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INTERNAL EMERGENCY ACTION PLAN IN DAM SAFETY MANAGEMENT OF RIGA HPP IN LATVIA[(*)]

Martin WIELAND
Senior Dam Engineer, Dipl. Ing. ETH, Dr. sc. techn.

Pöyry Energy Ltd., Zurich, SWITZERLAND

R. Peter BRENNER
Dam Consultant, Dipl. Ing. ETH, PhD

Weinfelden, SWITZERLAND

Juha LAASONEN
Project Manager, Lic. Tech.

Fortum Heat and Power Oy, Espoo, FINLAND

Dzintars OSTANIEVICS
Technical Director Daugava HES

Latvenergo Joint Stock Company, Riga, LATVIA

1. INTRODUCTION

The installation of hydropower plants in cascades is a common form with the large rivers that drain the rather flat catchment areas of northern and north-eastern Europe. These river courses are long (they may extend over more than one thousand kilometers) and the discharges are large while the heads utilized are usually small, i.e. in the range of 20 to 40 m. Such storage schemes consist often of a concrete part, encompassing powerhouse and spillway, and generally long and low embankment dam sections. The latter may be vulnerable to overtopping, internal erosion processes, or leakage through the foundation. But also the concrete structures may cause problems with the condition of the joints between blocks and/or uplift pressures in the foundation.

[(*)] *Plan d'alerte interne dans la gestion de la sécurité de l'aménagement hydro-électrique de Riga*

Besides large floods, adverse internal processes in the dam body and in the foundation (e.g. piping), or also in joints between structural elements can develop, initially very slowly, but they usually accelerate when the situation becomes more critical and approaches failure.

Although dams are designed and built as safe structures and, in a well-organized environment, their condition and performance are regularly checked by the Owner or by appointed experts, a residual risk for adverse incidents to happen still remains mainly due to man-made actions. The owner has to prepare for such situations by specially designed dam safety management procedures.

Dam safety management procedures used to avert major disasters in the downstream area of a dam with the aim to minimize the loss of lives in case of dam failure, are called Emergency Action Plans (EAPs). These are basically non-structural measures which, together with an Early Warning System (EWS), provide sufficient time for evacuating people from the endangered areas. Several organizations concerned with dam safety have issued guidelines for EAPs, see for example references [1] and [5].

It is, of course, in the interest of the dam owner that situations of imminent failure can be avoided by all means. Therefore, it is important that the behaviour of the dam and its appurtenances are observed regularly, both visually and by monitoring devices. The latter should preferably be connected to an automatic data acquisition system (ADAS) such that monitoring in real time becomes possible. In this way adverse processes may be detected at an early stage and corrective measures can be taken.

The Internal Emergency Action Plan (IEAP) is a management tool that helps the dam operator to check, in an orderly manner, all the relevant operational devices (civil, mechanical, electrical), including the data recorded by the ADAS, and it provides instructions on how to act in the case of an unusual observation. This management plan assigns responsibilities to the plant's staff at different levels and regulates communication both internally and, if necessary, also externally with the State Authorities. Hence, the IEAP is an integral part of emergency response notification and operation procedures which have to be established taking into account the specific characteristics and hazards prevailing at a particular dam site.

2. COMPONENTS OF AN INTERNAL EMERGENCY ACTION PLAN

The IEAP consists of several components or tasks, namely:

- Hazard classification, i.e. determination of the types of hazard that could affect the safety of the facility. Hazards can be associated with natural events and processes (e.g. floods, storms, earthquakes, internal erosion, etc), with the reliable operation of safety-relevant hydro-mechanical and electro-mechanical equipment (e.g. gate jamming, failure of monitoring equipment, etc), and with damages caused intentionally by people (sabotage, terrorism, war, etc.).
- Emergency classification, i.e. determination of the level of severity of an incident or unusual behaviour of a monitoring instrument or of a mechanical/electrical part. Three levels have been distinguished: (i) internal alert, (ii) developing situation, and (iii) imminent situation. As an aid for judging the level of severity an assessment matrix can be developed (which may change from one facility to another one, depending on the dam's characteristics and the environment).

- Communication or notification of the incident internally only or both, internally and externally. Externally means communication with local and state authorities, responsible for the execution of emergency actions. Communication can be facilitated by notification charts, which display the flow of information among concerned parties and the executive staff of the facility. Internally, the necessary measures will be carried out by an Emergency Task Group (ETG) composed of members of the operating staff.

A decision tree (Fig. 1) can assist in the classification of an unusual observation or adverse event. Upon discovery of, or after having been notified about, an unusual scenario, two possible situations must be judged, namely whether external assistance is needed *and* whether there are adverse impacts with a threat to population, structures or environment. The urgency of the situation is the major factor in classifying the severity an incident.

