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Directive on the Safety of Water Retaining Facilities

Part E: Emergency plan

Note: This document is a preprint of Part E of the Directive on the Safety of Water Retaining Facilities (revised version, 2014-2015).
The Directive is addressed to both the relevant supervisory authorities and the operators of water retaining facilities. It defines and explains terminology contained in the legislation governing water retaining facilities in order to ensure uniform practical implementation. Deviations from the Directive are permissible as long as they facilitate the attainment of the specified safety objectives.

This version replaces all earlier versions.

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1 Introduction

1.1 Objective of the emergency plan and content of this part of the Directive

In accordance with Chapter 2, Section 2 of the Water Retaining Facilities Act (WRFA) and Chapter 2, Section 3 of the Water Retaining Facilities Ordinance (WRFO), the objective of the emergency plan is to specify the precautions that have to be taken by the operator of a water retaining facility in the event that the safe operation of the facility can no longer be guaranteed.

This part of the Directive describes the requirements relating to the emergency plan that have to be met by the operator. Section 1.2 contains a description of the duties and responsibilities of those organisations that have to take action if an event should occur. The preparation of the emergency plan is dealt with in section 1.3. Sections 1.4, 1.5 and 1.6 focus on the special aspects of the requirements relating to the emergency plan for certain types of water retaining facilities. The concept for alarming the population is described in section 2, which also describes the responsibilities on the part of the operator of a water retaining facility with respect to alarming the population. Section 3 describes how the emergency plan has to be incorporated into the emergency regulations in accordance with Article 25 of the WRFO. The management of the emergency plan is dealt with in section 4.

Alarming the population, issuing instructions regarding their behaviour and ordering an evacuation in an emergency if deemed necessary, are the responsibility of the federal, cantonal and municipal civil protection authorities. The requirements relating to the emergency response planning of these authorities are not dealt with in this part of the Directive.

In order to ensure that an emergency can be dealt with successfully, the operator's emergency plan must be coordinated with the emergency response planning of the civil protection authorities. In particular, the means of communication and the content of the exchanged information have to be closely coordinated. The applicable requirements form an integral part of this part of the Directive.

1.2 Overview of responsibilities in the event of an emergency

In the event of an emergency that could result, or has resulted, in an uncontrolled discharge of a large quantity of water from a water retaining facility, the following organisations are responsible for dealing with the emergency:

- The operator's emergency response organisation;
- The emergency response organisation of the municipal and cantonal civil protection authorities;
- The National Alarm Centre.

The responsibilities of the individual organisations are listed below in order to make a clear distinction between their respective roles and duties. Any deviations from these defined responsibilities must be agreed between the directly involved organisations, and fully documented.

<u>Responsibilities of the operator of the water retaining facility</u>

In the event of an emergency, the operator of the facility is responsible for the following tasks:

- Taking the necessary measures to prevent a breach of the dam and an uncontrolled discharge of a large quantity of water – here, depending on the situation the operator has to call on the support of the facility's qualified professional (surveillance level 2) and, where available, the engineering and geology experts (surveillance level 3). Where necessary, the operator should also call on the professional support of other specialists and the supervisory authority (surveillance level 4);

- Ongoing assessment of the situation and communication to the cantonal civil protection authority concerning the current situation – this information must be communicated using the means agreed between the operator of the water retaining facility and the cantonal civil protection authorities, and as specified in the emergency regulations. The content of the information depends on the standardised danger levels defined in sections 2.1.2 and 3.4;
- In the case of facilities equipped with a water alarm system (cf. sections 2.3 and 3.4), activation of the water alarm as soon as the situation can no longer be kept under control or an uncontrolled discharge of a large quantity of water is likely or has already occurred (danger level 5);
- Notification of the supervisory authority about the current situation as soon as the most urgent measures have been taken.

Responsibilities of the cantonal civil protection authorities

The term “cantonal civil protection authorities” refers to all official cantonal and municipal bodies that intervene in the event of an emergency. As a rule they are governed by the cantonal management organisation.

The canton concerned or the above mentioned bodies are responsible for intervening in emergencies in order to protect the population. Their main duties are:

- Receiving warnings and information from the operator of the water retaining facility – these must be communicated using the means agreed between the operator of the water retaining facility and the cantonal civil protection authorities, and as specified in the operator’s emergency regulations. The content of the information depends on the standardised danger levels defined in sections 2.1.2 and 3.4;
- Ordering the necessary measures to be taken to deal with the emergency in accordance with their operational concept and planning. These measures include:
  - Sounding a general alarm based on the corresponding danger level;
  - In the case of water retaining facilities equipped with water alarm systems, triggering a water alarm upon the instructions of the operator (fall-back level);
  - Communication of behaviour instructions for the population via their standard channels (radio, television, Internet);
- Forwarding the necessary information to the National Alarm Centre and other civil protection authorities via the standard civil protection channels.

Responsibilities of the federal civil protection authorities

At the federal level, the National Alarm Centre is the sole civil protection body that is responsible for taking action in the event of an emergency. One of its main tasks is to establish contact between the canton and the federal authorities. In the event of an emergency, its duties are as follows:

- To inform all involved units of the federal administration and the federal emergency organisation (BST ABCN), as well as all other organisations in Switzerland and abroad, depending on the gravity of the situation;
- To record a description and depiction of the situation in the corresponding electronic tool;
- To support the involved canton(s) as necessary.

Responsibilities of the supervisory authority

In the event of an emergency, the relevant supervisory authority (for large water retaining facilities, the federal supervisory authority; for small facilities, the cantonal supervisory authority) primarily has to support the operator as necessary. It may also order the implementation of the following measures:

- Operational or technical measures with the aim of preventing a breach of the dam or an uncontrolled discharge of a large quantity of water, or lessening the potential consequences;
- Raising the danger level defined by the operator of the water retaining facility.

1.3 Overview of responsibilities associated with the formulation of an emergency response concept and the installation of alarming systems

The formulation of an emergency response concept and installation of alarming systems are intended to support the preparation of an emergency response as described in section 1.2. The responsibilities of the various organisations involved are listed below in order to make a clear distinction between their respective roles and duties. For a schematic overview, see Figure 1. Any deviations from these defined responsibilities must be agreed between the directly involved organisations, and fully documented.

Responsibilities of the operator of the water retaining facility

The operator is responsible for the following tasks in particular:

- Calculation of the zones that would be flooded in the event of a breach of the dam, and depiction of those zones on an inundation map (cf. section 3.2).
  The cantonal civil protection authorities use this map as the basis for preparing their emergency response planning and evacuation plans.
- Agreeing with the cantonal civil protection authorities on the means of communication to be used in the event of an emergency.
  Here the method of transmitting warnings (danger levels) must be defined, together with the necessary tools to be used and maintained.
- Formation of an internal organisation responsible for responding to emergencies, and specification of the applicable procedures and precautionary measures for responding to emergencies, including their integration into the emergency regulations.

These elements form an integral part of the operator's emergency regulations that have to be approved by the relevant supervisory authority (cf. section 3).

In the case of water retaining facilities that are equipped with a water alarm system (cf. section 2.3), the operator is also responsible for the planning, installation and maintenance of the on-site components of the system. This must be done in accordance with the instructions of the Federal Office for Civil Protection (FOCP) and in coordination with the cantonal civil protection authorities, as well as under the supervision of the FOCP.

Responsibilities of the municipal and cantonal civil protection authorities

Their main duties are:

- To develop their emergency response plan based on the inundation maps (cf. section 3.2) and emergency response dossiers (cf. section 3.6) produced by the relevant supervisory authority, as well as on any other pertinent information;
- Specification of the required warning devices in the near zone in accordance with the inundation map (for water retaining facilities equipped with a water alarm system).
- Identification of specially endangered locations (e.g. chemical facilities) and preparation of the plan for evacuating the population from the inundation zone (e.g. designation of assembly points, production of evacuation plans);
- Specification of means of communication together with the operator.

In addition, established processes in the event of an emergency do apply, especially concerning communication with the National Alarm Centre.

Responsibilities of the federal civil protection authorities

The National Alarm Centre is responsible for incorporating the information from the inundation map (cf. section 3.2) and the emergency response dossier (cf. section 3.6) into its intervention systems. The inundation map and emergency response dossier have to be provided by the relevant supervisory authority.

