Environment Research Program
of the German Federal Ministry for the Environment,
Nature Conservation and Nuclear Safety

Protection of existing and planned establishments and installations against hazardous environmental impacts, especially flood

- Summary-

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1 Introduction

After the flood disaster in 2002 at the Elbe river the German Federal Government set up a programme with the title „Steps to an improved flood protection". In a research project of the German Federal Environment Agency "Protection of existing and planned establishments and installations against hazardous environmental impacts, especially flood" the flood protection has to be regarded for the following plants with hazardous substances:

A Facilities for handling substances constituting a hazard to water according to § 19g German Federal Water Act (VAwS-installations)
B Installations for the storage of liquefied gases in vessels
C Establishments (plants), which fall under the scope of the 12th BImSchV (Major Accidents Ordinance, 12th Ordinance to the Federal Immission Control Act - BImSchG)

In this research project of the Federal Environment Agency the following main points have to be examined:

- regulations for a plant related protection
- flood protection of the installations and establishments in practice
- state-of-the-art of flood protection (technique and management)
- alarm and emergency planning, disaster control

Moreover, for establishments according to the 12th BImSchV the impacts of storm, earthquake and mining settlements have also to be studied. On the basis of this analysis numerous deficits have been recognized, recommendations are worked out and summarized in the following.

The research project has been carried out in cooperation with North Rhine-Westphalia, Saxony and Saxony-Anhalt. In these German federal states (Länder) several model regions had been chosen for a survey.

2 Protection against flood

2.1 Description of flood risks for installations and establishments

At the beginning it has to be pointed out, that primary in Germany everyone has to protect himself against flood (according to § 31a WHG). This principle includes the owner of installations and establishments. Nevertheless local administrations can build dykes and facilities to protect inhabitants against flood. **Figure 1** illustrates the typical situation of flood risks for installations and establishments, which exists in nearly all examined model regions.

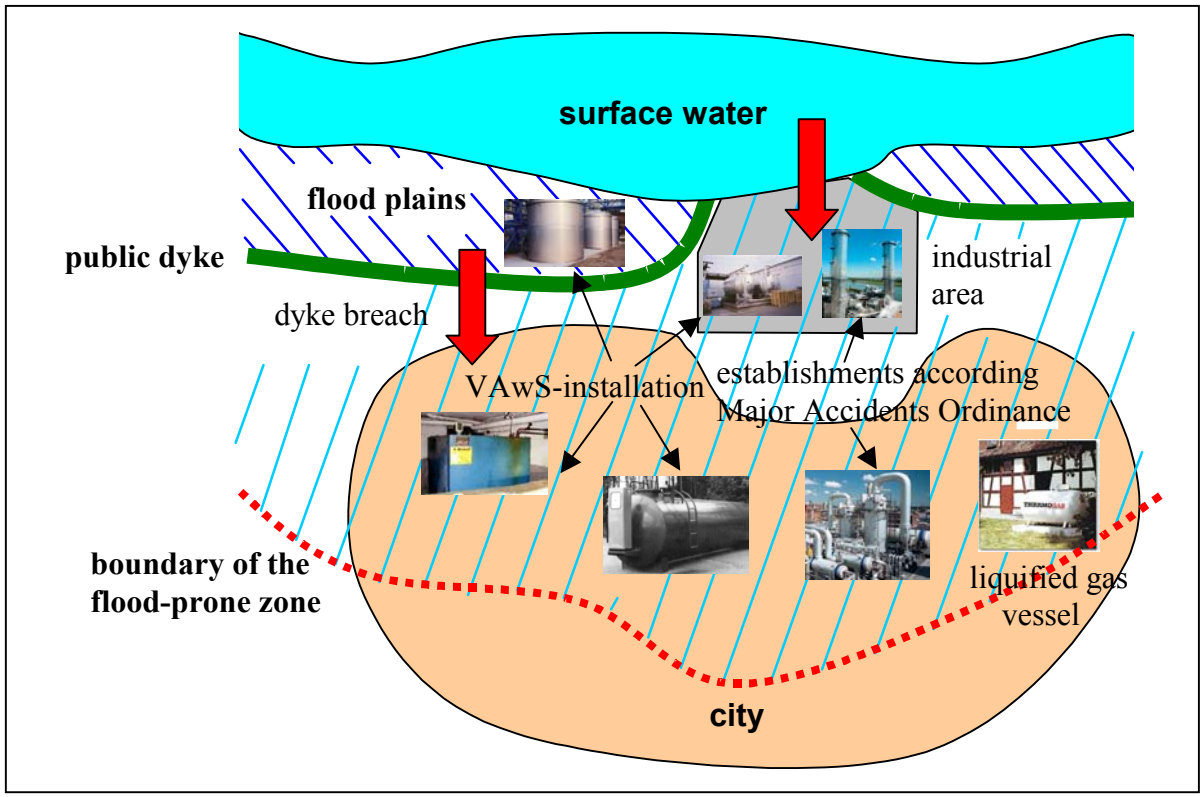

Figure 1: Situation to the flood protection in most of the investigated model regions

Flood plains (flood areas) as they are defined in the German Federal Water Act (WHG) are areas between surface waters and dykes or high banks. Dykes, which are dimensioned for a design flood with its resulting flood level, are designed for a certain protection aim. Protection aims base on the damage potential behind the dykes as well as on the local conditions along a river. They vary in practice for design floods

between HQ_{100} and HQ_{500} [1]. Special requirements for VAwS-installations in flood plains according to the VAwS of the Länder have to be regarded by the owner.