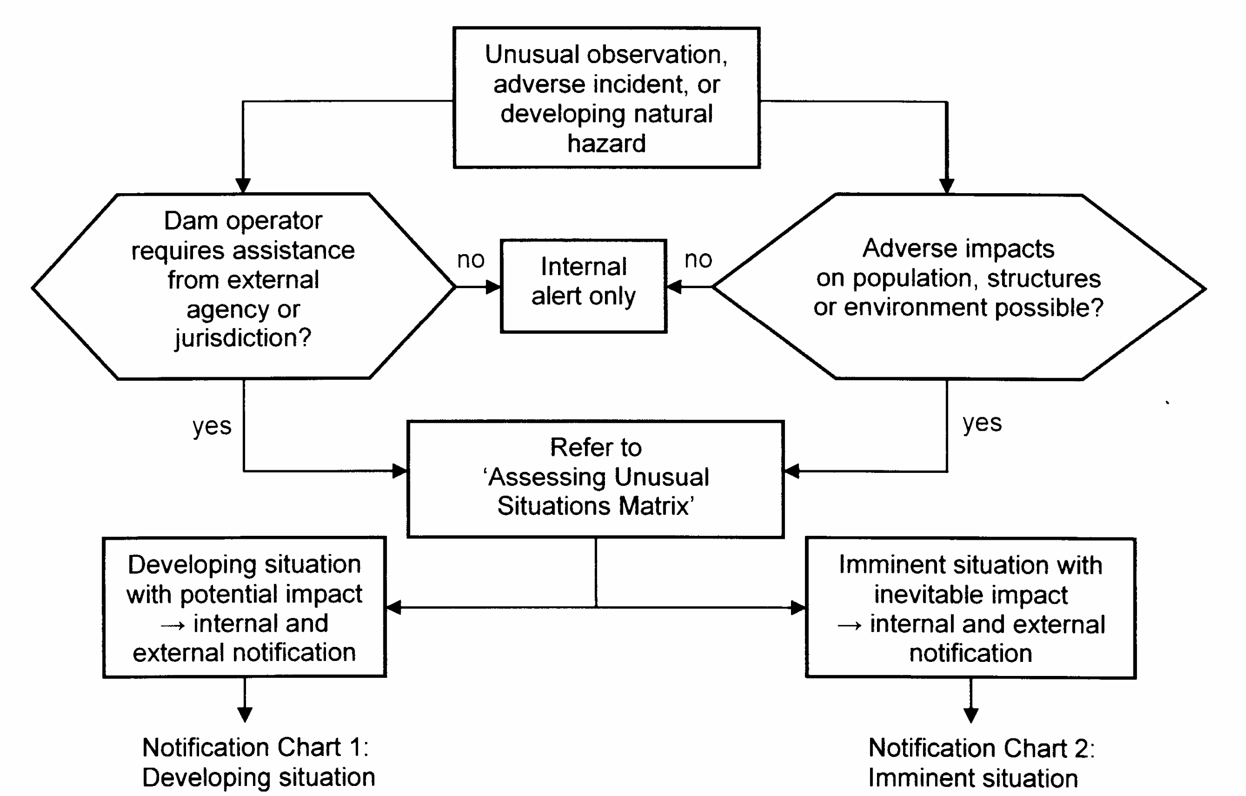

Fig. 1
Decision tree for judging the severity of an adverse event (modified from [2])
Arbre de decision pour juger la gravité d'un événement adverse

The *internal alert* triggered by an unusual situation can be managed and controlled by the dam's staff. Typical internal alert scenarios are flood warning prior to receiving information on the size of the flood and potential dangers, and also abnormal monitoring results where readings on certain instruments exceed pre-set safety limits (e.g. piezometric heads, discharge from drainage facilities or displacement of structures).

A *developing situation* exists when the observed incident or the information on a hazardous event clearly tends to turn into a serious threat to the dam's safety and the population in the downstream area. At this stage it is not yet known whether the situation can be brought under control.

An *imminent situation* has developed when it has become clear that the progress of the incident or threat cannot be stopped but its consequences can still be mitigated, such as the evacuation of the population in danger.

The flow of required information and communication is visualized most illustratively by a *Notification Chart* for the different severity levels, as shown below in the example of Fig. 5.

3. EXAMPLE: RIGA DAM, LATVIA

3.1 PROJECT DESCRIPTION

The Daugava cascade in Latvia is operated by Latvenergo, the main utility in Latvia, and consists of three run-of-river hydro-electric power plants (HPPs), namely, from upstream to downstream: Plavinas, Kegums and Riga (Fig. 2). Riga HPP is located about 20 km upstream of the capital city of Riga where it crosses an island in the river (Dole Island), as illustrated in Fig.3. It was commissioned in 1976. The reservoir has a capacity of 256 million m^3 at normal water level (+18 m asl) and approximately 288 million m^3 at flood water level. The facility consists of a 381 m long concrete structure with powerhouse and spillway, upstream and downstream aprons and retaining walls on both sides of the powerhouse, flanked by embankment dams on both sides. The embankment dams have a total length of 15.4 km and a crest elevation of 22 m asl. Their maximum height above foundation level is about 30 m. Figure 3 shows a layout of Riga dam.