The duties of the Federal Office for Civil Protection are as follows:

- Installation of the system for alarming the population, together with the cantons;
- Regarding the water alarm system
  - Specification of the technical requirements;
  - Assistance with, and approval of, the conception and technical aspects of the operator's water alarm system;
  - Monitoring and acceptance of the installation of the alarm system;
  - Supervision of the central control mechanism of the alarm system (national);
- Supervision of the preparation and distribution of the cantonal evacuation plans (cf. Article 27, WRFO);
- On behalf of the Swiss Federal Office of Energy (SFOE), review of the technical systems included in the emergency regulations relating to warnings and communication.

Responsibilities of the supervisory authority

The responsibilities of the relevant supervisory authority (in the case of large water retaining facilities, the federal supervisory authority; for small water retaining facilities, the cantonal supervisory authority) are as follows:

- Decision regarding the extent of the emergency regulations for water retaining facilities designed to protect against natural hazards or prevent water flows, and for very small water retaining facilities;
- Verification and approval of elements of the operator's emergency regulations;
- Forwarding the inundation maps and emergency response dossier to the relevant cantonal civil protection authority and the National Alarm Centre;
- Ordering the installation of a water alarm system in water retaining facilities with a reservoir with a capacity below 2 million cubic metres (cf. Article 11, WRFA), if the SFOE identifies a high level of risk in the inundation zone;
- In the case of facilities equipped with a water alarm system (cf. section 2.3): specification of the structural requirements concerning the water alarm centre and the observation sites.

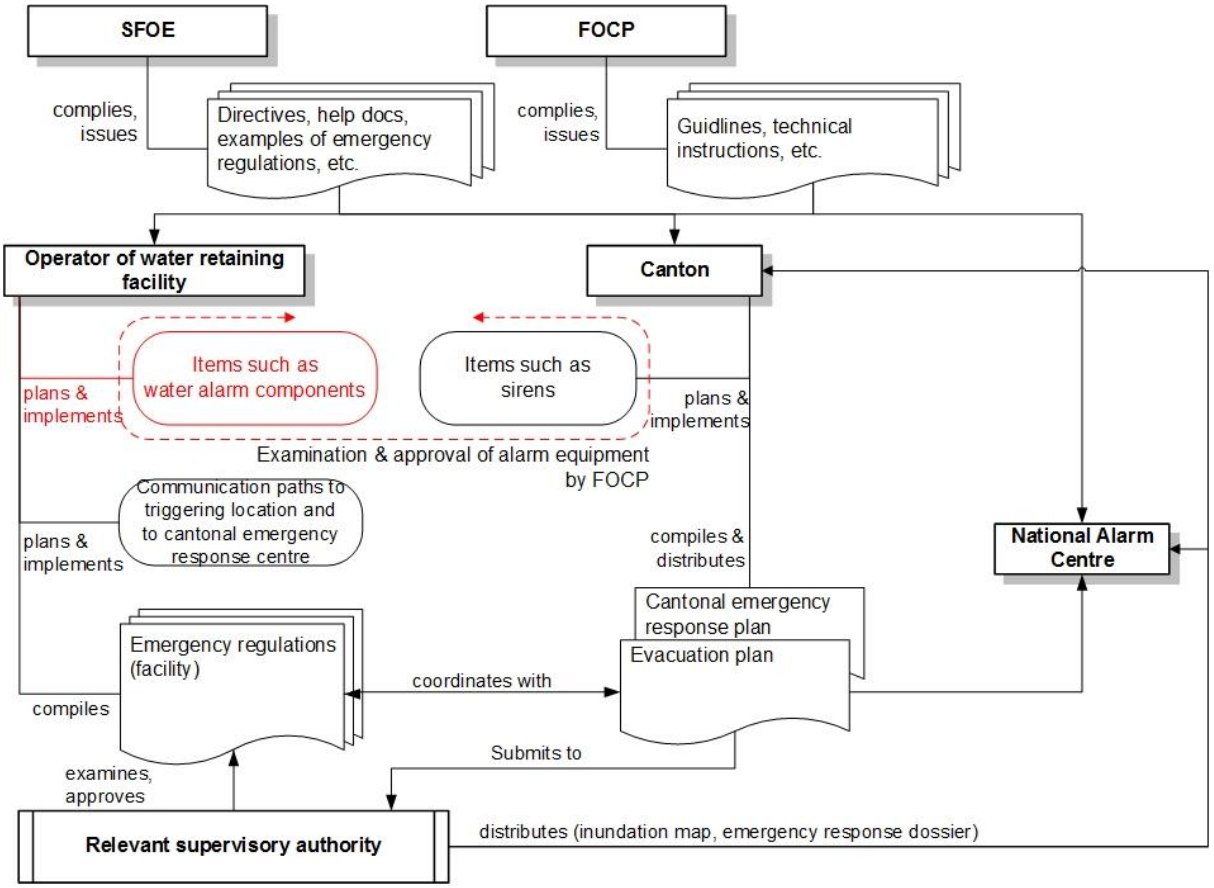

Figure 1: Organisations involved in the preparation of the emergency concept for water retaining facilities

1.4 Emergency regulations for water retaining facilities designed to protect against natural hazards

The precautions for dealing with emergencies in water retaining facilities that are designed solely to protect against natural hazards have to be incorporated into the canton's emergency response plan for dealing with natural hazards. An internal emergency response organisation does not have to be formed for the water retaining facility, and the emergency response regulations then only contain the inundation map (cf. section 3.2) and an appropriate emergency response dossier (cf. section 3.6).

1.5 Emergency regulations for run-of-river facilities

As a rule, the flood waves that are created following the breach of a run-of-river facility largely remain in the riverbed. If this is the case, the relevant supervisory authority should adapt the recommendations cited in this part of the Directive to the above circumstances. This applies to the components of any water alarm system to be installed, as well as to the content and structure of the emergency regulations. Here, appropriate attention should be paid to the use of the river as a recreation zone and for shipping purposes.

1.6 Emergency regulations of water retaining facilities that do not meet the size criterion specified in the WRFA

In the case of water retaining facilities that do not meet the size criterion specified in Article 2, paragraph 1 of the WRFA, the operator does not normally need an internal emergency organisation. In this case the emergency regulations are limited to an inundation map (cf. section 3.2) and an appropriate emergency response dossier (cf. section 3.6).

2 Alarm concept

2.1 Alarming the population

2.1.1 Systems

In the event of an emergency, the emergency response systems of the civil protection are engaged, in particular those designed to distribute instructions concerning the behaviour of the population and, if necessary, orders for the population to evacuate the area. The deployment of these systems is the responsibility of the federal, cantonal and municipal civil protection authorities.

Throughout Switzerland, the population is alarmed by sounding a general alarm (primarily with the aid of stationary and (if necessary) mobile sirens, as well as by telephone or via other media (cf. Article 4, Federal Ordinance on Warnings and Alarms). The relevant cantonal civil protection authority is responsible for the installation and operation of alarm systems.

In addition to the general alarm installations, in accordance with Article 11 of the WRFA water alarm systems have to be installed and operated in certain water retaining facilities (cf. section 2.3.1). The operation and maintenance of the components of water alarm systems must be carried out in accordance with Article 20 of the Federal Ordinance on Warnings and Alarms and the instructions of the Federal Office for Civil Protection, as well as upon consultation with the respective cantonal civil protection authority.

2.1.2 Danger levels

In the event of an emergency, the operator of the water retaining facility is responsible for notifying the civil protection authority based on the standardised danger levels 1 to 5 in accordance with the Federal Ordinance on Warnings and Alarms (the same levels are used in relation with natural hazards). The individual danger levels and how to trigger them are specified in the operator's emergency regulations (cf. strategy for dealing with emergencies, section 3.4). The population is informed or warned about the danger in accordance with Figure 2 using the corresponding civil protection systems.