Flood-prone zones (flood-endangered areas) as defined in the German Federal Water Act (WHG) are inundated areas in the case of a flood higher than the design flood or in case of a dyke breach. The assessment basis has not been defined yet by the legislator for determinating these flood-prone zones behind the dykes. Moreover, no specific requirements are fixed for VAwS-installations in flood-prone zones.

Figure 1 shows that the dyke line is interrupted at the boundaries of an industrial area. According to the Major Accidents Ordinance all relevant establishments have to be protected against flood by the operator by means of suitable technical and/or management measures. It does not exist however a defined protection aim according to the design for public dykes.

The following basic questions arise from figure 1 which is derived from the survey in the model regions:

1. On which assessment basis shall the flood-prone zone be determined in the water law?
2. Which requirements result for existing and new VAwS-installations with a special view on the private sector?
3. On which design basis do operators have to take up measures to protect their existing or new establishment (plants) which are subject to the 12th BImSchV?
4. Which risk proportional requirements result for the establishments?
5. Which requirements must be established for liquefied gas storages which are not subject to the Major Accidents Ordinance?

For a better understanding of the complete difficulties it must be pointed out that VAwS-installations are subject to the installations related water legislation and establishments to the Major Accidents Ordinance. Furthermore, it has to be taken into account that VAwS-installations and commercial liquefied gas storages can be also part of establishments (plants).

[1] HQ = Maximal stream flow; HQ_{100} = Maximal stream flow expected to occur one time in 100 years; HQ_{500} = Maximal stream flow expected to occur one time in 500 years.
It is calculated on the basis of historical floods, hydrological and economic factors.

2.2 Proposal for an assessment basis to determine the flood-prone zone

Flood-prone zones are areas behind dykes and could be inundated in the case of a dyke breach or if a flood is higher than the dyke, normally designed for HQ_{100}, in special cases up to HQ_{500}. The specifications of the design flood to determine flood-prone zones are still in discussion. Generally two alternatives are possible:

1. Definition of a national target value for a design flood, e.g. HQ_{200} or HQ_{300}.
   Such a general approach does not take into account that the damage extent is very different in the case of a dyke failure at different rivers and different river sections. Due to these facts the definition of a national target value for a design flood does not take into account the local conditions.

2. Flexible adoption to the local conditions
   As the protection aims for dyke design vary in practice between HQ_{100} und HQ_{500} (e.g. in some areas along the Rhine) the authors recommend to choose a design flood in this range adapted however to the local conditions and risk potentials.

Besides the specifications of the design flood the method to determine the flood-prone zones is also relevant. Two alternatives have to be considered (**figure 2**):

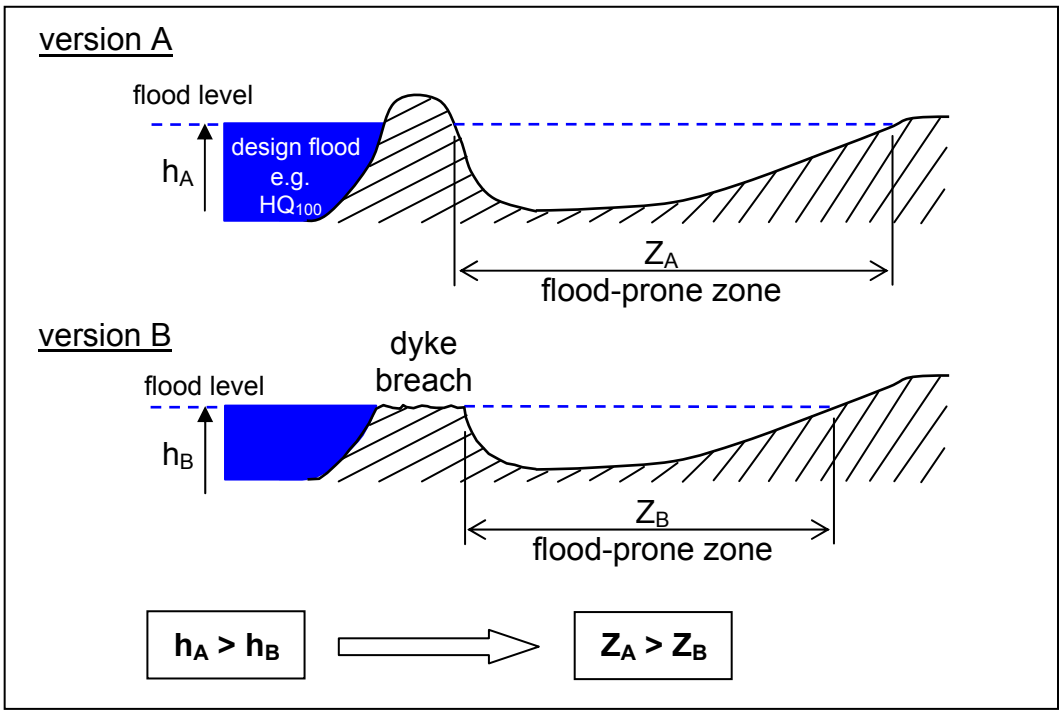

Figure 2: Alternatives to determine the flood-prone zones[2]

[2] Version A: The difference between the level of the design flood and the dyke top is for the consideration of wind and waves.

