of a plan without subdivision of a polder into cells



In the case of the represented example the damage has been reduced by 25 %. The low number of affected objects is partly counterbalanced by a higher flood depth on the remaining surfaces.

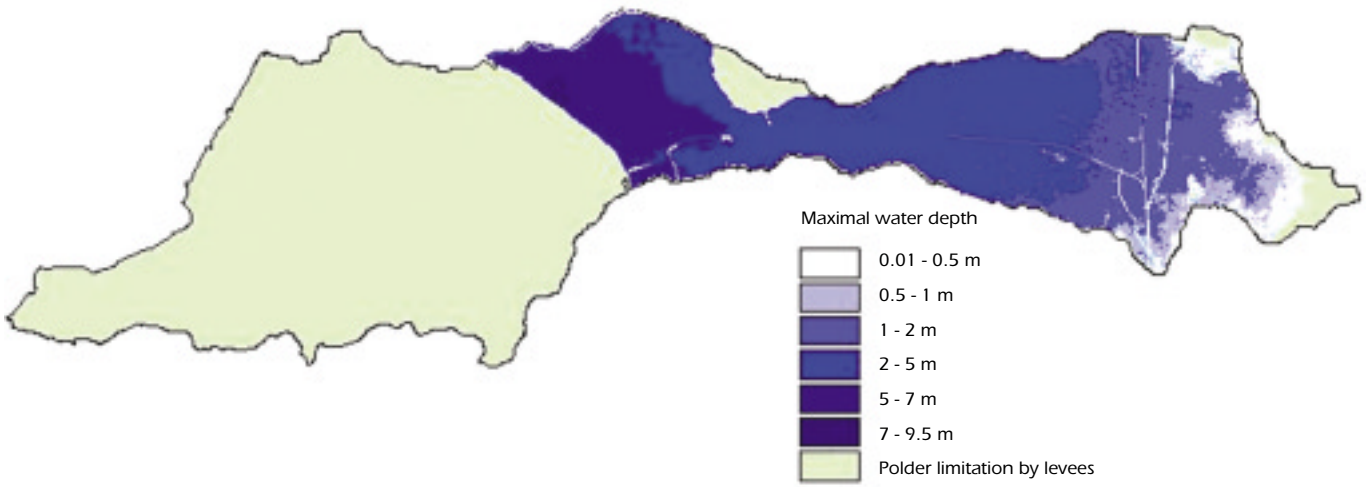
The use of emergency spillways does not restrict the possibilities of using this area within the defined specifications of spatial planning. It is important to maintain the normal level of protection or that fixed by law. The additional security provided is of benefit to the uses downstream considered to be of greater value.

Effectiveness

Tieler- and Culemborgerwaard
The Dutch chamber of economy has investigated into the economic consequences of designating the Tieler- and Culemborgerwaard as emergency spillway. Contrary to all expectations it turned out that economic consequences of this measure would be beneficial to the area.

In the Dutch Rhine delta the designation of surfaces to serve as emergency spillways constitutes an important measure aimed at limiting flood damage.

Example of a plan with subdivision of a polder into cells

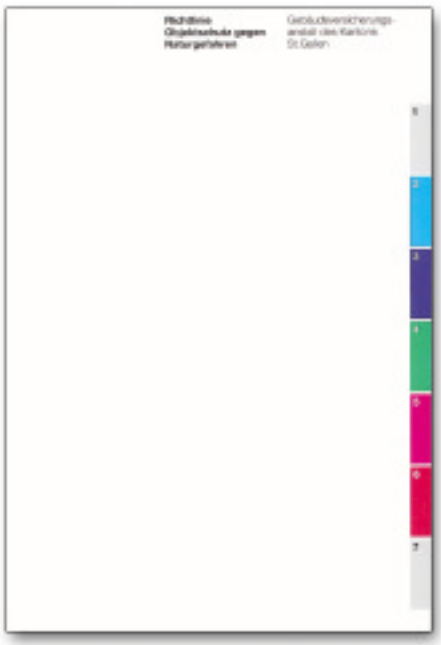


Emergency spillways are meant to avoid great unforeseeable and uncontrolled damages. A fair degree of effectiveness is obtained if there is a great difference between the damage potential of highly protected areas that of and less protected areas. The degree of effectiveness may not generally be quantified.