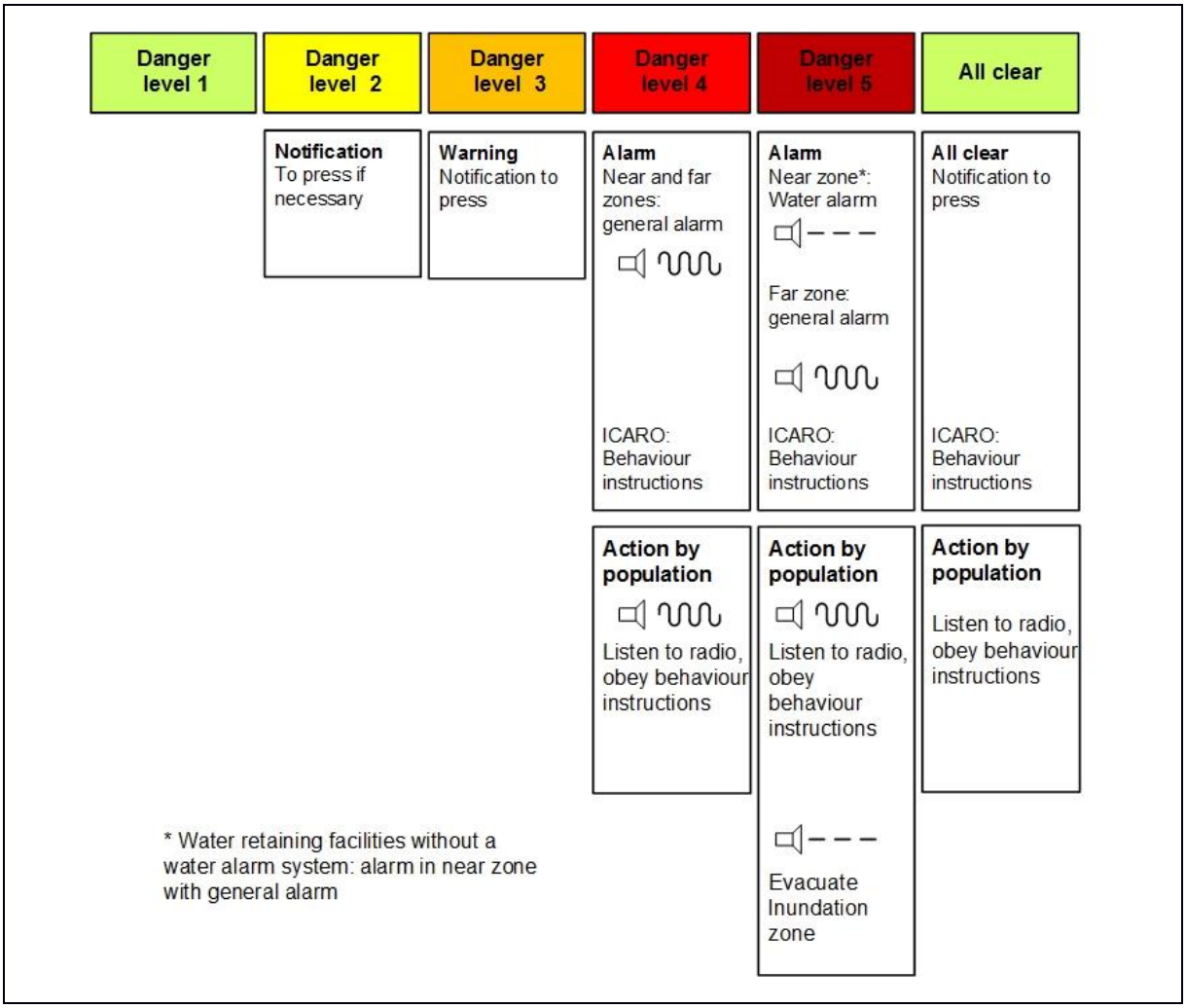

Figure 2: Informing and alarming the population in the event of a possible uncontrolled discharge of a large quantity of water (definition of near zone, cf. Figure 4)

2.2 General alarm

2.2.1 Alarming

In the event of the threat or occurrence of an uncontrolled discharge of a large quantity of water, the population is alarmed by the cantonal civil protection authority, which sounds a general alarm. When a general alarm is triggered, the population are required to listen to the radio and obey the instructions that are broadcast (cf. Figure 2).

2.2.2 Duties of the operator of the water retaining facility

The operator of the water retaining facility is responsible for assessing the situation on site and informing and warning the cantonal civil protection authority. It must have the means necessary to master the various associated tasks. This includes the following items (cf. Figure 3:

- A readable gauge for measuring the water level in the upper section of the dam (including in the event of a flood);
- Provision of the necessary communication tools in accordance with section 3.5.2, “Warnings and communication”.

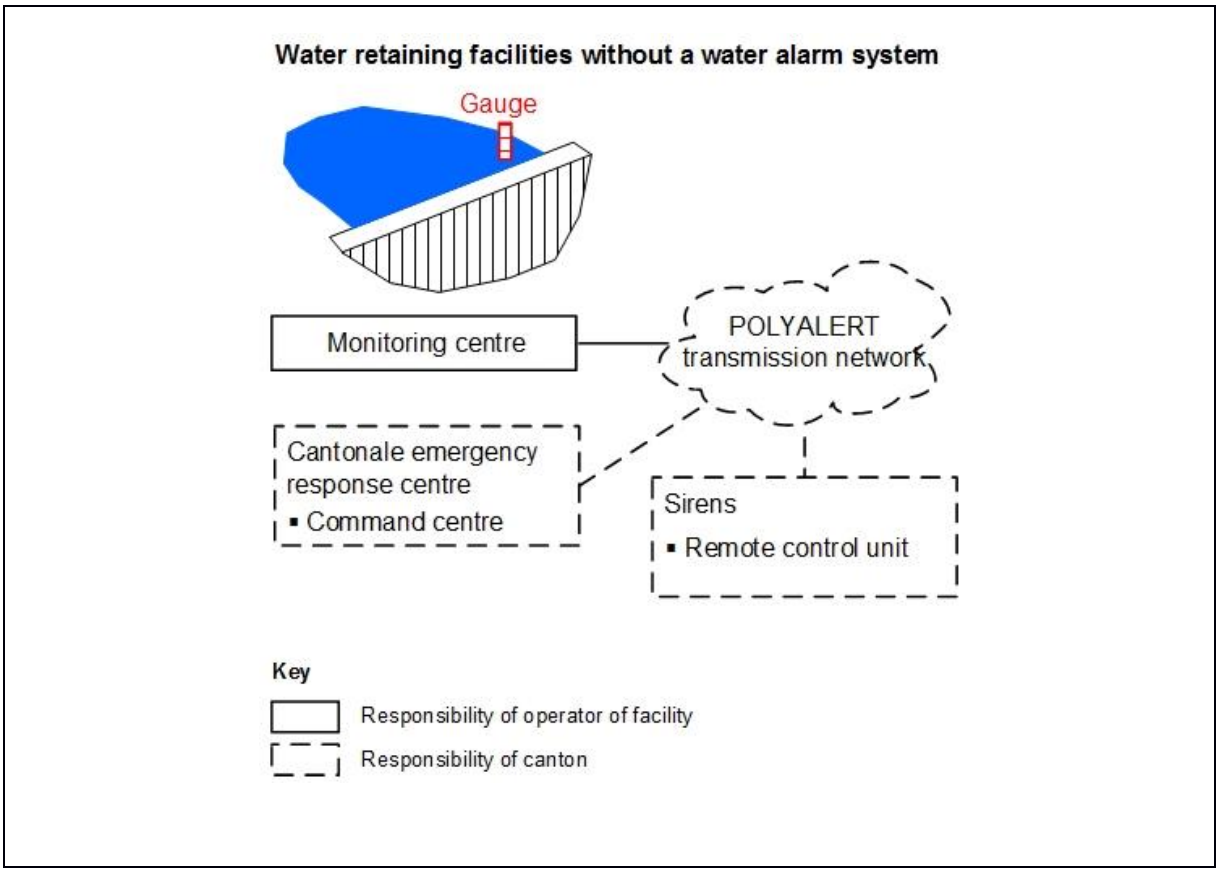

Figure 3: Schematic depiction of the system components in water retaining facilities without a water alarm system (example). The monitoring centre is the location from which the operator of the water retaining facility is able to monitor the status of the facility or observe, control and interpret the measurement data.

2.3 Water alarms

2.3.1 Alarming

A water alarm system must be installed and operated in the following facilities (cf. Article 11, WRFA and Article 26, WRFO):

- Facilities with a reservoir capacity of more than 2 million cubic metres;
- Facilities with a reservoir with a capacity below 2 million cubic metres if stipulated by the relevant supervisory authority, should the SFOE identify a high level of risk in the inundation zone.

  Note: This regulation should only apply to water retaining facilities that are subject to direct federal supervision. If this is not the case, a handover of supervision from the canton to the SFOE should be considered in accordance with Article 24, WRFA.