Version A) The easiest alternative arises from the determination of the design flood in m³/sec associated with the local river morphology. Both factors determine the local flood level. The flood-prone zone results from the horizontal projection of this level onto the area behind the dyke. This method is relatively simple and close to the reality, if a dyke breach has only little effect on the flood level. A clear overestimation is only given, if the effluent caused by dyke breach lowers the flood level. Exactly this case is taken into consideration in version B.

Version B) This method considers the actual effect of a dyke breach on the water level in the regarded river section. As the maximum level is lower than in the first method the flood-prone zone is smaller. However, this version takes much more effort, since it requires a modelling of a dyke breach for the respective river section.

If an upper limit of flood-prone zones for the specifications in accordance to WHG shall be determined, the version A should be preferred, because it is a simple and conservative method. If it is necessary in special cases the water authorities (and if necessary the operators) can determine the flood-prone zone by version B (individual case proof).

2.3 Requirements for existing and new VAwS-installations in flood plains and flood-prone zones with a special view on the private sector

The requirements for VAwS-installations are regulated in the Ordinance on Facilities for Handling Substances Hazardous to Water and on Specialist Firms (VAwS) of the German states (Länder). Due to the reform of the constitution in 2006 the German Federal Government is able to adopt a national ordinance on VAwS-installations. But as it does not exist a national ordinance yet (2007), the ordinances of the German states (Länder) are still in force.

For a better flood protection these ordinances have to be amended in the following points:

1. Consideration of the recommendations of the International Commissions for the Protection of the Elbe and the Rhine

   The recommendations of the International Commissions for the Protection of the Elbe (IKSE) and the Rhine (IKSR) on flood protection of installations have to be considered in the ordinances. This includes technical requirements as well as management advices during the flood, e.g. the evacuation of open tanks.

2. Refitting of existing private fuel oil installations

   As most of the Länder reduce the staff of their authorities the refitting of existing private fuel oil installations can only be organized by the operator himself. Therefore the authors recommend a regulation that experts have to examine the enforcement of new legal requirements in the context of recurring inspections.

3. Prohibition of new fuel oil tanks in flood-prone zones, if necessary.

4. Requirements for VAwS-installations in flood-prone zones must be regulated in the ordinances. These requirements have to be proportional to the different risk potentials in front of a dyke and behind it.

Risk proportionality can be considered by the following two steps:

1. Distinction of the dyke quality

   In the German Federal Water Act the cause for flood-prone areas is the failure of a dyke, either by a breach or by a dyke overflow. In Germany we have to distinguish dykes according to DIN 19 712 (German standard on river dykes) from dykes, especially old dykes, which do not comply with DIN 19 712. As the experiences in recent years show, the risk of a dyke breach is significant higher for old dykes in comparison with new dykes complying with DIN 19 712. Due to theses facts there is no need for technical or management requirements in the ordinances for VAwS-installations behind such new dykes.

In opposite to new dykes the residual risk of dykes, which do not comply with DIN 19 712, cannot be accepted. Moreover, neither the time nor the location of a dyke breach can be predicted. So if a dyke breach happens it can be presumed that in most cases there is no sufficient time for emergency management measures. Therefore, the operators of VAwS-installations have to implement suitable technical measures to secure the installations against flood. In consequence the requirements for plants in flood plains have to be extended to VAwS-installations in flood-prone zones.

In principle, it has to be critically noticed that requirements depending on the quality of public dykes for private and commercial installations as well as establishments could cause a considerable conflict potential, because the operators will always refer to the necessity of a dyke quality according to DIN 19 712. Due to this possible conflict the legislators should analyze once again, whether the scenario “breach in the dyke“ is suitable for the determination of flood-prone zones as well as for the derivation of possible requirements on VAwS-installations.

2. Risk potential for VAwS-Installations in case of a dyke overflow

In case of a dyke overflow the risk potential for VAwS-installations only depends on the level of the dyke and no more on the dyke quality. The higher the design flood level is the lower is the hazard for the flood-prone zones. This simple and pragmatic approach formed the basis for the VAwS Ordinance of Baden-Wuerttemberg (BW) of Nov. 2005 for installations in flood-prone zones. At first the ordinance demands the state-of-the-art of technology for VAwS-installations in flood-prone zones. With the help of risk potential classes, the VAwS then selects those installations, which have to be protected against flood. These classes depend on hazardous properties and the quantity of substances in the installation.

Because the dyke level bases on a design flood the Ordinance of Baden-Wuerttemberg combines the different design floods with risk potential classes of the installations. With increasing design floods, this means with an increasing dyke level, the risk of an overflow decreases and the requirements for VAwS-installations are focused on those installations with higher risk potential classes. **Figure 3** illustrates the context between design flood and requirements on installations with different risk potential classes. The risk proportion-

ality arises from the risk potential classes of the installations and not from a graded technology standard.