“Provide for a subsistence level in case that something should go wrong.“

Financial preparedness

Insurance companies spread the damage to a larger community, thus making it bearable to the individual person in case of an event. In order to avoid any unjustified passing on of risks they may require the insured to take measures aimed at reducing the damage potential.
For example:
Directive on property protection against risks posed by nature (Insurance company for buildings of the canton St. Gallen, Switzerland)



Flood preparedness
According to the conditions of insurance, the insured party is obliged to reduce damage in case of imminent flooding. Generally speaking, the insured may be encouraged to take initiative towards reducing the damage by contracts providing for cost sharing measures adapted to the risk.

Private or public prevention

Basically, private prevention, that is building up financial reserves to face bad times comes first. Signing an insurance contract to which the state may contribute, e.g. by means of an obligatory insurance is one kind of private prevention. If no insurance is proposed (as e.g. in the Netherlands) or if, for different reasons, no insurance contract has been taken out, the community of donators or the state must contribute to maintain the subsistence level. In this case, the equal treatment of all petitioners must be granted. If there is a possibility of taking out an insurance but it has not been done, petitioners for donations or state subventions must not be preferred to insured parties or be treated at an equal level with them. This would jeopardise the insurance business.

Insurance

An insurance covers unpredictable damage due to rare and very rare events by having the members of a risk community share it. Thus, in order to be able to afford insurance coverage, the risk must be carried by a well balanced group which is as large as possible. If there is no obligation to take out an insurance contract, rare events may result in people at risk renouncing insurance coverage. A well balanced system may consist of

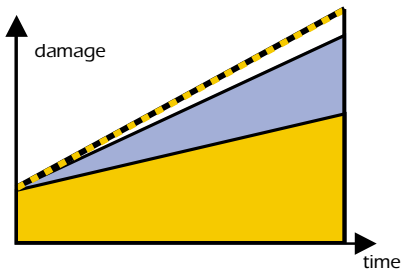
- a union of different private insurance companies in order to form a group covering damage due to flooding
- connecting this group “damage due to flooding” to a higher ranking group “elementary damage”
- introducing an obligatory insurance (monopoly) including “elementary damage” and principally insuring everybody.

In the law on insurance, the state fixes the framework conditions. The insurance companies may draft recommendations on damage prevention and distribute them according to the dissemination of insurance contracts. The implementation of damage prevention depends on the insurance system. Appropriate insurance conditions, e.g. cost sharing adapted to the risk and / or adapted conditions may encourage the insured to take appropriate damage prevention measures and will grant insurance coverage in case of rare or very rare events.

If everything goes wrong – photos of the 1953 flood disaster in the Nederlands

Effectiveness of insurance contracts
Development of the damage potential.
Blue: uninfluenced development
Yellow: development of the damage potential including insurance conditions aimed at damage limitation
Yellow-black line: development of damage potential under too obliging damage regulation

Reducing the increase of damage potential due to insurance contracts



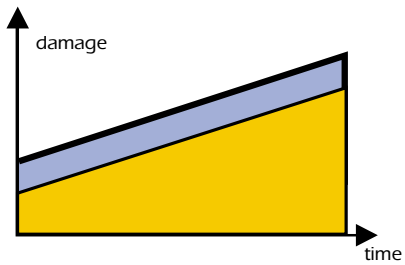
Effectiveness
Appropriate insurance coverage makes the remaining residual risk of rare and extreme events tolerable. Appropriate insurance conditions may encourage flood proofing constructions and flood preparedness. Thus, insurance companies may fulfil an important function in the process of raising awareness, information and education.
Without the obligation for individual prevention, in particular concerning frequently occurring events, a limitation in the increase of damage potential is not to be expected.

"Which measure has which effect?"

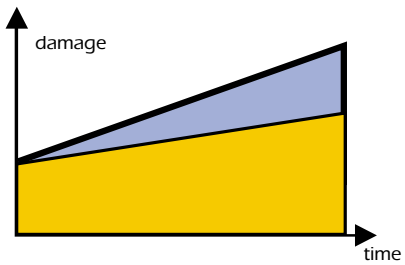
Types of effect

Blue: development without any measures
Yellow: development taking account of measures

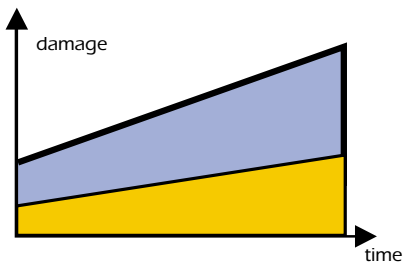
Influencing the existing damage potential



Influencing the increase of damage potential



Combination of the two different types of effect



Type of effect

The measures of non structural flood plain management presented in this report point out different types of effect. On the one hand, there are those reducing the existing damage potential, on the other there are those limiting the increase in damage potential.