In the near zone of these facilities (i.e. the area that would be flooded within two hours following a sudden total breach of the dam – cf. Figure 4), in the event of a threatening or occurring uncontrolled discharge of a large quantity of water the operator must sound the water alarm to instruct the population to immediately evacuate the inundation zone.

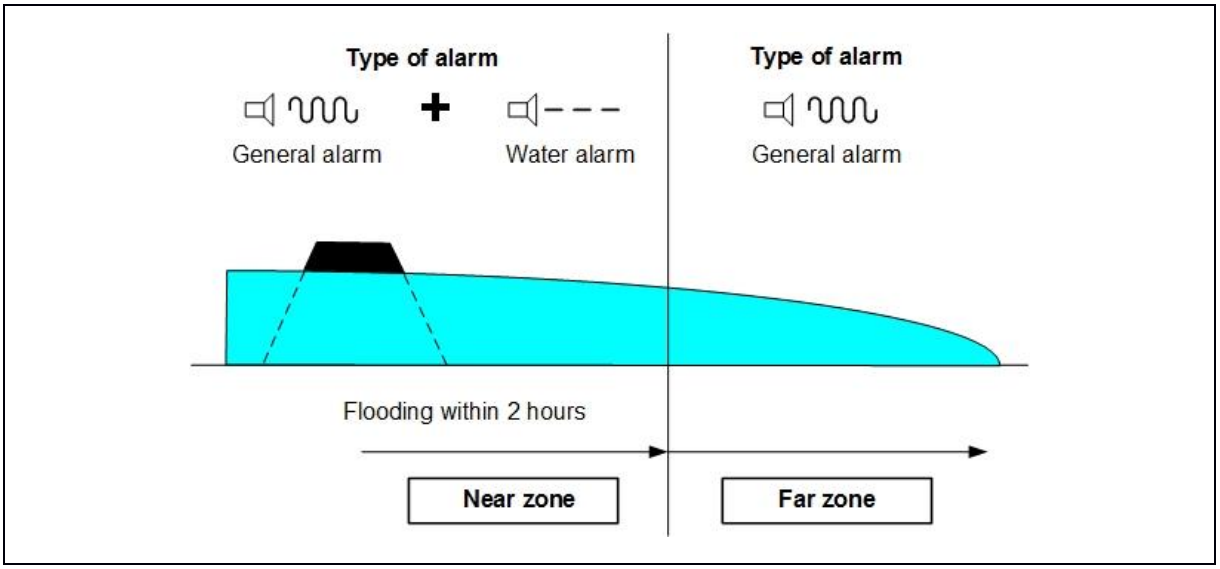

Figure 4: Schematic depiction of the method of alarming the population in water retaining facilities equipped with a water alarm system.

2.3.2 Duties of the operator of the water retaining facility

In accordance with Article 20 of the Federal Ordinance on Warnings and Alarms, the operator of a water retaining facility equipped with a water alarm system is responsible for the maintenance of the decentralised components of the system and for ensuring its constant readiness for operation. Generally speaking, the planning of siren systems and the regulations governing the operation and maintenance of the triggering and system components are the responsibility of the cantonal civil protection authority. The implementation has to be coordinated with the involved municipalities and the operator of the water retaining facility.

The elements of the water alarm system are listed below. Those marked with asterisks (***) must be installed and operated in accordance with the instructions of the Federal Office for Civil Protection (FOCP) and under the supervision of the latter. The federal government assumes a share of these costs. The installation and operation of the other elements are subject to the supervision of the relevant supervisory authority. The federal government does not assume a share of these costs.

Water retaining facilities with a reservoir with a capacity greater than 2 million cubic metres

The water alarm system comprises the following elements (cf. Figure 5):

a) Infrastructure components of the water retaining facility

- Alarm loop*** that indicates a breach of the dam;
- A readable gauge for measuring the water level in the upper section of the dam (including in the event of a flood);
- Water alarm centre that meets the following criteria:
  - Placement outside the inundation zone and in the vicinity of the facility, with line of sight to the dam. If the dam is not directly visible from the water alarm centre, placement of a protected site outside the inundation zone with line of sight to the dam and connection to the water alarm centre;
  - Reinforced steel construction (walls, ceiling at least 20 centimetres thick) or integration into rock; windows (equipped with bars) and doors that comply with resistance class 4 in accordance with standard EN 1627:2011; earthquake resistance such as to withstand the earthquake hazard for which the dam has to be verified; protected against gravity-related natural hazards such as mudslides, landslides, rockfalls, avalanches; the relevant supervisory authority may grant exemptions in justified circumstances;
  - Accommodation for the personnel of the water alarm centre and protected site, in the vicinity of the facility but outside the inundation zone;
  - Access for authorised personnel only;
  - Equipment with loop analysis*** (POLYALERT SAP);
  - Equipment with water alarm triggering component*** (POLYALERT control unit)
  - Equipment with water level indicator;
  - Equipment with voice communication system (cf. section 3.5.2, “Warnings and communication”).

b) Further water alarm triggering components***

The FOCP is responsible for deciding whether there is a need for other water alarm triggering components, especially in the vicinity of a power plant (monitoring centre), and if so, for specifying the associated requirements. The FOCP is also responsible for supervising their implementation.

Water retaining facilities with a reservoir with a capacity below 2 million cubic metres and a high risk level

The water alarm system comprises the following elements (cf. Figure 5):

a) Infrastructure components of the water retaining facility

- A readable gauge for measuring the water level in the upper section of the dam (including in the event of a flood);

- Observation site that meets the following criteria:
  - Placement outside the inundation zone;
  - Reinforced steel construction (walls, ceiling at least 20 centimetres thick) or integration into rock; windows (equipped with bars) and doors that comply with resistance class 4 in accordance with standard EN 1627:2011; earthquake resistance such as to withstand the earthquake hazard for which the dam has to be verified; protected against gravity-related natural hazards such as mudslides, landslides, rockfalls, avalanches; the relevant supervisory authority may grant exemptions in justified circumstances;
  - Access for authorised personnel only;
  - Equipment with water alarm triggering component*** (POLYALERT control unit)
  - Equipment with water level indicator;
  - Equipment with voice communication system (cf. section 3.5.2, “Warnings and communication”).

b) Further water alarm triggering components***

The FOCP is responsible for deciding whether there is a need for further water alarm triggering components, especially in the vicinity of a power plant (monitoring centre), and if so, for specifying the associated requirements. The FOCP is also responsible for supervising their implementation.

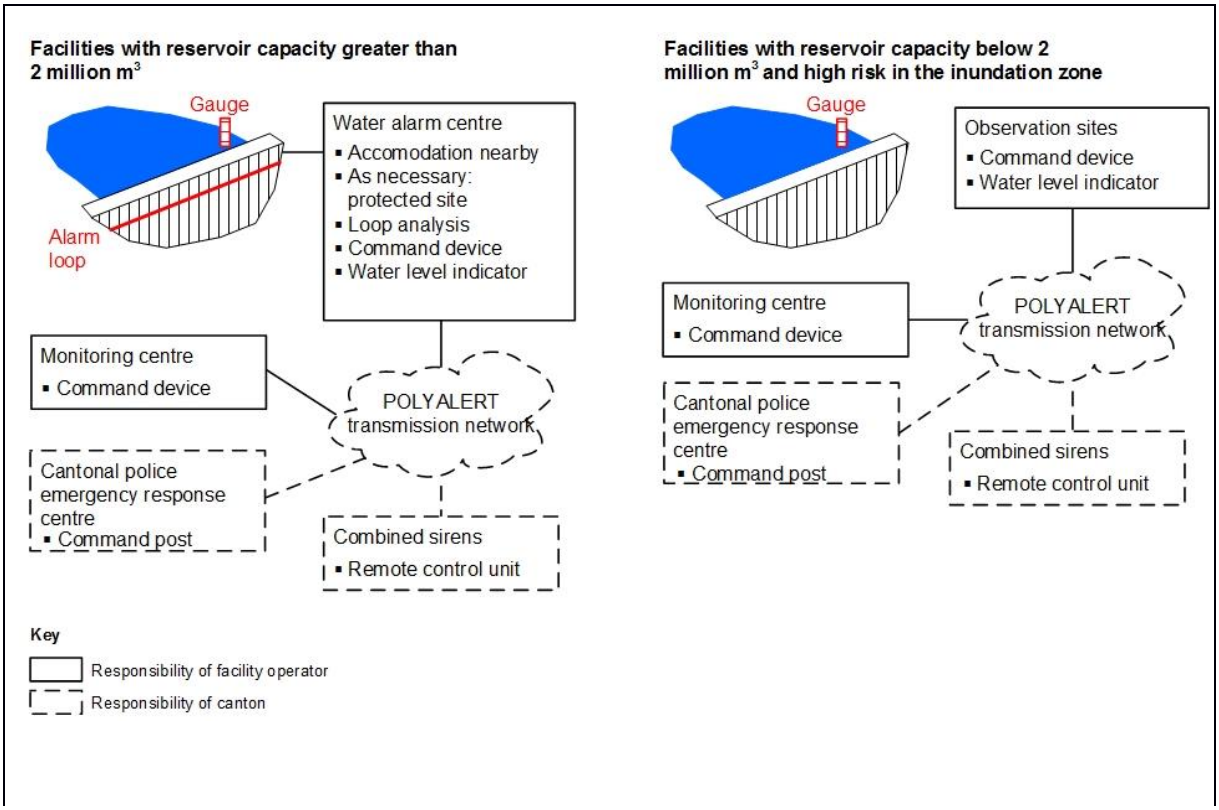

Figure 5: Schematic depiction of the elements of the water alarm system in water retaining facilities equipped with such a system (example)