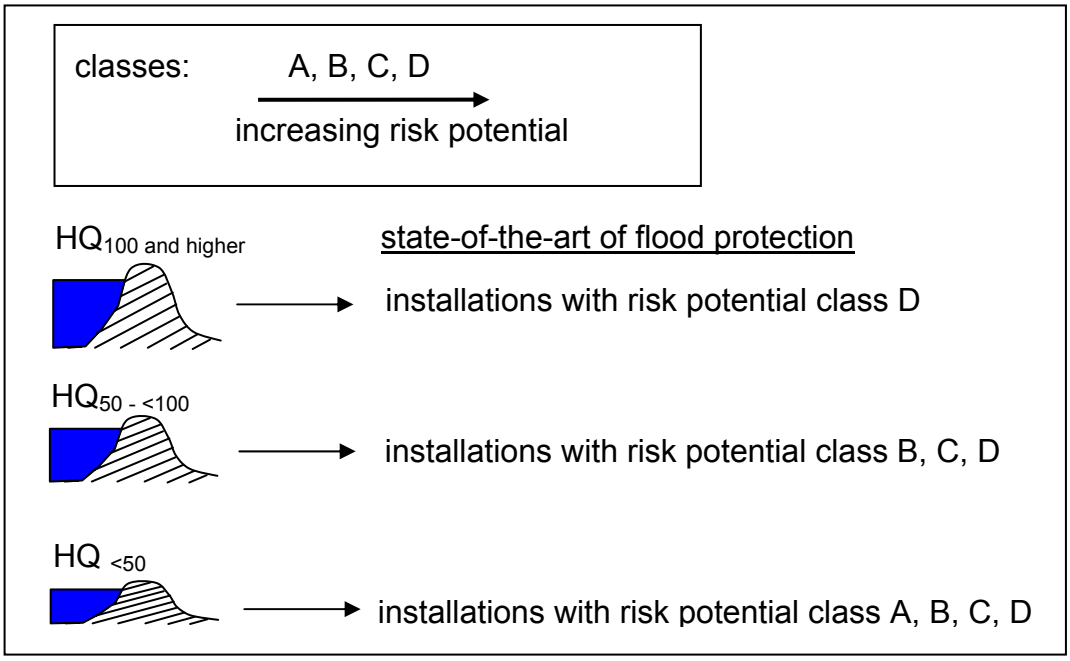

Figure 3: Context between design flood and requirements on installations with different risk potential classes according to the VAwS Ordinance in Baden-Württemberg

The operator can implement the requirements by suitable technical or management measures. All management measures presuppose a sufficient warning time. Principally, this may be the case in plane regions, but less in case of river catchments areas with a greater slope. Particularly after the experiences of the flood 2002 at the Elbe river and her tributaries the warning systems for the population were substantially improved. Especially by more precise weather forecast including thunderstorm warnings longer warning times could be reached in Germany. Therefore, management measures could be acceptable, if they are equivalent to technical measures. In the case of a dyke overflow the VAwS Ordinance of Baden-Wuerttemberg offers a practicable approach for national requirements on VAwS-installations in flood-prone zones.

2.4 Design Basis for existing or new establishments according to Major Accidents Ordinance against flood

In the Major Accidents Ordinance the consideration of environment-induced sources of hazards, like flood or earthquake, by operators is generally required, but without giving further detailed requirements.

Moreover, the Major Accidents Ordinance does not have any direct reference to the flood-prone zones defined in the Federal Water Act. Nevertheless the operators of establishments will be committed more strongly than before to evaluate the flood risk to their establishments, especially in flood-prone zones. For a clear regulation the authors suggest referring explicitly to the flood-prone zones in the Major Accidents Ordinance. This would make clear that for establishments, which are located in these endangered areas, the risk of a flood has to be evaluated, in principle. New requirements should include measures against floating material and ice as well.

As shown in figure 1 establishments closed to surface water are often not protected against flood by public dykes. The operators have to secure their establishments by own measures. But until now no design basis or protection aim - similar to design public dykes - has been determined in the Major Accidents Ordinance yet. Therefore the authors suggest to determine a design basis for establishments derived from the protection aim for public dykes upstream and downstream the individual establishments.

2.5 Risk propotional requirements to establishments

According to the discussion about risk proportional requirements similar to VAwS-installations it had to be checked, whether graded requirements should be introduced for establishments in flood-prone zones. In the German Water Act a dyke failure is mentioned as a possible hazard, but not explicitly in the Major Accidents Ordinance. This means that for the derivation of suitable measures, at first a risk analysis should be made, e.g. using probabilistic methods.

For a probabilistic analysis the following two hazards have to be regarded:

- the hazards to a dyke
- the hazard for establishments in case of a dyke failure

A probabilistic method was developed in the Netherlands to assess the probability of failures of flood protection facilities. The probabilistic method combines human failures like not closing a sluice gate with structural failures of flood protection facilities. Experts regard this as a special advantage of this method. But it has to be mentioned that the use of probabilistic methods requires a very high effort. In order to limit this effort such a risk analysis may applied only to selected dyke sections. But an equivalent risk analysis regarding the above mentioned hazards by probabilistic methods was not made in Germany according to the knowledge of the authors up to now. Therefore, the operators of establishments, which are subject to the Major Accidents Ordinance, have no basis for the assessment of the hazards to a dyke.

For this reason it seems more practical, similar to the discussion about VAwS-installations, to make case distinctions for establishments. The following case distinctions can be made:

- position of establishments behind a public dyke ***or*** closed to surface water without any protection facilities (figure 1)
- dykes complying with DIN 19712 ***or*** not

Another distinction can be made according to warning times. For old dykes whose stability can be insufficient, as shown in many cases in the year 2002, a sufficient warning time can not be assumed due to possible rapid dyke failures. In opposition to a dyke breach the hazard of a dyke overflow can be predicted with the help of new warning systems, which have been established in the recent years. So a warning time of several hours or days is usually given for acute risks of dyke overflows.

With these distinctions suitable measures can be derived to secure establishments against flood depending on the individual risk potential. The described case distinction is graphically shown in **figure 4**.