Impact on the damage level:

A classical method of reducing the existing damage potential is to remove furniture. Comparisons of the flood events in 1993 and 1995 in Cologne and in the Netherlands prove that this is an efficient means of reducing damage. However, this measure on its own does not take any influence on the increase of damage.

Influence on increasing damage potential:

The classical means of avoiding an increase in damage potential is to keep areas open. The example of Dresden shows, how damage in a large city may be kept rather low over the centuries. In places where settlements exist in flood prone areas – in many places this has been the case for centuries – damage due to flooding must be kept low by adapting the constructions to the risk. In most cases measures for flood proofing constructions may only be implemented in new buildings, during extensive renovations or during repair work after a flood event.

Only a

reasonable combination of all measures of non structural flood plain management

may reduce the existing damage potential and damage growth. New developments should be avoided in areas at high risk. In areas which are less at risk, development may be admitted provided that the measures required by building codes and flood preparedness are respected. Measures of urban development improve the adaptation of existing settlements in areas at risk. Local differences along the different stretches of the Rhine must however be taken into account when measuring the effectiveness of measures.

"Which measures reduce damage by how much?"

Effect of measures

Survey of the effects of measures

	land use control		flood proofing construction					flood preparedness			emergency planning		
	keeping areas open	building codes and zoning ordinances	spatial use	equipment	sealing	shielding	hazardous substances	information, preparation	warning	emergency measures	flood fighting disaster control	emergency spillway	financial preparedness
Reduction of increase of damage potential	●	●	●					●					●
Reduction of damage potential			●	●	●	●	●		●	●	●	●	
0 - 25 %				■					■		■	■	
25 - 50 %			■						■	■	■		
50 - 75 %					■	■	■		■	■	■		
75 - 100 %					■	■	■		■		■		

Remark: the indicated effects of preventive construction measures are related to moderate water surface elevation (< 2 m).

The yellow squares illustrate the quantified reduction of the measures' damage potential. The blue squares indicate measures influencing the increase of damage potential.

Importance of measures with respect to frequency and intensity

Intensity, above all flood depth takes influence on the costs of measures. Frequency influences cost-effectiveness and acceptance.

	land use control		flood proofing construction					flood preparedness			emergency planning		
	keeping areas open	building codes and zoning ordinances	spatial use	equipment	sealing	shielding	hazardous substances	information, preparation	warning	emergency measures	flood fighting disaster control	emergency spillway	financial preparedness
Frequent events	■	■	■	■	■	■	■	■	■	■			
Very rare events						■	■	■	■	■	■	■	■
Low flood depth	■	■	■	■	■	■	■	■	■	■			
High flood depth							■	■	■		■	■	■

The yellow squares illustrate the main fields of application of the types of measures, the blue squares rather indicate subordinate uses.

"Who are the actors?"

Actors

Who does what?
The table represents all actors and their potential part in limiting damage potential.

	land use control		flood proofing construction					flood preparedness			emergency planning		
	keeping areas open	building codes and zoning ordinances	spatial use	equipment	sealing	shielding	hazardous substances	information, preparation	warning	emergency measures	flood fighting disaster control	emergency spillway	financial preparedness
Parties concerned													
Inhabitants			●	●	●	●	●	●	●	●			●
Trade				●	●	●	●	●	●	●			●
Industry					●	●	●	●	●	●			●
Agriculture							●	●	●	●			
Infrastructure								●	●	●			
Authorities													
Water supply and distribution								●	●		●	●	
Construction and planning	●	●						●				●	
Municipalities	●	●	●	●	●	●	●	●	●		●	●	
Construction experts													
Engineers/architects		●	●	●	●	●	●	●		●		●	
Workmen				●	●	●	●	●		●			
Emergency organisation													
Command									●		●	●	
Police									●		●	●	
Armed services and other emergency services									●	●	●	●	
Health and medical care											●	●	
Insurance													
Public insurance		●	●	●	●	●	●	●		●			●
Private insurance			●	●	●	●	●	●		●			●
Elementary damage funds													●

"Flood control concerns everyone!"