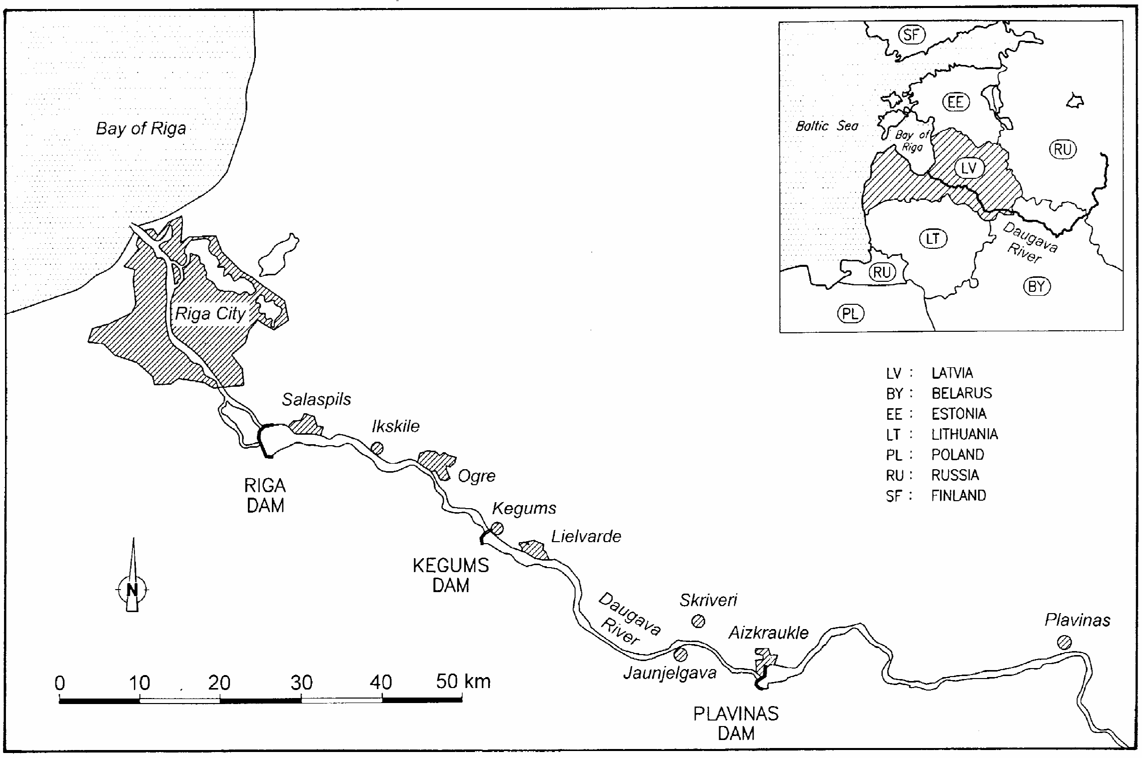

Fig. 2
Locations of the Plavinas, Kegums and Riga power plants on the Daugava river in Latvia
Positions des trois usines de Plavinas, Kegums et Riga sur le fleuve de Daugava en Lettonie

The 165 m long spillway dam on the right-hand side of the powerhouse is a concrete gravity dam with a central joint and consists of six bays with radial gates. All six gates are identical with a height of 11.30 m and a length of 20.0 m. The maximum height of the spillway dam is 35 m. At the full supply level, FSL (or normal water level), which is 18.0 m asl, the spillway capacity is 8695 m^3/s The highest permissible reservoir level (HFL) is at 18.9 m asl which allows to pass a flood of 10,030 m^3/s. At the HFL, the maximum flood discharge capacity amounts to about 10,000 m^3/s, but assuming one gate blocked this reduces to only 8200 m^3/s. The mean annual flow of the Daugava river at the Riga dam site is about 640 m^3/s. Additional releases can be made through the power plant with six Kaplan turbines, enabling a total discharge of 3345 m^3/s at FSL and 3470 at HWL. Hence, the maximum total discharge capacity with six gates open and all the turbines in operation, amounts to 12,040 m^3/s for FSL and 13,500 m^3/s at the HFL. This would suffice to pass the probable maximum flood (PMF) which has been estimated as12,800 m^3/s. However, it is common practice to assume that one of the spillway gates is not operable and that the power plant could not operate under PMF conditions. The spillway capacity is therefore insufficient to pass the PMF and the dam would be overtopped, resulting in the failure of the embankment dams.