Due to the potential risk of a dyke overflow, all establishments in flood-prone zones have to be considered. Operators of establishments located behind dykes complying with DIN 19 712 have normally enough time to secure their establishments in case of a flood. The state-of-the-art of safety technology can be achieved by technical as well as by management measures. It must be checked in each individual case, which measures are most favourable for the respective establishment. In opinion of the authors all measures have to be defined in an alarm and emergency plan also including those establishments, which are subject only to the “basic obligations” according to

the Major Accidents Ordinance (i.e. “lower tier” establishments according to the EU Seveso-Directive).

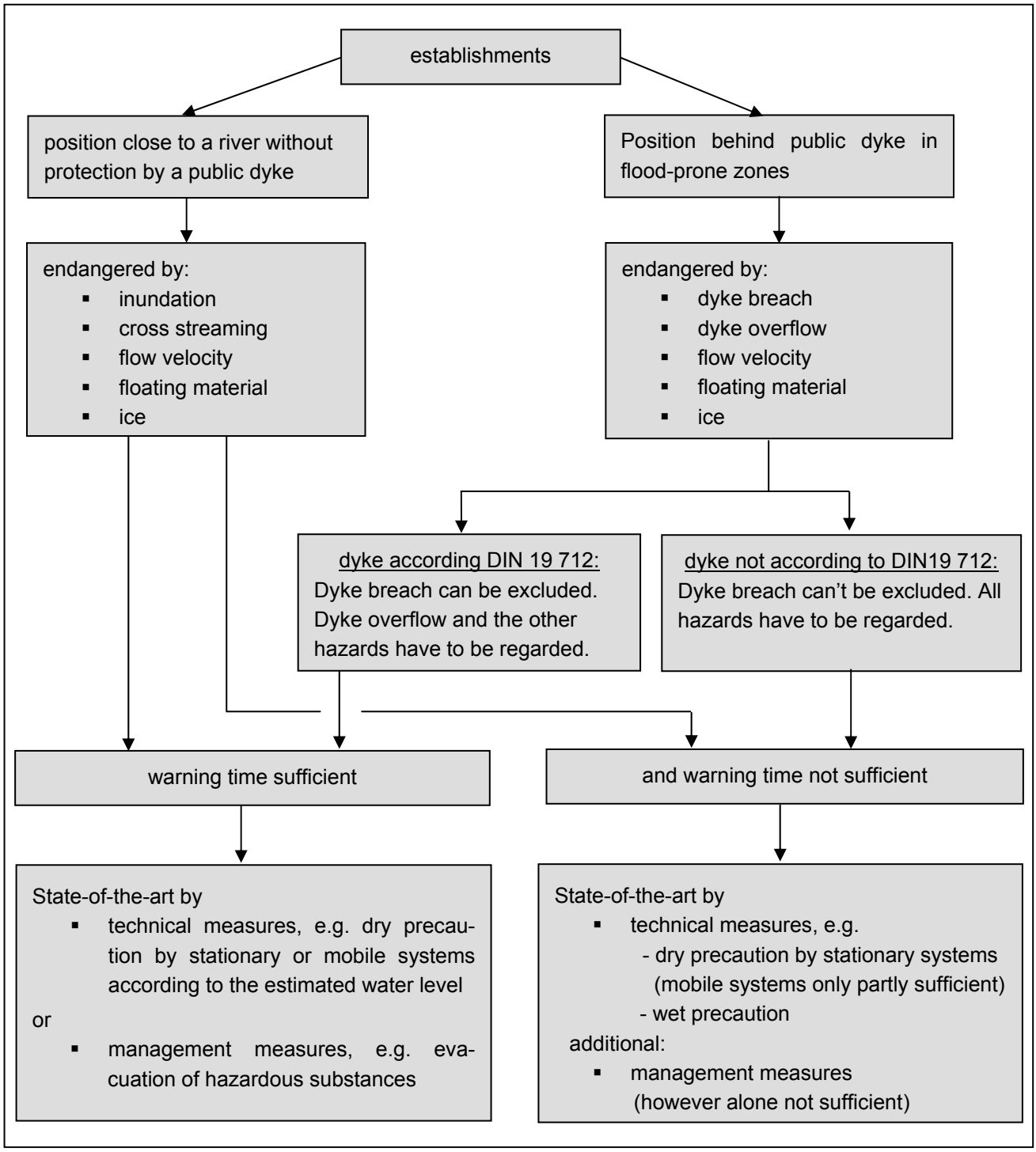

Figure 4: Case distinction for the derivation of possible requirements on establishments

Moreover, the hazard of a dyke breach has to be considered for those establishments located in a flood-prone zone behind dykes, which do not comply with DIN 19712. As for these cases the warning time is not sufficient, a protection of the establishments is required by stationary measures. “Wet precautions”[3], which are hardly used in practice, are principally also conceivable. Mobile protection systems and management measures can additionally be used.

The case distinction as shown in figure 4 represents a generalization, which is based on plausible and comprehensible distinctive marks. With such a case distinction the legislator is able to formulate risk proportional requirements. Nevertheless it must be assumed that there are individual cases, which differ from this case distinction. Divergent cases have to be individually evaluated by the operator or by an expert.

