TAILSAFE

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Report

Tailings Management Facilities
-
Legislation, Authorisation, Management, Monitoring and Inspection Practices

by

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Tailings Management Facilities – Legislation, Authorisation, Management, Monitoring and Inspection Practices

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Foreword

Mines have different topographical, geological, and mineralogical properties and operate according to different management systems, level of skills or level of understanding of tailings disposal. This results in each tailings product being unique. Although all EU countries have laws applicable to tailings management facilities many failures of tailings dams occur at mines owned by reputable mining companies employing experienced consultants. A common reason for the failure is that dams are not operated according to their design criteria or water balance and construction are not controlled properly or there is a general lack of understanding of the features that control safe operation (Copeland, Lyell 2002). From this point of view, well organized and functioning dam safety legislation and regulations are of crucial importance.

Tailings dams share several features with water retention dams but also have considerable differences. One main difference is that they are usually raised in stages during the life of the associated mine. In the past their construction was usually under the control of mining personnel who might not have been experts in dam construction.

In this report an overview of the issues concerning legislation, management and surveillance procedures for the tailings dam is presented. The procedures concerning water storage dams are presented first as many of these procedures are also applicable to tailings dams. A few examples of the European countries presented in this chapter might not necessarily reflect the best practice in the world but they still give a hint of a practical point of view on the subject.

The report concentrates also on the legal situation concerning tailings dams in some of the European countries and presents the current legislation applicable to tailings dams in the European Union. Much attention is further devoted to the EU proposal for a directive on the management of waste from the extractive industries which is supposed to be adopted in the near future.

The sections devoted to authorisation, responsibilities, management, surveillance, monitoring and inspections of the tailings management facilities give an overview of the situation in some of the European countries and in the world. It has been attempted to present some good practice examples in this field.

The final section offers suggestions for efficient implementation of new regulations on mining waste and some ideas how to maintain them on at a high level.

1. Legislation and regulations

Legislation and regulations applicable to tailings dams differ considerably amongst the member states of the EU. The sensible drafting and creation of heterogeneous regulations is a solution to various problems concerning the safety of tailings dams. However, in most countries tailings dams remain largely outside the scope of dam safety regulations in force for water retention dams.

The International Commission on Large Dams - ICOLD (1989) provides various recommendations on how tailings dam statutory legislation could be arranged. These contain, *inter alia,* provisions for commissions, registers, permit procedures for design, construction, operations and maintenance, supervision, authorities, inspections and rehabilitation.

Golder Associates (2001) suggest that the regulations concerning the tailings storage facilities should be flexible enough to accommodate variations in physical, technical and social considerations of different sites. An ideal regulatory framework would accommodate future changes as technical knowledge and community expectations increase. Regulations should also be written to proactively address potential challenges and hazards, rather than as a reaction to unacceptable events and performance.

The form of the regulations can be either focused or diffused. In some countries the regulatory scheme relies on specific dam safety legislation. On the other hand, there are countries where dam safety is treated as one aspect of more general legislation, for example combined with water, dams, energy or natural resources (Bradlow et al. 2002).

1.1 An overview of water retention dams' classification in some of the European countries

One of the purposes of this section is to present general information concerning water retention dam safety legislation. The European Dam Safety Club (BETCGB, 2001) has collected existing material concerning dam safety legislation from the following countries: Austria, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal, Romania, Spain, Slovenia, Sweden, Switzerland and the United Kingdom. It has been realised that the standards and procedures in dam safety legislation vary considerably. The criteria of classification applied in dam legislation includes height, volume and risk posed by a dam. Dam height might vary from 3 - 15 m and volumes from 50,000 m^3 to 1,500,000 m^3. The classified hazards to human and environmental safety can be distinguished as high-risk, medium-risk and low-risk dams. Moreover, water retention dam legislation sets out very clear requirements concerning responsibilities and activities to be undertaken in order to secure the safety of a dam.

In **Austria** it is the Federal Water Law that regulates all issues concerning water retention dams, including river barrages. The Water Authority - an administration body enforcing the Law - authorises construction and operation and also exerts supervision as to the state and behaviour of a dam and the owner's activities concerning dam safety.

In **Finland** the Dam Safety Act and the Dam Safety Decree were enacted in 1984 to improve the safety of all dams including waste dams in different industries. Both the Dam Safety Act and Decree and the Dam Safety Code of Practice have to be applied to dams not less than

three metres high[1]. However, the Act should also be applied to a lower dam, if the volume of the substance in the basin impounded by the dam is so large or if the substance in the basin is of such a type that in the event of an accident it manifestly endangers human life or health or manifestly seriously endangers the environment or property.

According to the law on water in **France**, an authorisation issued by the administration is needed for a construction of any dam regardless of its height. For this authorisation, a technical file is presented by the owner. However, the French regulation is more strict about dams higher than 20 m or which represent a hazard to population. At the moment, about 15% of the dams falling under this particular regulation is of a height less than 20 m. A new classification of dams will increase this percentage to 35%. The concession of hydroelectric dams can add supplementary rules especially for medium high dams (higher than 10 m). Special rules for small dams are under consideration. In addition, dams higher than 20 m and with a reservoir capacity above 150,000 m^3 are subject to a regulation for emergency planning.