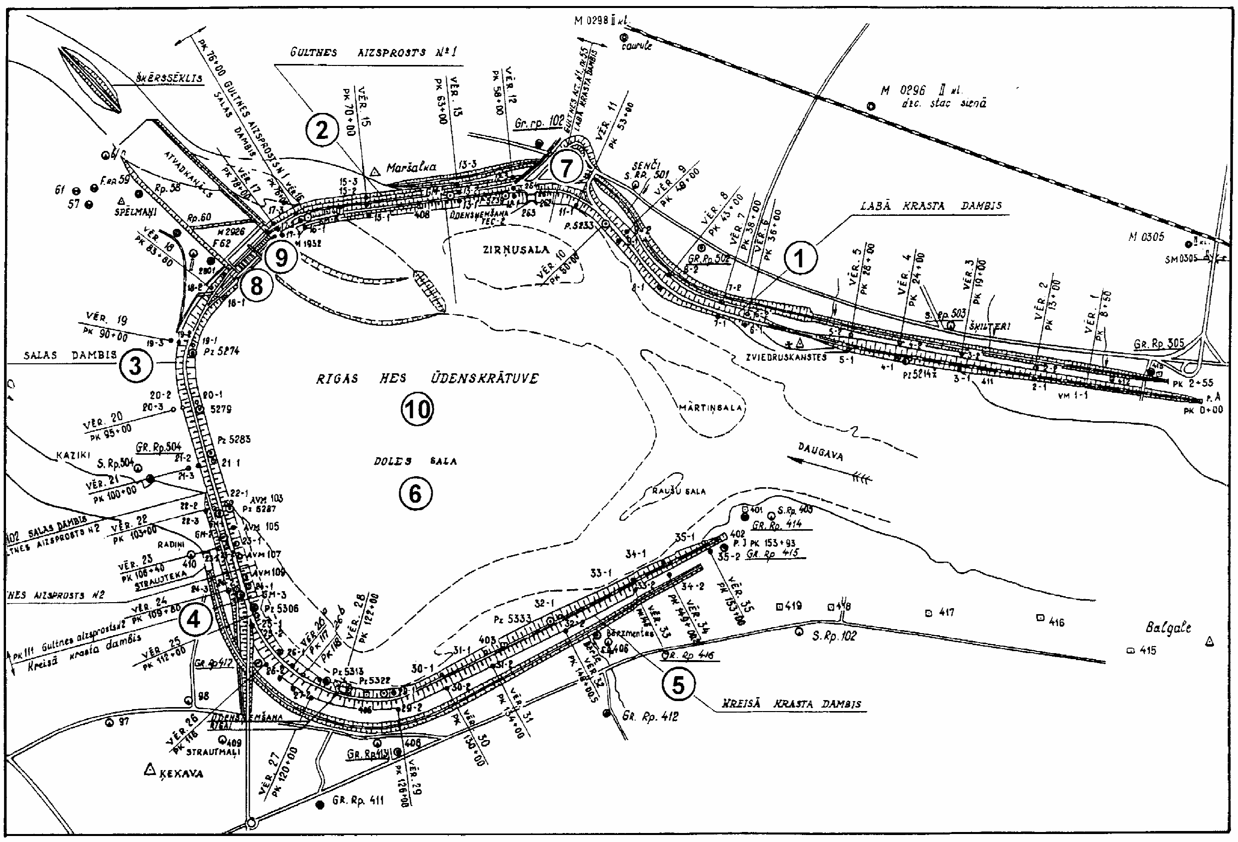

Fig. 3
Lay-out of Riga Dam
Disposition du barrage de Riga

1	Right bank embankment dam	Digue rive droite	6	Dole Island	Île de Dole
2	Main dam no. 1	Digue principale no.1	7	Relief wells	Puits de décompression
3	Island dam	Digue sur l'île	8	Powerhouse	Usine
4	Main dam no. 2	Digue principale no.2	9	Spillway	Évacuateur de crue
5	Left bank embankment dam	Digue rive gauche	10	Riga reservoir	Réservoir de Riga

The powerhouse has an installed capacity of 402 MW with six units of 67 MW each for energy production, but it also serves for flood control and public recreation (Fig. 4).

Powerhouse and spillway are partly founded on Quaternary alluvium but mainly on dolomite of Devonian age. The dolomite is slightly karstic. The embankments are placed on glacial till of variable thickness, i.e. between about 3 to 10 m. Construction of the embankment was by hydraulic filling. In this process the material is first dredged and then piped to its place in the dam. This process produces a relatively loose but uniform fill. Densification is through consolidation by self-weight. Hydraulic fill dams are vulnerable to rapid erosion in case of overtopping and to liquefaction under earthquake loading. A section of the foundation along the right bank embankment which follows one branch of the former river channel is drained by free-flowing relief wells. The distribution of the discharge among these wells is not uniform and the water flowing from the wells also contains solids of the order of 10 milligrams per liter.

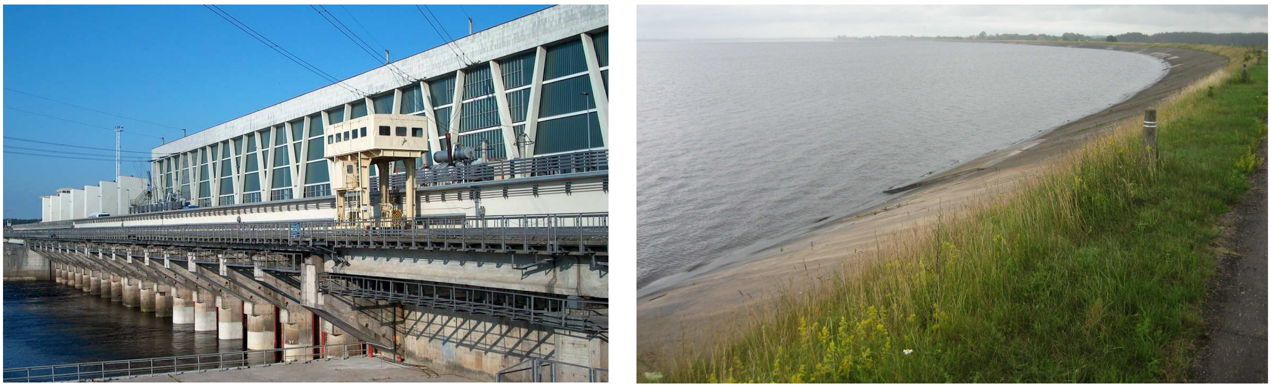

Fig. 4
Riga dam: Powerhouse (left) and embankment dam (right)
Barrage de Riga: Usine (à gauche) et digue (à droite)