2.6 Requirements for liquefied gas vessels, which aren’t subject to the Major Accidents Ordinance

The requirements for the storage of liquefied gas are given in different rules, e.g. the pressure vessel rules. Additionally storage vessels with 50 t or more capacity are subject of regulations of the Major Accidents Ordinance. None of these codes includes special rules for installations in flood prone zones. Therefore the authors suggest a special ordinance to regulate all requirements on flood protection for liquefied gas vessels in flood-prone zones corresponding to the rules in the ordinances for VAwS-installations. The requirements must include structural measures for the buoyancy safety as well as safety facilities for material and ice drift.

The following distinction of the possible requirements should analogously be carried out for the case distinction according figure 4 with the corresponding boundary conditions also for liquefied gas storages:

<u>Installations behind dykes, which do not comply with DIN 19 712:</u>

Hazards: dyke breach
dyke overflow
flow velocity
drifting material
ice drift

[3] For the terms „wet precaution“ and „dry precaution“ see 2.10.

Requirements: suitable structural requirements
alternative: stationary measures, such as flood protection wall
mobile protective measures only partly sufficient

Installations behind dykes, which comply with DIN 19 712 as well as installations without protection by public dykes:

Hazards: Dyke overflow
flow velocity
drifting material
ice drift

Requirements: suitable structural requirements
alternative: stationary measures, e.g. a wall, and mobile protective measures

Management measures, such as evacuation, are not possible for liquefied gas vessels due to safety reasons. Therefore they are no alternatives to technical safety measures for liquefied gas storage installations.

2.7 Registration of small private fuel oil tanks and liquefied gas vessels

As the surveys in the model regions have shown, the registration of private fuel oil tanks and liquefied gas installations is partly very difficult for the authorities. Private fuel oil tanks with less than 1,000 l are principally no subject to any inspection obligation and therefore are not notified to the authorities either. Installations with a size of 1,000 - 10,000 l are subject to a single inspection. They are however in many cases not notified to the authorities, too. Although many heating oil installations are notified in the frame of permissions under building law to the responsible municipal administration, the water authorities are not informed about their existence.

The knowledge of authorities on private fuel oil tanks gets relevant, if the installations are located in flood-prone zones. In this case the installations have to be inspected every 5 years. The storage of small quantities (< 5 m³ or < 3 t) of liquefied gas is also problematic, because these installations are no subject to any approval duty. With the

exception of North Rhine-Westphalia a duty of notification does not exist. Therefore the authorities do not know the location of most small liquefied gas vessels.

The authors recommend the following measures as assistance for the authorities:

1. Obligatory information transfer about the locations of heating oil tanks and small liquefied gas vessels from the building departments to the water authorities

2. Introduction of a notification duty for liquefied gas vessels including small vessels

2.8 Revision of technical rules for consideration of flood protection

An intensive examination of the technical rules for installations or establishments showed that concerning the design of installations against flood only few remarks or specifications exist. In order to ensure a high standard of flood protection the present rules have to be judged as incomplete and insufficient for the design of installations and establishments. Therefore, no recommendations for a revision of the existing rules can be derived. Due to this situation the authors propose to work out a technical code for flood protection. This includes technical requirements for design and operation. The rules should be applied on establishments according to the Major Accidents Ordinance, installations according §19g Federal Water Act and storage installations for liquefied gas.

2.9 Surveys in the model regions

The results of the surveys in the model regions can be summarized and generalized as follows:

1. Decision structures

   The decision structures within the chemistry parks in Germany are very different. In Leverkusen there is a central decision level, which is responsible for the whole industry park. In case of a flood this central staff collects and evaluates all information and decides about necessary precaution measures. It exists a special alarm and emergency plan for the whole industry park, in

which all required measures for flood protection are elaborated. Furthermore the operators of establishments dispose of their own individual alarm and emergency plan.
In other industry parks, like in Bitterfeld, no central staff exists to coordinate the measures for flood protection. From the beginning the chemistry location Bitterfeld has been arranged for independent enterprises, without a central decision level for the complete location. Due to the lack of this structure there is no alarm and emergency plan for the whole site.

In smaller and medium enterprises a sufficient alarm and emergency plan for flood protection often does not exist.

2. Acting during flood

As the analysis of the management measures in the examined enterprises shows, a significant fault in technical and management measures in the enterprises during the flood in August 2002 could not be recognized. All executed measures can be judged as foresighted and aim oriented.

3. Information transfer and planning

As the surveys show numerous measures for flood protection were not coordinated between the local authorities and the management of the enterprises during the flood in 2002. The reason was an insufficient information transfer on the implemented measures. Due to the extent of the flood disaster some actions still seem understandable. Considering the present plannings for renewing public dykes the insufficient information transfer and the partly different interests between authorities and operators are still obvious.

Moreover, the lack of coordination between internal and external alarm and emergency plans has been recognized as one of the main deficits.

4. Enforcement of the technical rules

The surveys in the frame of this research project show that most of the operators have implemented the technical rules.

2.10 State-of-the-art of flood protection

The state-of-the-art of flood protection is described by

- suitable measures for “dry precautions” as well as “wet precautions”,
- available measures which are deemed to indicate the practical suitability
- technical possibilities for the refitting and
- management measures.