Since **Germany** is a federal republic, each state has its own "Water Act". For example, the "State Water Law" of the state North Rhine-Westphalia (NRW) covers dams defined by height and volume, e.g. $h \geq 5$ m and $V \geq 100{,}000$ m^3. Furthermore the state of the art for planning, construction, maintenance and operation is defined in the "Water Act". The Act defines six different types of dam (Table 1). All states consider the DIN 19700 and additional guidelines as state of the art. As far as technical requirements are concerned DIN 19700 distinguishes five types of dam but does not include any restriction by height or volume. No classification (e.g. based on risk) exists.

Table 1: Dam classification in Germany

TYPES OF DAMS	
State Water Law (NRW) legal requirements	**DIN 19700 technical requirements**
$h \geq 5$ m and $V \geq 100{,}000$ m^3	all dams
Type 1: dams and weirs	Part 10: all dams *
Type 2: tailings dams (within waters)	Part 11: reservoirs
Type 3: similar safety measures like type 1	Part 12: flood control reservoirs
Type 4: flood control reservoirs	Part 13: weirs
Type 5: pumped storage reservoirs (upper reservoir)	Part 14: pumped storage reservoirs
Type 6: tailings dams (outside of waters)	Part 15: tailings dams

* Part 10 refers to the section No 10 of the standard DIN 19700.

According to the law of August 8th 1994, the **Italian** regulations cover dams with $h \geq 15$ m and $V \geq 1{,}000{,}000$ m^3. In the past the regulations applied lower values (10 m and 100,000 m^3). For smaller dams, there are procedures of authorisation and inspection either on a central (Ministry of Civil Works) or regional level.

In the **Netherlands** the vast majority of dams are flood protection structures. Depending on the potential flooding damage and/or casualties, these flood protection structures are divided

[1] The height of a dam is the difference between the lowest point of the external boundary of the dam structure and the highest intended surface for the impounded substance.

into two classes: 1) primary flood protection structures of national interest (about 2500 kilometres in length, varying in height from 3 to 13 metres, 1984b) and 2) secondary structures, mostly smaller dikes. The Flood Defences Act (1996a) sets conditions for the primary flood protection structures in terms of the responsibilities of the authorities involved, the safety standards, the regular safety assessment, the procedure for reconstruction of structures and the framework for financing of reconstruction and maintenance.

In **Norway** a new Water Resources Act came into force in January 2001. Since there is almost no construction of new dams in Norway, operation and maintenance are the dominant issues. The new dam regulations – Regulation for Safety and Supervision of Structures in Watercourses – stress the importance of the requirements on the operational phase. This includes:

- qualification requirements
- requirements for internal control system
- emergency action planning and dam break analysis with inundation mapping.

Risk analysis can be required, for example to point out the most critical parts of a dam or the weaknesses within the owner's organization. The new regulations demand the establishment of procedures for safe operation of a dam. Such procedures include the description of operation, function and performance of a dam with appurtenant structures. Safety measures to prevent accidents to the public are also required. They include safety measures on a dam adjacent to the reservoir and in the river course downstream.

Dams subjected to public control are divided into three hazard classes. Each hazard class is defined on the basis of the number of buildings affected by a potential dam-break.

Table 2: Classification of dams in Norway (Molkersrød, Konow 2001).

	Consequence class	**Affected dwelling units**
Class 1	Low hazard	0
Class 2	Significant hazard dams	1-20
Class 3	High hazard dams	More than 20

When a dam failure can cause damage to infrastructure and other functions vital to society that can also give rise to hazard for life, then this should be assessed separately. When a failure gives rise to damage to national and county highways and railway lines, then the dam cannot be classified lower than 2. Loss of water and production, and damage to production equipment, property and the environment has to be evaluated independently and can result in a higher class than would be the case where a few or no housing units come into contact with water as a result of a failure in the watercourse structure (NVE, 2000).

In **Poland** there are 4 classes of dams and classification depends on the following criteria:

- height
- volume
- area flooded during a potential dam break
- PAR/LOL (population at risk/loss of life)

Legislation concerning safety of all hydrological constructions (regulations from March 1997) applies to water retention dams and tailings dams – however no separate dam safety law exists.

In **Portugal** there are two classes of dams. High dams are defined by height (h above foundation > 15 m), volume (V > 1,000,000 m^3) or significant hazard to human life and property. For small dams the new regulation has been in use since June 14th 1994.

The legislation in **Romania** contains specific rules according to the class of the dam which are presented in Table 3.

Table 3: Romanian dam classification.