The embankment dams, powerhouse and spillway are monitored comprehensively. Seepage through and underneath the embankments is collected in an elaborate drainage system with drainage wells and drainage canals, which allow measurements at different locations along the embankment. Nearly 200 open standpipe piezometers in 37 sections monitor pore water pressures inside the embankment and in the foundation. Another 50 piezometers are installed below the powerhouse and the spillway. Settlements and horizontal deformations are measured at the surface, i.e. on the crest and on the slopes of the embankments. The concrete structures are monitored mainly at their joints by joint meters, which enable recording of displacements either two- or three-dimensionally. All measurements are read manually; however, it is intended to install an automatic data acquisition system as this was done for the surveillance of the Plavinas power plant.

3.2 HAZARDS

Potential hazards that could affect the Riga power plant are the following:

From the *natural environment*:

- Floods: When the reservoir is completely full, i.e. at the crest level of 22.0 m asl, the spillway capacity would be about 11,900 m^3/s which is still less than the PMF. However, such a scenario is unsafe and unrealistic and cannot be considered. Overtopping is therefore a serious hazard.

- Ice: Thick lumps of ice and icicles can develop with leaking gates and impede gate operation. Ice pressure must be considered as an additional load on structures.
- Earthquakes: Usually a serious hazard, but in Latvia the seismicity is low to moderate and there are no records of destructive earthquakes. The same can be stated for liquefaction which would be critical with hydraulic fill dams.
- Storms and lightning: High speed winds can damage transmission lines and switchyards, thus interrupting the power supply to operate cranes and gates.

From *man-made earth or concrete structures*:

- Failure of control equipment, in particular spillway gates, cranes for stoplogs, etc caused by mechanical or electrical break-downs. Gate jamming may occur from wooden debris, especially during flood events.
- Joint failure: The joints between the various structural elements of the powerhouse and the spillway are filled with bitumen, subject to ageing processes and slow loss due to leakage. Joints may fail as a result of a sudden movement of one of these structural elements.
- Interaction of water with earth and concrete structures: Possible processes include (i) gradual clogging of the drainage system, (ii) increase in the loss of sand from the foundation through the relief wells, (iii) blockage of one or more relief wells, (iv) leaching of gypsum from the foundation rock, and (v) piping through the embankment or its foundation.

From the man-made environment:

- Fire in the power plant
- Releases of hazardous materials upstream or inside of the power plant (e.g. oil from hydraulic equipment or from transformers)
- Criminal acts, sabotage, terrorism, and acts of war
- Human errors

A hazard matrix can be established to guide the dam operators. Table 1 summarizes the possible hazards for Riga dam and classifies the protective actions according to severity levels.

The most significant hazard for Riga dam does not come from the dam itself but from the power plants upstream. The situation at the Plavinas dam site has been described in [2] and [3], also including a risk analysis. Dam break analyses have revealed that in the case Plavinas dam fails due to overtopping of the embankment dam sections in a PMF event, Kegums and Riga dams would also fail with serious consequences for the towns along the river and Riga City, the captital of Latvia and largest city of the Baltic States with some 730,000 inhabitants (Fig. 2).

3.3 ASSESSING UNUSUAL SITUATIONS

Unusual situations occur with natural and with structural hazards, which are both externally controlled. What are the criteria for an unusual situation and what is the relationship to the severity level? In order to assist the dam operators, maintenance personnel and personnel at the management level the “Assessing Unusual Situation Matrix” has been conceived [2]. It lists the potential structural and hydraulic problems that may affect the safety of both concrete and embankment dam structures or their appurtenances. It also addresses man-made accidents and shows the various indicators that may develop into a situation compromising the safety of the dam. The indicators are expressed mainly in qualitative terms. Tables 2 and 3 present the Unusual Situation Matrices for ‘Developing’ and for ‘Imminent’ situations, respectively.

Table 1
Hazard matrix for Riga dam

	PROTECTIVE MEASURES				
HAZARD	Rehabi-litation	Partial drawdown	Drawdown to min. reservoir level	Evacuation	Post-event evacuation
Natural hazards					
Floods	A	B		C	
Ice problems	A				
Earthquake					C
Storm and lightning	A				
Structural hazards					
Abnormal instrumentation readings	A	B		C	
Spillway gates and equipment failure			C	C	
Joint failure	A			C	
Differential movement of concrete structure	A	B	C	C	
Embankment piping or seepage		B	C		
Electrical/mechanical failure and power plant shut-down	A				
Man-made hazards					
Fire	A	B			
Oil or hazardous material spill or release	A				
Criminal action, sabotage and terrorism, acts of war		B			C
Human error	A				

A: internal alert; B: developing situation; C: imminent situation

Abnormal instrumentation data can be quantified as follows:
Piezometer readings: A sudden increase in the piezometric head in the order of 1.5 to 2 m may signify the blockage of a nearby drainage well or for piezometers below a concrete structure it may indicate the clogging of the relevant drainage facilities.
Settlement readings: A sudden settlement of a structural element of say more than 5 mm, may indicate some distress in one of the joints.