The measures for the “dry precaution” can be summarized as follows:

- raising of the area level
- construction of dykes around the area
- construction of stationary or mobile protection systems
- installation of channel closures
- tanks for sewage storage during a flood event
- safeguarding of the energy supply
- safeguarding of the utility supply for establishments
- safeguarding of the communication channels for the establishments

The measures for the “wet precaution” can be summarized as follows:

- buoyancy safety of tanks by fixing of the tanks on a floor plate or by a sufficient covering depth for underground installations
- application of certified tanks which resist the outer water pressure
- location of ventilations above the waterline
- waterproof type of connections, which are below the waterline
- no basement using
- safeguarding of energy and utility supplies
- location of endangered electric facilities, such as main distribution facilities above the waterline
- safeguarding of the installations and pipes against floating material and ice drift by baffles

- high storage of dangerous substances on steel or concrete constructions
- block down systems for establishments
- protected process control systems for a safe shut-down of installations and establishments
- safeguarding of the communication systems

In principle, all refitting possibilities to save existing installations must be checked individually. Normally the measures for the dry precaution are preferred. If the measures for dry precautions can not be executed, the possibilities of wet precaution have to be checked. Most of the measures of wet precaution are also applicable as refitting measure for establishments according to the Major Accident Ordinance, VAwS-installations and liquefied gas vessels.

The management measures for flood protection enclose the following aspects from the view of the enterprises or the responsible industrial park company:

- collecting information about:
  - possible water levels at the location,
  - river characteristics
  - public precaution measures
- elaboration of a flood protection concept according to the possibilities of the dry and wet precaution
- elaboration of internal alarm and emergency plans under special consideration of flood, incl. emergency planning for establishments with “extended obligations” according to the Major Accidents Ordinance (“upper tier” establishments according to the EU Seveso-Directive) and coordination with the precaution measures of the disaster control authorities
- coordination of internal und external alarm and emergency plans with the responsible authorities
- testing of the alarm and emergency plan with the resposible authorities
- in the case of a flood:
  - communication with the disaster control authorities,
  - assessment of information and
  - implementation of measures for flood protection
- in the case of a spill organization of measures to reduce the release of hazardous substances in the environment

In the presented research report the possibilities for the prevention of a spill into the environment in the case of a leakage are also described. It has to be stated that a hold-back of pollutants is hardly possible during a flood. Chances for a hold-back exist only for floating substances, like oil, whose emission can locally be prevented by oil barriers under certain circumstances.

Furthermore, numerous methods for the calculation of the spill of pollutants via the water path are introduced and critically discussed. It has to be noticed that there is no method, especially for solved substances, to estimate the spill extension during a flood. The existing alarm models for Rhine and Elbe are developed for normal water levels and not extreme floods. Therefore further research efforts are required to clear this deficit.

3 Protection against storms and earthquakes

Today the state-of-the-art in civil engineering for risk determination and delimitation of theses hazards is very well described regarding the construction standards and the degree of regulation in Germany. This includes also complicated computer based static analysis. Nevertheless, the reliable determination and delimitation of the complete risk of an establishment must be analysed, especially, if construction risks and operational risks due to the presence of hazardous substances occur at the same time and have a negative combination effect.

The authors determined the following deficits:

- Technical safety deficits:
  - conceptional difficulties in the evaluation of combined risks, e.g. construction risk in combination with operational risks due to the presence of hazardous substances.
  - increased design requirements according to the new DIN 1055-4 (impact on constructions part 4: wind) for the northern parts of Germany, particularly relevant for light production constructions.
  - frequently inappropriate assessment of storm hazard caused by interferences resulting from the surroundings topology.
  - ignorance of the protection aim of DIN 4149 (Constructions in German earthquake prone areas) (i.e. personal security); in the case of an earthquake considerable plastic deformations can be tolerated according to DIN 4149, which, however, could cause releases in the environment at installations.
  - unknown seismic vulnerability for most establishments and installations located in German earthquake prone areas.
  - missing regulation of emergency management measures after an earthquake in German building laws.

- Safety deficits in the licensing proceedures:

  - construction standards with different state-of-the-art.
  - construction safety deficits caused by the issue of environmental permits according to the BImSchG including the building licence (co-permissions) (insufficient considering the German building regulations).
  - systemic safety deficits in the licensing procedure according to BImSchG like missing consideration of the official expertises on construction safety in the official expertises on installation safety as well as the safety reports according to the Major Accidents Ordinance.
  - insufficient knowledge about protection aims and construction standards in the frame of BImSchG permissions, especially relevant for establishments according to the Major Accidents Ordinance.
  - insufficient information exchange between process engineers and civil engineers during the planning and examination process for installations and establishments.

As earthquakes and storm are not sufficiently considered for an optimal hazard defence, the authors recommend completing the 9th BImSchV (ordinance on the licensing procedure according to the BImSchG) with an obligation for the BImSchG authority for a close cooperation with the building authority in case of increased construction risks caused by earthquakes or storm. The examination and approval reports of the building supervision have to be integrated into official expertises and inspection reports according to 12th BImSchV in order to determine the combined risk of an establishment correctly.

It is further recommended to determine a coordination between all responsible authorities, the operators of the establishments and if necessary external experts (according to § 29a BImSchG on installation safety). Furthermore the authors recommend the elaboration of a rule “technical rules for installation safety in storm and earthquake prone areas“ as a suitable method to sensitize the involved parties.

Concerning the protection aims DIN 1055-4 and DIN 4149 are particularly problematic. Both standards like all building regulations according to DIN 1055-100 are elaborated to minimize the construction risks for private and public buildings. Their primary protection aim is to avoid losses of human life. The protection of material and installations is regarded as secondary in the building laws and the DIN´s. This safety philosophy is not acceptable for establishments, because it is not compatible with a

modern view on risk limitation. This becomes particularly obvious in DIN 4149. This DIN shall ensure the personal security for an earthquake with a 475-year return period. But as long as no human life is endangered, the building (i.e. the installation) is allowed to be destroyed totally.