Contribution of the actors

Persons affected

Inhabitants

The inhabitants, proprietors or tenants, are asked to implement measures of flood proofing constructions and flood preparedness targeted at limiting damage. Eventual residual risks, particularly those related to very rare events, may be covered by property insurance. Another possibility is to create disaster rescue funds covering damage caused by exceptional flood events.

Trade and industry

Trade and industry must prepare their businesses with the help of construction measures and an emergency plan. Event control demands that even a limited interruption of power supply, telephone and water supply will not endanger the existence of a business.

Farms

The main efforts should concentrate on the protection of animals (flood preparedness) and the safe stocking of substances hazardous to the environment (fertilisers, pesticides, etc.). Flood proofing constructions should limit damage to highly technical installations.

Infrastructure business

Businesses in supply and waste removal as well as in road and railway may use the hazard maps in order to take their own targeted measures of flood preparedness and to draft the corresponding emergency plans. These activities must be co-ordinated with those of emergency organisation (e.g. road blocks, railway replacement, emergency supply, etc.).

Authorities

Water resources authorities

Within flood protection they are in charge of flood information and warning and they support the emergency organisation

Building and planning authorities

Building and planning authorities have the main responsibility for land use control. On the basis of flood hazard maps it is possible to define those cells to be kept open and those where development may be accepted if building codes and zoning ordonances appropriate to the flood hazard are respected. Comprehensive information must be given to those affected.

Municipalities

Municipalities draft building codes and zoning ordonances. They are the contacts defining appropriate measures of flood preparedness and disaster control.

The actors of implementation – Who does what?

A short description of the actors' contribution to limit damage is given opposite.

Continuation: Contribution of the actors

Construction experts

Engineers and architects

New constructions as well as renovation works require that the risk corresponding to the site is taken account of from the beginning to the end of the project. If necessary, experts for sealing measures must be consulted. The plan for zoning and emergencies must be drafted in co-operation with the property developer.

Workmen

Measures aimed at flood proofing constructions require particular performances of the workmen. This is in particular the case when buildings must be sealed.

Emergency organisation

Control

Hazard maps and possible flood scenarios are at the basis of preparing disaster control services for their emergency intervention. The command unit must plan for the required means and their intervention. Particular attention must be paid to the information of the population affected and of the press.

Police

The police must be part of emergency exercises. Its main tasks are to set off an alarm, to implement large-scale securing measures, to block roads and to help with evacuations.

Armed services and other emergency services

Hazard maps are at the basis of preparing efficient participation of armed services in exercises. The use of means depends entirely on the kind of risk (embankment breaches, overtopping of banks, bank side erosion, debris damming, etc.) and the kind of damage potential (settlements, industry, agriculture, etc.).

Health services and care

The maps on the damage potential may help to make out the need for provisional accommodation in areas not at flood risk (or in rescue areas). Hospitals, nursing homes and similar vulnerable installations must be examined with respect to their security in case of flooding.

Insurance

On the basis of legal regulations, insurance companies may contribute to damage prevention through appropriate insurance conditions. Drafting recommendations or guidelines, fixing conditions and eventually limiting insurance coverage serve this purpose. Public insurance companies have a public mission and, in general, they insure all buildings in their field of action. Due to the framework conditions they are most apt to enhance private responsibility with respect to preventive construction and conduct.

„Persuasion is necessary."

Measures

Regulations

Regulatory stipulations are necessary in the following fields:

- Regional planning: flood risk and demands in connection with land utilisation may be co-ordinated with the help of regulations in the field of spatial planning and building codes. Thus it is being taken into account that floods are part of life near rivers and that their extent – in particular in case of extreme flooding - cannot be influenced. In such cases the protection of public welfare is primordial.
- Protection of persons: the security of persons must be granted by appropriate regulations. The safety of persons must be examined when consenting to new constructions and reconstructions in flood prone areas.
- Environmental protection: Regulations must avoid or at least substantially limit hazardous substances being released during flooding.

Conditions

The conception of specific conditions is in particular advisable in order to limit material damage. These specific conditions are fixed in individual contracts. This possibility exists within insurance contracts as well as within the framework of financing buildings (mortgage loan).

Information

Information is primordial

- within the enhancement of individual preventive measures
- within measures of flood preparedness

Convincing information is a prerequisite for all measures, as conditions and regulations may hardly be enforced without obvious reasons.

Means of implementation – Regulations, conditions, information
Irrespective of the actor, appropriate binding forces must be striven for under implementation.

If persuasion is successful, few regulations are necessary. If it is not successful and there is no control, regulations will not be respected either.

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