Today’s monitoring systems have the capability to trigger an alarm when assigned critical values are exceeded. Such a system is not yet installed at the Riga dam but is available at Plavinas. Any abnormal reading must be followed by a visual inspection at the location of the instrument.

Table 2

Assessing unusual situations matrix (DEVELOPING SITUATIONS)

PROBLEM	**Determine if a situation is 'Developing' or 'Imminent' then refer to the appropriate Notification Chart (see Fig. 5).** **Developing Situations (minor or major)** 1) There are potential adverse impacts, OR 2) The Dam Owner/Operator needs assistance from external agencies. (Qualifiers: potential threat, progressing slowly, can mitigate, some time is available)
Embankment piping	Significant new or increasing seepage or sand boils downstream from the embankment.
	Significant new or larger sinkhole(s) or crest settlement.
	Reservoir level is falling without apparent cause (such as outlet or spillway releases).
	New, stable, or slowly increasing seepage rates transporting some sediment.
Embankment cracking	Cracks significantly increased in length, width, or offset.
	Cracking is the beginning of a large slide. Refer to 'embankment deformations' below.
Embankment deformations	Large deformations or slides. Potential for breach of dam.
Embankment overtopping	The reservoir is projected to rise above the dam crest. Potential for embankment erosional failure or piping
Movement of concrete sections (sliding or overturning)	Significant new or enlarged cracks or offsets. May be accompanied by abnormal instrumentation data (decreased drain flows, increased uplift pressures) and/or increased seepage through structure.
Failure of spillway gates, outlet works, or supporting structures	Significant new or enlarged cracks or offsets.
	Damage may occur with releases expected to exceed the design limit of 10,030 m^3/s at maximum reservoir elevation of 18.9 m asl.
	Significant changes in flow conditions. May be accompanied by significant erosion occurring in spillway or outlet works.
Spillway and outlet works releases	Releases expected to exceed (or contribute to streamflows which exceed) safe channel capacity
Concrete dam overtopping	Overtopping may occur. Foundation or abutment erosion may occur, which could lead to dam failure.
Earthquake occurs	Refer to indicators for embankment piping, embankment cracking, embankment deformations, and movement of concrete section.
Abnormal instrumentation data	Readings outside expected range and data confirmed.
Other problems: Equipment failure, fire, criminal action, accident, oil or hazardous material spill or releases	Potential adverse impacts, progressing slowly, mitigation is possible, some time is available before adverse impacts.

Table 3
Assessing unusual situations matrix (IMMINENT SITUATIONS)

PROBLEM	**Determine if a situation is 'Developing' or 'Imminent' then refer to the appropriate Notification Chart (see Fig. 5).** **Imminent Situations (minor or major)** 1) There are immediate or inevitable adverse impacts, OR 2) The Dam Owner/Operator needs assistance from external agencies or jurisdictions. (Qualifiers: immediate or inevitable threat, progressing rapidly, cannot mitigate, no time available)
Embankment piping	Rapidly increasing seepage and/or transporting significant quantities of materials. Sand boils rapidly increasing in size or number and/or rapidly increasing flows. Failure expected.
	Sinkhole(s) or settlement rapidly increasing in size or number. Failure expected.
	Whirlpool or other signs of the reservoir draining rapidly through the dam or foundation.
	Rapidly increasing seepage transporting significant to large amounts of sediments. Failure expected.
Embankment cracking	Rapidly increasing flow through crack(s) and transporting materials. Failure expected.
	Refer to 'embankment deformations' below.
Embankment deformations	Large deformations and breach of dam is imminent or occurring.
Embankment overtopping	Overtopping is imminent or occurring. See embankment piping information. Failure expected.
Movement of power plant (sliding or overturning)	Movement of concrete section(s) with water flowing through cracks and section(s) or breach of the dam.
Failure of spillway gates, outlet works, or supporting structures	Rapidly increasing cracks or offsets. Failure expected.
	Failure may occur with releases exceeding the design limit of 10,030 m^3/s at maximum reservoir elevation of 18.9 m asl or at reservoir elevation of 22.0 m asl.
	Major and rapidly developing erosion or head cutting. Breach expected.
Spillway and outlet works releases	Releases exceeding safe channel capacity.
Concrete dam overtopping	Overtopping and major foundation or abutment erosion is rapidly occurring. Movement is occurring. Failure is expected.
Earthquake occurs	Dam is failing, will fail, or has failed due to vulnerability of facility and magnitude of earthquake. (Failure predicted by analysis.)
Abnormal instrumentation data	Early warning system; instrumentation indicates failure of the dam or structure(s).
Other problems: Equipment failure, fire, criminal action, accident, oil or hazardous material spill or releases	Immediate or inevitable adverse impacts, progressing rapidly, mitigation not possible, no time is available before adverse impacts occur.

3.4 RESPONSE PROCEDURES AND COMMUNICATIONS

Dam incidents may occur with no advance notice and they may develop rapidly. An emergency organization must be able to respond quickly to the special needs of the incident. As a first level, the Owner has established an Emergency Task Group (ETG) and as a second level, i.e. in the case of an actual emergency situation, there is a Crisis Management Group (CMG) with a Crisis Control Center (CCC).