2.3.3 Adaptation of the requirements for the water alarm system

Upon consultation with the involved canton, the operator of the water retaining facility and the FOCP, the relevant supervisory authority may adapt the requirements placed on the water alarm system, in particular in the following situations:

- If, in the event of a sudden total breach, the resulting flood wave largely remains in the riverbed (e.g. run-of-river plant, cf. section 1.5);
- If, in the event of a sudden total breach, the resulting flood wave can be completely and safely absorbed by a lower-lying reservoir (e.g. a secondary basin of a pump storage power plant).

3 Regulations governing emergency procedures

3.1 Content and structure

The emergency regulations have to be compiled by the operator of the water retaining facility and approved by the relevant supervisory authority. These regulations must fully document the analyses that have been carried out and the precautionary measures that the operator of the facility deems necessary for dealing with an emergency. The regulations must contain the following items:

- Inundation map (cf. section 3.2),
- Risk analysis (cf. section 3.3),
- Emergency response strategy (cf. section 3.4),
- Emergency response organisation (cf. section 3.5),
- Emergency response dossier (cf. section 3.6).

Recommendations regarding the content of the emergency regulations for small water retaining facilities and those that are designed solely to protect against natural hazards or breaches of run-of-river plants, are cited in sections 1.4, 1.5 and 1.6.

After the emergency regulations have been approved by the relevant supervisory authority, the operator of the water retaining facility must distribute the emergency response dossier to the following personnel and units:

- All personnel of the internal emergency response organisation;
- The water alarm centre, all observation posts, locations from which water alarm is triggered.

The relevant supervisory authority is responsible for distributing the inundation map and emergency response dossier to the following entities:

- Canton: The management organisations in the involved canton(s);
- Federal Office for Civil Protection: National Alarm Centre

3.2 Inundation map

The inundation map (cf. Article 25, paragraph 1a, WRFO) must depict the extent of the flood zone in the event of a sudden total breach of the dam when the reservoir is full, together with the amount of time before the flood wave reaches the inundation zone. The perimeters of the inundation zone are defined by the energy line (= water depth h_w + energy height $v^2/2g$). The following guidelines apply for assessing the flood wave:

<u>Initial conditions</u>

- It should be assumed that the reservoir is full prior to the breach. The water level prior to the breach should be equivalent to the corresponding level for determining the height of the dam (cf, Part A of the Directive);
- A sudden (instantaneous) breach of the retaining structure should be assumed:
  - In the case of arch dams, total breach of the structure;
  - In the case of gravity dams, total breach of the structure;
  - In the case of weirs, involvement of three weir fields (scenario: initial malfunction of a weir field leading to collapse of the adjacent pillars);
  - In the case of embankment dams and lateral embankments of weirs, trapezoidal breach with a base width of twice the dam height and 1:1 lateral slopes.

– A progressive breach formation or a progressive breach or a partial collapse should not be assumed.

Assessment procedure

– The assessment procedure has to be adapted to the local circumstances;
– The assessment of a flood wave is based on a “water only” assumption. Other assumptions may be made, e.g. regarding a potential mud flow, if this can be substantiated with the aid of scientifically founded methods;
– The tools developed by the SFOE – [BFE 2014a] and [BFE 2014b] – represent simple procedures for estimating flood waves based on [Beffa 2000] and [CTGREF 1978];
– For water retaining facilities situated behind one another and forming a cascade, the procedure is as follows:
  – If the flood wave from the uppermost facility or facilities should reach an embankment dam, it has to be assumed that the latter will be breached and a combination breach will occur. The initial conditions of the lower-lying water retaining facilities have to be adapted to the specific circumstances. As a rule it is assumed that the reservoir is full;
  – If the flood wave from the uppermost facility or facilities should reach another type of dam, it should be assumed that:
    a The latter will be breached and a combination breach will occur if the flood wave causes the water level in the lower-lying facilities to rise above their danger level;
    b The latter will remain intact and a breach of the lower-lying facilities will not occur if the flood wave does not cause the water level in the lower-lying facilities to rise above their danger level. The initial conditions of the lower-lying water retaining facility have to be adapted to the specific circumstances. As a rule it is assumed that the reservoir is full.

For the verification by the supervisory authority, the calculations must be presented comprehensibly. This means that the associated reports should contain the following elements:

– Description of the applied fundamentals;
– Brief description of the applied calculation procedure or reference to the corresponding fundamentals;
– Description of the breach scenario, including the initial conditions and the location of the breach;
– Results of the calculations: volume of water, flow velocity and water depth in the individual cross-sections for the one-dimensional calculation procedure, or in selected cells in two directions for the two-dimensional calculation procedure;
– Depiction of water depth and energy level, including the corresponding shape files for adoption into a GIS environment.

3.3 Risk analysis

The effectiveness of the measures for dealing with an emergency must be verified on the basis of a risk analysis (cf. Article 25, paragraph 1b, WRFO). Here the aim is to identify those risks that could strongly interfere with or prevent an emergency response. Based on these findings, the necessary precautionary measures have to be defined (e.g. selection of suitable locations for triggering the sirens, specification of the time of deployment of the emergency response personnel). If the existing measures or fall-back levels for securing an emergency response should not be sufficient, additional measures must be defined.

A risk analysis has to be carried out for the following emergency response aspects in particular:

- Access: access to all locations that need to be reached in the event of an emergency. This includes the retaining structure, observation sites, water alarm triggering locations, the most important measurement instrument and reading locations (on site, in the remote control centre), technical centres of strategic importance (at the dam, in the control centre), e.g. control centre for the discharge systems;
- Control and relief systems: energy supply and control mechanisms of gates;
- Communication: communication within the emergency response organisation and to external locations such as the operations centre of the cantonal police force; alarms and methods for warning the population (applies to those alarms for which the operator of the water retaining facility is responsible).

For a general list as basis for risk identification, please refer to Table 1.

Table 1: Catalogue of risks

Risks
Natural hazards Flooding (incl. overflow of dam) Earthquakes Avalanches Mudslides, landslides Rockfalls Ice falls Snow and ice Subsidence Clogging due to driftwood or sedimentation (blockage of bottom outlet or spillway) Storms or other extraordinary weather conditions (heavy precipitation, fog) Forest fires ...
Technical risks Malfunction of components such as gates Failure of measuring instruments Failure of communication equipment Breakdown of means of transport Power cuts ...
Hazards triggered by human error or activities Settlements, rock movements due to underground structures, drainage, etc. Faulty operation of gates, etc. Shortage of emergency response organisation personnel Flooding due to operation of spillway Vandalism ...
Please note: This list is not exhaustive. Sabotage of instruments and machines, communication tools or control systems can be dealt with under failure of these systems.

3.4 Emergency response strategy

The emergency response strategy (cf. Article 25, paragraph 1c, WRFO) has to describe the circumstances in which the operator of the water retaining facility triggers an alarm, plus the corresponding danger level and the measures to be taken.

The definition of the danger level is based on the current situation, the assessment of the condition of the facility, the effectiveness of the implemented measures and the development of the situation. Depending on the threat, it is the assessment of the condition of the dam after the occurrence of the hazard (= situation A), or the assessment of the effectiveness of the measures in consideration of the development of the situation (= situation B) that is of relevance for defining the danger level.