Such a scenario is unacceptable for establishments according to the Major Accidents Ordinance as small damages (plastifications) can cause a great secondary damage (release). The application of the regulations of KTA 2201 (nuclear committee), which regard this case, would be difficult, because of its conservative assessments (structure dynamic proofs of the nuclear installation).

The problems of the delimitation of seismic stress can only be solved by considerable application-oriented research efforts in the concept of a modern “performance-based seismic engineering“. Research needs are indicated in the seismic structure dynamics of many special constructions of establishments and installations. Because their seismic vulnerability is largely unknown, it can not be lowered by systematic construction measures. However, research needs consist in an even higher extent in the determination and systematic lowering of the seismic vulnerability of a complete establishment or installation, which is often, integrated into a network of internal infrastructure facilities.

The significance of this context for the safety of establishments and installations is obvious at Cologne and its surroundings in the Rhine area with its high density of chemical industries and outstanding seismic danger.

4 Mining settlements

In opposition to flood, storm and earthquake mining induced ground movements are a continuous process caused by human activities (with the exception of mining induced earthquakes). The consequences of mining to the surface area are in principle well foreseeable. Possible influences on buildings can realistically be determined and the effect on structures can be calculated by means of computer based models. With this knowledge measures can be derived to ensure the stability of the buildings. Furthermore, the slowness of the settlement process in connection with a monitoring permits adequate corrections of the security concept. Unlike the influences caused by storm and earthquakes an obligatory technical set of rules is missing for the design of buildings against mining induced ground movements.

According to present legislation the mining company is responsible for the execution of suitable measures to prevent hazard caused by mining. The guidelines worked out by the standardisation committee for building and construction represent only recommendations for the buildings in the area of underground mining.

By the so called “public frame operation plan” for mining operators of establishments and installations will be informed about a planned mining. Expected ground movements are investigated by the mining company and checked independently by the responsible mining authorities. Type and extent of the protection measures against mining induced influences are determined by mutual agreement between the mining company and the company on the surface.

Due to the specific requirements of the mining company the investor of new establishments or installations has to adapt his plant to the mining induced influences (adjusting duty).

In special cases the government in North Rhine-Westphalia can determine building restriction areas, in which the construction, expansion or modified use of the plant may be carried out only with the agreement of the mining authorities. The design for a damage free construction against influences from mining settlements is in the responsibility of the plant owner and the mining company. According to the present legal situation a control or check of the safety precautions is not provided by the authorities. The mining authority can only require measuring of ground movement according to § 125 BBergG (Federal Mining Law) to observe the influences of mining. Furthermore, if unacceptable damages of the property (establishments or installations) on the surface area have to be expected, the mining authority can restrict or forbid the extraction of mineral resources according to a judgement of the Federal Administrative Court.

The authors recommend a supervision of establishments and installations in the mining areas by an independent authority. Furthermore the authors recommend carrying out a detailed topographic mapping of the present and future mining areas including the forecast settlement lines and all establishments on the surface area. An example has been worked out by the authors of this report.

5 Alarm and emergency planning, disaster control

5.1 Obligations for information transfer

In the Major Accidents Ordinance the demand to set up an internal alarm and emergency plan (AGAP) refers only to establishments with “extended obligations”. Internal alarm and emergency plans for establishments with only “basic obligations“ can only be requested after an individual consideration by the authorities. So in principle it does not exist any AGAP for those establishments.

On the other hand the enterprises are obliged to present information, which the local authorities must consider in their external alarm and emergency plans. Therefore, the authors recommend extending the obligation of elaborating internal alarm and emergency plans also on establishments with only “basic obligations”. Concerning flood plains and flood-prone zones an alarm and emergency plan should always be presented for all establishments (with basic or extended obligations).

5.2 Examination of alarm and emergency plans

The examination of alarm and emergency plans is not clearly regulated in the ordinances and laws. Although internal alarm and emergency plans for establishment with “extended obligations” have to be presented in licensing procedures, in most cases an examination of these documents does not take place. Therefore the authors recommend an examination obligation for alarm and emergency plans to be enforced by the licensing authority or experts according to § 29a BImSchG. This demand can be achieved by an amendment in the ordinances according to the BImSchG.

5.3 Forecast of events

After the experiences of 2002 alarm systems to predict floods have importantly been improved. The information transfer via internet can now be considered as excellent.

6 Suggestions for enforcement assistance and public relations

In the context of this research project different suggestions for enforcement assistance and public relations have been developed. They are annexed to this research report and cover the following topics:

Annex 1 Suggestion for a guideline for the evaluation of documents submitted in a permission request with respect to flood, storm, earthquake and mining settlements according to the requirements of the Major Accidents Ordinance

Annex II Suggestion for a guideline for the examination of a safety report according to the Major Accidents Ordinance with respect to flood, storm, earthquake and mining settlements

Annex III Suggestion for a guideline for the inspection of establishments with respect to flood, storm, earthquake and mining settlements

Annex IV Suggestion for a guideline for the examination of private fuel oil tanks and liquefied gas vessels concerning hazards by floods.

Annex V Assistance in public relations

Annex VI Pattern and standards for an internal (operational) alarm and emergency plan against flood (AGAP HW).

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