The ETG has 14 members. These are led by the Technical Director of the three Daugava Hydropower Plants). The Deputy Technical Director and the Heads of the three hydropower plants are task group deputies. The other members of the ETG are the heads of the operational equipment units, dam safety department, transportation unit, supporting unit, electro-mechanical maintenance, and the integrated security system. The ETG has distinct management tasks, as listed below:

- Command
- Planning
- Dam safety monitoring
- Operation
- Logistic
- Finance
- Public information
- Personal safety during and after incident
- Liaisons

Command: Coordination and managing of the emergency operations. The responsibility is with the Leader of the ETG, i.e. the Technical Director of the Daugava HPPs. Initially, the person at the scene of the incident with the highest rank shall be responsible for managing the incident. Hence group leaders must be trained to recognize unusual situations.

Planning: Determination of the extent of the incident and preparation of an action plan in non-standard situations. For standard situations, action plans for fire, hazardous spills, and shut-down of power plant must be prepared beforehand. The responsible person is the Deputy Technical Director (Maintenance).

Dam safety monitoring: Collection, processing and analyzing manual data which shall support the planning and provide information for personal safety during and after the incident. The responsible leader is the Head of the Dam Safety Department.

Operation: Issuing instructions according to the action plan. Response and mitigating actions are performed by the respective task groups (e.g. spillway, civil maintenance, etc.). The responsible leader is the Head of the Riga HPP Operational Unit.

Logistic: Providing the resources (e.g. transportation services, materials and equipment) which are needed to support the mitigating measures. Responsible leader is the Head of the Supporting Department.

Finance: Monitoring the costs of the incident and updating of contractors and suppliers list during non-emergency situations. Responsible leader is the Head of the Technical Department.

Public information: Communication and distribution of information on the incident to the media. The leader of the ETG will decide to which extent the incident will be communicated to the media, if needed. The responsible leader is the Head of the Work Safety and Security Department.

Personal safety during and after incident: Maintaining the safety of the rescue personnel and workers involved in maintenance work during the incident (e.g. protection from hazardous locations, such as a collapsing structure).

Liaisons: The ETG serves as a technical representative to affected jurisdictions. The responsible leader is the Head of Integrated Security Systems.

The responsible leaders of the ETG must be provided with a check list containing their main tasks. This check list should be updated annually and particularly after an incident has occurred.

The Crisis Management Group will be activated when an incident becomes too large to be handled by the normally assigned operations staff, or also whenever a large-scale event occurs involving more than one power plant on the Daugava. The location/place where the CMG is operating is called the Crisis Control Center. It is usually located away from the scene of the incident to ensure maintaining communication, gathering and disseminating information, acquiring resources, keeping records, and tracking costs.

Notification Charts 1 and 2 for Riga dam are shown in Fig. 5 as a single flow chart. Notification Chart 1 is used for 'Internal Alert' and 'Developing Situations' while Notification Chart 2 is for 'Imminent Situations'. The upper part of the flow chart is identical for both notification charts. A separation occurs in the lower part of the flow chart for the external notifications.

3.5 REPORTING

Documentation of an incident from its beginning to the end together with the measures taken and the costs incurred is an essential task of the IEAP and must be handled carefully and comprehensively. For this purpose it is best to prepare appropriate report forms which facilitate recording of the various details of the incident. For the Riga dam site the following forms have been recommended:

- Emergency Event/Unusual Occurrence Report – for reporting emergency events and unusual occurrences other than earthquake, bomb threats, and oils or hazardous spills.
- Earthquake, Sabotage, Terrorism, and Acts of War Damage Report – for reporting effects of earthquakes, sabotage, terrorism and acts of war.
- Oil and Hazardous Spill Report – for reporting oil and hazardous spills.
- Bomb Threat Report – for reporting bomb threats.

In addition to these reports, the following information must also be documented:

- All persons involved in the incident (including name, title, phone number and e-mail address);
- All agencies and persons notified about the incident;
- Corrective actions taken;
- Source of funding required; and
- Updates on the status of the post-event situation.