Similar to what is defined for natural hazards as defined in the Federal Ordinance on Warnings and Alarms, a five-level scale is used for warning the civil protection authorities and the population.

- Danger level 1: Little or no danger

  The behaviour and condition of the water retaining facility indicate that it can be operated safely.
- Danger level 2: Medium danger

  An anomalous behaviour or condition of relevance to safety has been detected. Additional clarifications or the implementation of structural or operational measures are required. An uncontrolled discharge of a large quantity of water is not anticipated.
- Danger level 3: Significant danger

  The situation can be kept under control. An uncontrolled discharge of a large quantity of water is not very likely.
- Danger level 4: High danger

  The situation can currently be kept under control. An uncontrolled discharge of a large quantity of water cannot be ruled out at a later stage.
- Danger level 5: Very high danger

  The situation is no longer under control. An uncontrolled discharge of a large quantity of water is likely or has already occurred.

When preparing the emergency response strategy for the facility, the operator must consider the possibility of the following occurrences in particular:

- Extraordinary rise in the water level

  in particular in connection with an extreme flood situation, possibly in combination with the malfunction of a discharge mechanism (e.g. due to clogging), can result in a rise in the water level that can no longer be kept under control with the aid of the procedures specified in the gate regulations.

  For such an eventuality, the operator must specify which measures have to be taken, and when, as well as which danger level applies, and when. The boundary conditions to consider are described in [BFE 2015], which deals with the emergency response strategy to be adopted in the event of an extraordinary rise in the water level.

- Impulse waves caused by masses falling into the reservoir

  Occurrences such as landslides, rockfalls, avalanches and ice falls can give rise to impulse waves in the reservoir that could overflow or damage the dam.

  If there is a threat of such an occurrence, the water in the reservoir should be lowered to a safe level. When the water level should be lowered, as well as how and how much, should be specified in the emergency response strategy, together with the corresponding danger levels that have to be declared.

  The basis for this is a geological assessment of landslides or other hazards that could have an impact on the reservoir. The degree to which the water level needs to be lowered can be estimated on the basis of the specifications in [ETHZ 2009], “Landslide generated impulse waves in reservoirs – basics and computation”, or other suitable procedures. As a rule it should be assumed that the reservoir is full as initial condition.

- Extreme earthquake

  The inspections to be carried out after an earthquake must be specified in the monitoring regulations of the water retaining facility (cf. section 11.7.4, “Post-earthquake inspections”, Directive on the Safety of Water Retaining Facilities, version 1.1, November 2002). Depending on the findings, the necessary measures have to be taken by the operator of the facility and the corresponding danger level has to be declared.

  The specified measures must also take account of the potential damage that could arise following an earthquake, including accessibility to the installations, malfunctions of measurement instruments, communication equipment, etc.

- Loop alarm in water retaining facilities equipped with a water alarm system

  The verifications to be carried out after a loop alarm has been triggered must be described. Verification may, for example, take the form of an inspection of the remotely transmitted monitoring data and an immediate inspection on site. Other measures must be taken depending on the result of these inspections.

- Sabotage, terrorism, military threats

  All installations, discharge mechanisms and other safety-relevant systems, the unauthorised operation of which could give rise to an uncontrolled discharge of a large quantity of water, must be identified and listed. Access to these installations and systems must only be possible for authorised personnel. A description of how these installations and discharge systems are monitored must also be provided.

  In the event of a specific threat of sabotage or terrorism, the monitoring of all safety-relevant installations and discharge systems must be intensified. If an attack has occurred, the same inspections must be carried out afterwards as those to be carried out after an earthquake.

  In the event of a military threat, in accordance with Article 12 of the WRFA and Article 28 of the WRFO, the federal emergency organisation, ABCN (cf. ABCN emergency response ordinance), is responsible for ordering precautionary measures, e.g. lowering the water level in the reservoir.

For danger levels 2 to 5, a general overview of the tasks and measures for all organisations involved in an emergency response is provided in Table 2.

Table 2: Overview of the tasks and measures for organisations involved in an emergency response

	Danger level 2: Medium danger	**Danger level 3: Significant danger**	**Danger level 4: High danger**	**Danger level 5: Very high danger**
Description	– Uncontrolled discharge of a large quantity of water not anticipated. – Inflow and outflow controllable under normal operation of the facility. – Situation A: extraordinary operating status with notification requirement (public may be aware that actions are taken at the facility). – Situation B: identified safety-relevant anomaly or threat.	– Uncontrolled discharge of a large quantity of water not anticipated. – Situation can be kept under control. – Situation A: threat no longer exists. No relevant damage to the facility. – Situation B: threat exists. As a rule, can be dealt with by introducing appropriate measures.	– Uncontrolled discharge of a large quantity of water cannot be ruled out at a later stage. – Situation can currently be kept under control. – Situation A: threat no longer exists. Facility has suffered damage, but this will not cause an immediate breach. – Situation B: threat exists. Introduction of measures does not necessarily bring about the desired easing.	– Uncontrolled discharge of a large quantity of water likely or has already occurred. – Situation can no longer be kept under control. – Situation A1: an uncontrolled discharge of a large quantity of water has occurred. – Situation A2: threat no longer exists. Facility has suffered damage that could give rise to a breach. – Situation B: threat exists. The introduced measures have not had the desired easing effect.
	Situation A: condition of the dam following the occurrence of the threat. Situation B: condition of the dam, including effect of measures, taking account of the development of the situation.			
Tasks of **Operator of the facility**	– Notification of the supervisory authority – Implementation of technical and operational measures, depending on the situation [1)]. – Verification of the readiness of the	– Implementation of technical and operational measures, depending on the situation [1)]. – Readiness for deployment of the emergency response operation personnel.	– Implementation of technical and operational measures, depending on the situation [1)]. – Deployment of emergency response personnel on site. – Issue of warning to the canton by the	– Implementation of technical and operational measures, depending on the situation[1)]. – Issue of warning to the canton by the head of the emergency response organisation (water retaining facilities without a water alarm system).

	Danger level 2: Medium danger	**Danger level 3: Significant danger**	**Danger level 4: High danger**	**Danger level 5: Very high danger**
	emergency response organisation for deployment and readiness of the necessary equipment for use. – As necessary: notification of the canton by the head of the emergency response centre (e.g. if actions outside the facility are required).	– Issue of warning to the canton by the head of the emergency response organisation. – Issue of warning to the operator of the downstream facility. – Notification of the supervisory authority	head of the emergency response organisation. – Issue of warning to the operator of the downstream facility. – Notification of the supervisory authority	– Triggering the water alarm (facilities with water alarm system). – Issue of warning to the operator of the downstream facility. – Notification of the supervisory authority

1) Potential measures:
– Repetition of the measurements carried out with the existing equipment, more frequent measurements;
– Carrying out additional measurements, e.g. partial or complete geodetic measurement, measurements with additional instruments;
– Visual inspections;
– Partial or total lowering of water level;
– Construction, remedial work;
– Monitoring of development of water level;

	Danger level 2: Medium danger	**Danger level 3: Significant danger**	**Danger level 4: High danger**	**Danger level 5: Very high danger**
Tasks of **Canton** (Responsibility for civil protection)	– Internal processing, preparation of answers to enquiries from the population. – As necessary: notification of the population (based on information provided by the operator of the water retaining facility). – Depending on the situation: Increased readiness for action. – Depending on the situation in the event of an extraordinary rise in water level, or following an earthquake: notification of the National Alarm Centre.	– Implementation of measures in accordance with the emergency response plan, e.g. formation of management teams, closure of zones, removal of objects obstructing flow through. – Precautionary notification of the population about the situation which could result in an evacuation order in the event of a negative development. – Notification of the National Alarm Centre.	– Water retaining facilities equipped with a water alarm system: triggering the general alarm (near and far zones). – Water retaining facilities without a water alarm system: triggering and distributing the general alarm in the inundation zone. – Distribution of behaviour instructions to the population. – Communication of the status of the situation and of the assessment of its development to the National Alarm Centre. – Implementation of measures in accordance with the emergency response plan, e.g., preparation of evacuation and escape routes.	– Water retaining facilities equipped with a water alarm system: triggering the general alarm (far zone). Triggering the water alarm (near zone) when instructed by the operator o the facility. – Water retaining facilities without a water alarm system: triggering and distributing the general alarm in the inundation zone. – Distribution of behaviour instructions to the population. – Communication of the status of the situation and of its assessment to the National Alarm Centre. – Implementation of measures in accordance with the emergency response plan, e.g. evacuation of the affected population, manning of assembly points as defined in the evacuation concept, closure of roads.
Tasks of **Population**	– Depending on the situation: awareness of the situation and the precautionary measures taken at the water retaining facility.	– Awareness of the required action as specified in the cantonal emergency response plan. – Depending on the situation: carrying out preparatory measures, e.g. removal of sensitive objects	– Preparation of escape from the danger zone in accordance with the cantonal evacuation plan.	– Escape from the danger zone to the assembly points as specified in the cantonal evacuation plan.

	Danger level 2: Medium danger	**Danger level 3: Significant danger**	**Danger level 4: High danger**	**Danger level 5: Very high danger**
Tasks of **Federal Office for Civil Protection, National Alarm Centre**	– Provision of a single point of contact. – Securing the warning of all necessary organisations.	– Provision of a single point of contact. – Securing the warning of all necessary organisations.	– Provision of a single point of contact. – Notification of all necessary organisations in Switzerland and abroad. – Notification of the federal emergency organisation (SC BST ABCN). – Description / depiction of the situation in the corresponding electronic situation tool if more than one canton is affected or if requested by the affected canton.	– Provision of a single point of contact. – Warning all necessary organisations in Switzerland and abroad. Situation: one canton involved. Canton does not request support. – Notification of the federal emergency organisation (SC BST ABCN). – Description / depiction of the situation in the corresponding electronic tool. Situation: more than one canton involved, or one canton involved that requests support. – Deployment of federal emergency organisation if more than one canton is involved. – Notification of the federal emergency organisation if one canton is involved and asks for support. – Provision of support by the National Alarm Centre, opening of event file in electronic situation tool.

	Danger level 2: Medium danger	**Danger level 3: Significant danger**	**Danger level 4: High danger**	**Danger level 5: Very high danger**
Tasks of **Supervisory authority**	– Assistance of the operator of the water retaining facility. – If necessary, ordering of danger levels.	– Assistance of the operator of the water retaining facility. – If necessary, ordering of danger levels. – Water retaining facilities subject to supervision by the canton: notification of the Swiss Federal Office of Energy (SFOE) as highest supervisory authority.	– Assistance of the operator of the water retaining facility. – If necessary, ordering of danger levels. – Water retaining facilities subject to supervision by the canton: notification of the Swiss Federal Office of Energy (SFOE) as highest supervisory authority.	– Assistance of the operator of the water retaining facility. – Water retaining facilities subject to supervision by the canton: notification of the Swiss Federal Office of Energy (SFOE) as highest supervisory authority.

3.5 Emergency response organisation

3.5.1 Structure

The emergency response organisation of the operator of the water retaining facility (cf. Article 25, paragraph 1d, WRFO) is based on the defined emergency response strategy. The individual functions of the emergency response organisation must be specified, together with its mandates and the warning procedure. In addition, the interfaces with the cantonal civil protection authorities and the authority responsible for the supervision of the water retaining facility also have to be defined.

As a rule, the emergency response organisation comprises the following functions:

- Compiler of the emergency regulations, also responsible for instructing the personnel and updating the regulations, as well as for the maintenance of the required warning and communication equipment;
- Deployment manager and coordinator of the emergency response organisation;
- Manager responsible for defining the danger levels and for punctually triggering warnings;
- Qualified professionals (surveillance level 2) and engineering and geology experts (surveillance level 3, if applicable), plus other specialists as required for assessing the situation and specifying the measures to be taken.

The following additional functions are required in water retaining facilities equipped with a water alarm system:

- Water alarm manager with the following duties:
  - Coordination of the regulations governing the water alarm system;
  - Deployment and coordination of the emergency response organisation;
  - Punctual triggering of the water alarm;
- Alarm triggering, observation post and/or water alarm centre personnel.

For the individual emergency response organisation functions, the management staff and their deputies must be designated. One person may be designated responsible for several functions.

The structure of the emergency response organisation must include the names of the persons responsible for each function.

3.5.2 Alarm and communication

The operator of the water retaining facility is responsible for securing communication within the internal emergency response organisation, as well as with the civil protection authorities or the emergency response unit of the cantonal police force, and with the relevant supervisory authority. The voice communication equipment must be listed in detail.

The voice communication equipment must meet the following criteria:

- Communication within the facility's emergency response organisation, including connection with the observation and alarm triggering units, the water alarm centre, etc.

  The equipment must be able to function even in the event of an emergency (fallback level required, depending on the installed equipment; assessment to be carried out within the scope of the risk analysis).
- Communication between the operator of the facility and the cantonal civil protection authorities:
  - Clear identification of both parties;

  - The equipment must be able to function even in the event of an emergency (fallback level required, assessment to be carried out within the scope of the risk analysis).

  The modalities (equipment, method, identification procedures) must be defined directly between the operator of the facility and the cantonal civil protection authorities.
- Communication between the operator of the facility and the relevant supervisory authority:
  - Communication via the public network.

During an alarm procedure a record must be kept of who is warning or notifying whom. The organisations responsible for issuing warnings or information must be provided with the corresponding contact details for all times of day or night, as well as with instructions concerning the means of communication to be used. The procedure for reporting false alarms is the same as that for sounding alarms.

The procedure for issuing alarms and information during an emergency is depicted in Figure 6 .

3.5.3 Description of water alarm system

If the water retaining facility is equipped with a water alarm system, the system must be described in detail (diagram), together with the regulations governing its maintenance and operation.

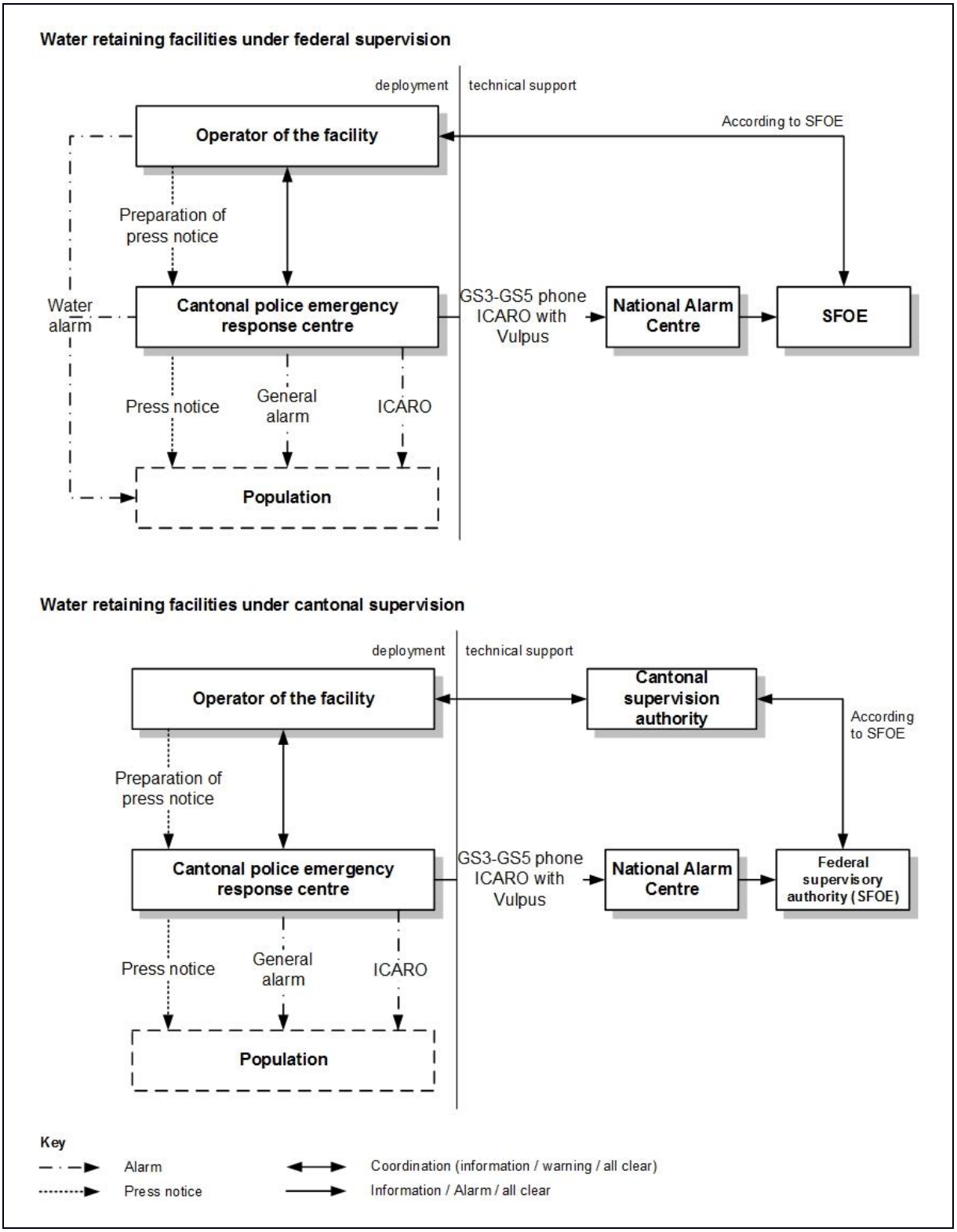

Figure 6: Procedure for issuing alarms and information during an emergency

3.6 Emergency response dossier

The emergency response dossier (cf. Article 25, paragraph 1e, WRFO) only contains documents that are required by the facility operator's emergency response organisation for dealing with emergencies. It must comprise at least the following elements:

- Organisational chart of the operator's emergency response organisation;
- Description of the tasks of each function of the emergency response organisation;
- Alarming procedure, including the danger levels of emergency response organisation personnel and the external organisations to be warned or notified;
- List of contacts, including details of how to reach the personnel of the emergency response organisation, plus means of communication and contact numbers.
- Forms for notifying the emergency response centre at the cantonal police force, including certain predefined messages for warning and downgrading for the individual danger levels. The same forms may also be used for notifying the relevant supervisory authority.
- Standard forms for recording situation assessments, warnings, notifications and measures that have been initiated during an emergency.

Where necessary for improving comprehensibility or understanding, the emergency response dossier should be supplemented with plans or maps, e.g. depicting the situation or cross-sections, or with diagrams depicting the various control mechanisms.

The relevant supervisory authority submits the emergency response dossier to the National Alarm Centre as well as to the relevant civil protection authorities (as a rule, the cantonal management organisation).

3.7 Examination and approval of the emergency response regulations by the relevant supervisory authority

Examination of emergency response regulations of all water retaining facilities

The relevant supervisory authority checks whether the emergency response regulations are complete and their content is plausible. The examination encompasses the following aspects in particular:

- Inundation map: validity of the initial conditions (dam height, reservoir volume, breach form) and calculation procedure; completeness of depiction and documentation; plausibility of the calculated inundation zone.
- Risk analysis: completeness of the observed situations and elements; identification of weak points; formulation of the necessary countermeasures.
- Emergency response strategy: completeness and plausibility of the scenarios considered; effectiveness of the selected emergency response strategy.
- Emergency response organisation: reliability of the internal organisation and the equipment for communication to the outside; verification that the connections to the cantonal civil protection authorities have been duly coordinated.
- Emergency response dossier: clarity and comprehensibility.

Additional verifications in water retaining facilities equipped with a water alarm system:

As a rule, the Swiss Federal Office of Energy (SFOE) is the relevant supervisory authority here. It has to additionally examine:

- Whether the Federal Office for Civil Protection (FOCP) has approved the components designated with asterisks (***) in section 2.3, and
- Whether the other required components and infrastructure have been installed.

Approval

The relevant supervisory authority approves the emergency regulations as long as all the specified requirements have been met. It then submits a copy of the inundation map and emergency response dossier to the National Alarm Centre and the cantonal civil protection authorities (as a rule, the cantonal management authorisation). If agreed in advance, the National Alarm Centre may forward these items to the cantonal civil protection authorities.

3.8 Examples of emergency regulations

The following examples of emergency regulations are available on the SFOE website:

- Example of a set of emergency regulations for a water retaining facility without a water alarm system, together with an example of an emergency response dossier for this type of water retaining facility.
- Example of a set of emergency regulations for a water retaining facility designed to protect against natural hazards – flood control reservoir, together with an example of an emergency response dossier for this type of facility.
- Example of a set of emergency regulations for a water retaining facility equipped with a water alarm system, together with an example of an emergency response dossier for this type of water retaining facility.
- Example of a set of emergency regulations for a run-of-river facility, together with an example of an emergency response dossier for this type of facility.

4 Updating, maintenance, training

4.1 Updating the emergency regulations

The emergency regulations must be reviewed by the operator of the water retaining facility at least once a year, and updated where necessary. Updating encompasses the following tasks in particular:

- Adaptation of the content to reflect any changes in the emergency response organisation or modifications of the communication and alarm equipment or the reservoir;
- Verification of the risk analysis in order to identify any changes, and where necessary adaptation to the changed situation. If any changes have taken place: assessment of the effect on the emergency regulations, and where necessary adaptation of the latter;
- Verification of the interface with the canton.

The rules relating to updating must be specified in the emergency regulations.

4.2 Maintenance of installations

The warning equipment must be tested annually within the framework of a siren test under the supervision of the FOCP. With respect to maintenance, the requirements of the FOCP must be complied with.

All alarm and communication equipment that is at the disposal of the operator of the water retaining facility during an emergency and is not subject to the regulations of the FOCP must be adequately maintained. Function tests must be carried out annually. The corresponding rules must be specified in the emergency regulations.

4.3 Training

Training must be provided for all existing and new personnel of the emergency response organisation. They must be given instruction regarding their duties, the premises and the alarm and communication equipment used by the facility. Their know-how must be refreshed annually (preferably at the same time as the performance of the siren tests).

As a rule, every five years the operator of the facility must conduct an internal exercise with simulation of an emergency. This requirement must be specified in the emergency regulations.

At the request of the cantonal civil protection authorities, such exercises must be conducted in cooperation with the civil protection personnel.

5 References

(Note: the list of references will be integrated at a later date into the full list for the Directive.)

Legal bases
Documents
Ordinance on the organisation of deployment in the event of emergencies and natural hazards (SR 520.17), 20 October 2010 (status as of 1 January 2013)
Ordinance on Warnings and Alarms (SR 520.12), 18 August 2010 (status as of 1 January 2014)
Federal Water Retaining Facilities Act (SR 721.101), 1 October 2010 (status as of 1 January 2013)
Federal Water Retaining Facilities Ordinance (SR 721.101.1), 17 October 2012 (status as of 1 January 2013)
National Alarm Centre Ordinance (SR 520.18), 17 October 2007 (status as of 1 January 2011)

References	
Abbreviation	**Reference**
[Beffa 2000]	Beffa, C.: Ein Parameterverfahren zur Bestimmung der flächigen Ausbreitung von Breschenabflüssen. “wasser, energie, luft – eau, énergie, air”, 93. Jahrgang, Heft 3/4, 2000
[BFE 2014a]	Swiss Federal Office of Energy: Diagramme zur Bestimmung der flächigen Ausbreitung von Breschenabflüssen (Verfahren "Beffa"). BFE Hilfsmittel, Version 2.0, 26.06.2014
[BFE 2014b]	Swiss Federal Office of Energy: Vereinfachtes Verfahren zur Berechnung einer Flutwelle mit primär eindimensionaler Ausbreitung (Verfahren "CTGREF"). BFE Hilfsmittel, Version 2.0, 18.06.2014
[BFE 2015]	Swiss Federal Office of Energy: Notfallstrategie im Falle eines ausserordentlichen Anstiegs des Wasserspiegels. Version 1 May 2015
[CTGREF 1978]	Centre technique du génie rural des eaux et des forêts (CTGREF)*: Appréciation globale des difficultés et des risques entraînés par la construction des barrages. Note n°5, juin 1978 * Since 2011: Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture (irstea)
[ETHZ 2009]	Federal Institute of Technology, Zurich, Laboratory of Hydraulics, Hydrology and Glaciology: Landslide generated impulse waves in reservoirs – Basics and computation. Report VAW 4257, 27 February 2009

Abbreviations	
Abbreviations	**Term**
FGP	POLYALERT remote control device (transmission of triggering signal and status report to and from stationary siren system)
FOCP	Federal Office for Civil Protection
ICARO	Information Catastrophe Alarm Radio Organisation: Swiss Radio service for transmitting behaviour instructions to the population in the event of an emergency
KGP	POLYALERT command device (triggering alarm)
KSP	POLYALERT command unit (triggering alarm, monitoring and management of system components and sirens)
SAP	POLYALERT loop evaluation
SFOE	Swiss Federal Office of Energy