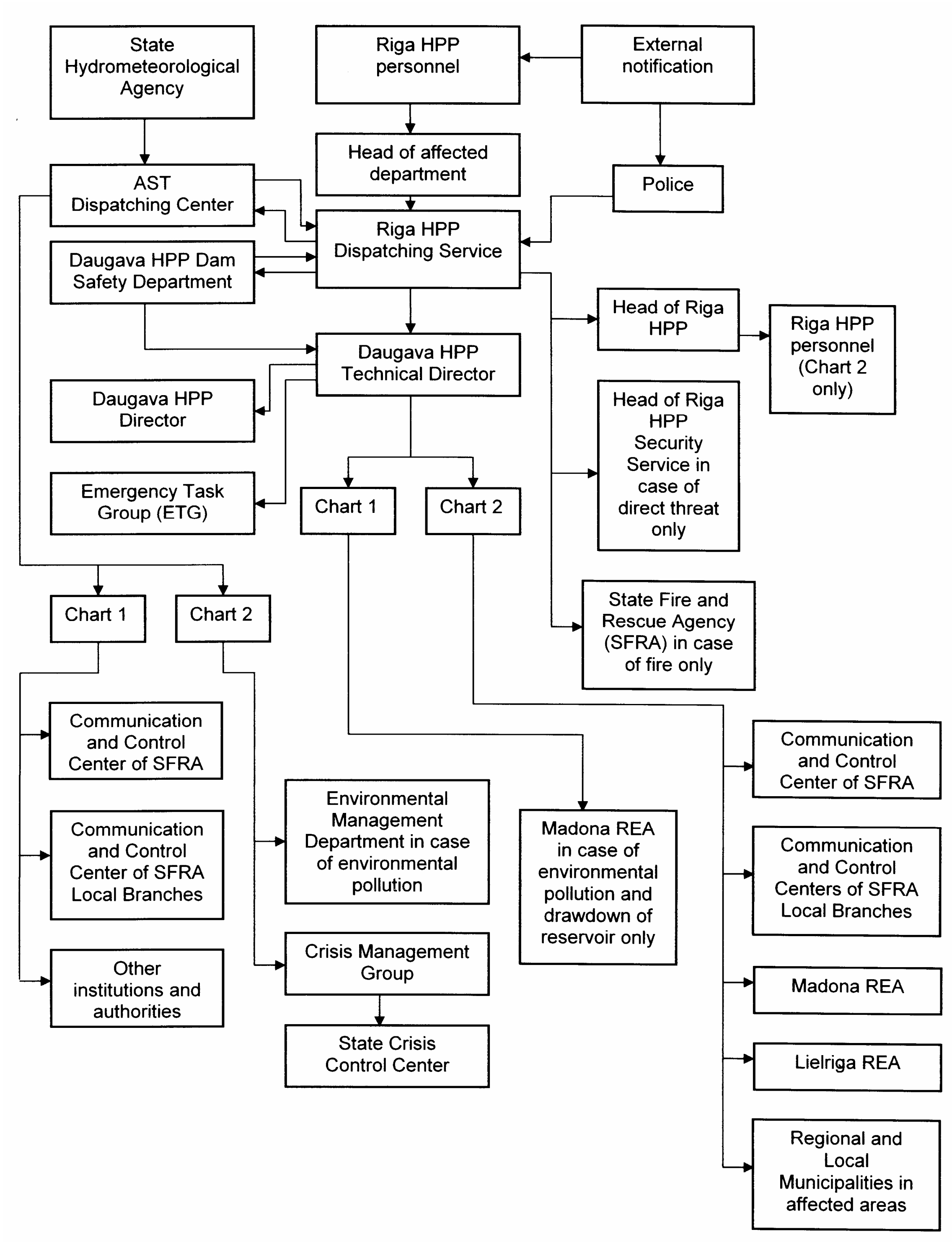

Fig. 5
Notification Charts 1 and 2
Graphiques de notification 1 et 2

Chart 1: Internal Alert and Developing Situation	*Graphique 1: Alerte interne et situation en développement*
Chart 2: Imminent Situation	*Graphique 2 : Situation imminent*
SFRA = State Fire and Rescue Agency	*Agence d'état de sauvage en cas de feu*
REA = Regional Environmental Agency	*Agence de l'environment régional*

4. CONCLUSIONS

The Internal Emergency Action Plan (IEAP) for storage and run-of-river hydro-electric facilities is an efficient dam safety management tool assisting the dam owner or operator in the handling of possible adverse impacts that may originate at the dam or in its environment.

The components of the IEAP, i.e. hazard identification and classification, 'unusual situations' matrix and emergency classification and as well notification charts present clear steps to follow in the case an unusual observation has been noticed requiring corrective or mitigating actions.

The IEAP facilitates decision making and streamlines communication among the responsible persons. It provides support to the key response actions to be taken within the dam owner's organization.

As an example, the IEAP was applied to the Riga HPP in Latvia, which involves a large dam in a cascade of a major river. The case history illustrates the hazards characteristic for the type of dam, its foundation and the physical environment.

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SUMMARY

The principles and objectives of an Internal Emergency Action Plan (IEAP) are explained. The IEAP is a useful tool in dam safety management. It regulates the responsibilities of dam owners or operators in the case of an emergency situation which could endanger the integrity of the dam or appurtenances and which may require immediate action. The IEAP consists basically of hazard identification and classification, categorizing the severity of the emergency situation, and in communicating the necessary actions among the responsible operating staff and also the notification of the incident to outside emergency management agencies for the implementation of protective measures for the downstream communities. The procedure and notification charts are illustrated with a case history involving the Riga run-of-river power plant and dam on the Daugava river in Latvia.

RÉSUMÉ

On explique les principes et les objectifs du plan d'alerte interne. Ce plan est un outil utile dans la gestion de sécurité des barrages. Il règle les responsabilités des propriétaires des barrages ou de ses opérateurs en cas d'une situation critique qui pourrait mettre en danger l'intégrité du barrage ou de ses accessoires et qui pourrait exiger des actions immédiates. Au fond, le plan d'alerte se compose d'identification et classification des aléas, de classer la sévérité d'une situation critique et de communiquer les actions nécessaires parmi le personnel opératif responsable et aussi la notification de l'incident à des agences externes pour l'exécution des mesures de protection vis-à-vis les communes aval. On illustre les procédures et les graphiques de notification avec un exemple concernant l'usine au fil de l'eau sur le fleuve de Daugava en Lettonie.