	Height (m)	**Volume (hm^3)**
Class 1	$h \geq 100$	$V \geq 500$
Class 2	$25 \leq h < 100$	$20 \leq V \leq 500$
Class 3	$10 \leq h \leq 25$	$1 \leq V \leq 20$
Class 4	$h < 10$	$V < 1$

The dams covered by legislation in **Slovenia** are those considered as large dams by ICOLD. The criteria take into account the following items:

- h (above foundation) ≥ 15 m or h ≥ 10 and length of crest ≥ 500 m
- volume of reservoir ≥ 1 hm^3
- flood ≥ 2000 m^3/s

In **Spain** the instructions are called “Standard on the safety of dams and reservoirs" for the dams within the authority of the Ministry of Public Works, Transports and Environment. The dams are divided into three classes according to the level of potential hazard in the case of break or faulty operation: Class A with risk of human loss, damage in urban area, important material or environmental damage, Class B with limited risk of human loss, damage on sparsely population area or not very important infrastructures and Class C with risk of human loss only in exceptional circumstances, low damage. The rules apply to dams that are either of class A or B, or to those that fit the criteria of ICOLD.

Sweden has a long tradition of initiatives concerning dam safety:

- 1970 revision of the first directions for control of the maintenance and safety of dams
- 1977 recommendations for control of the maintenance and safety of dams
- 1983-1999 the Dam Safety Committee produced several documents concerning recommendations for maintenance and supervision of dams
- 1987 investigation of dam safety and protection against floods
- 1997 first edition of RIDAS (Hydropower Industry Dam Safety Guidelines) main document
- 2002 revision of the main document of RIDAS (Benckert 2003).

The Swedish regulations do not specify a lower limit for dams that are classified according to the potential hazard downstream (human loss, damage to infrastructures or environment, economic loss). The inventory of dams begins with h ≥ 5 m or V ≥ 50,000 m^3.

The dams in **Switzerland** are subject to the supervision by the "Authority of surveillance" (confederation or cantons) when they meet the criteria $h \geq 10$ m, $h \geq 5$ m and $V \geq 50{,}000$ m^3 or there is great danger for people or property. Dams are not subject to inspection if it is proved that they do not pose any particular danger for people or goods.

In the **United Kingdom** dam safety law falls under the Reservoir Act 1975 (chapter 23 which entered into force on December 1, 1991). UK legislation provides a mandatory safety regime for all reservoirs which are capable of holding more than 25,000 m^3 of water above natural ground level.

1.2 Legislation applicable to tailings dams

1.2.1 Mining legislation in some European countries and in the world

In most cases tailings dams are operated by mining companies and supervised by State Mining Authorities. This might easily result in a situation where the State Mining Authority has other tasks to cope with such as mine production and worker safety etc., and therefore tailings dam safety might be considered a minor issue.

All the **new EU member states** and the **candidate states** went through political and economic changes in the late eighties and early nineties. In all cases new legislation was introduced in the field of mining law. The first innovative legislative ideas were usually followed by corrective actions and subsequent amendments of the mining laws.

The term “mining law” has been often replaced by some other title, as for example Subsurface Resources Act in **Bulgaria**, Earth’s Crust Act in **Estonia**, Law on the Subsoil in **Latvia**, and Law on the Underground in **Lithuania**. **Poland** has combined legislation on geology and mining (Geological and Mining Law Act) and **Slovakia** has two separate acts governing the issue, an Act on the protection and utilisation of mining resources and an Act on mining operation activities. However, in **Hungary**, **Romania** and **Slovenia** there still exists traditional Mining Acts. According to Hamor (2002), the lack of the traditional "mining law” terms in the new legislation is a sign of the acceptance and adoption of the sustainability concept and a manifestation that the relevant acts deal with the sustainable management of the complex geo-environment.

Tailings facilities safety is often not the priority of mining safety legislation, if it is considered at all. In this case, there exist considerable differences among the new EU member states. For instance, in **Poland** tailings dams are the outside the scope of the Geological and Mining Law Act. They are regulated mainly by the Construction Law and the Polish Norms (design and construction). In **Romania** specific regulations on tailing ponds are covered by the law and special orders are issued by the Ministry of Water and Environment Protection and the Ministry of Industry and Resources. In **Hungary** a specific regulation on tailing ponds is being drafted (Hamor 2002).

Regulation of mining in the **USA** is the responsibility of the individual states. Jurisdictional processes vary from state to state with a focus on outcomes rather than operating procedures. For example in the state of Nevada, the Bureau of Mining Regulation and Reclamation (in cooperation with other state, federal and local agencies) regulates mining activities under regulations adopted in 1989.

In **Australia** the legislation concerning mining includes the Mining Act and the Mines Safety and Inspection Act. In some cases, additional Acts (Aboriginal Heritage Act, Conservation

and Land Management Act, Land Administration Act, Local Government Act, Soil and Land Conservation Act, Wildlife Conservations Act, Native Title Act) are also adapted. All TSF in **Western Australia** are categorised as a Category 1, 2 or 3 facility. The TSF categorisation is based on its "hazard rating", coupled with the maximum embankment height. All TSF over 15 m in height are considered to be Category 1 facilities, i.e. those requiring the most stringent attention.

Mining in **South Africa** is regulated by the Water Act, 1998, the Minerals Act, 1991 and the Mine Health and Safety Act, 1996. The Department of Minerals and Energy (DME) is responsible for implementing the provisions of the Acts. Government Mining Regulations had come into force in 1976 and they required a minimum freeboard of 0.5 m to be maintained at all situations for a tailings dam, in order to store rainfall occurring once in a hundred year without any fear of overtopping (Penman 2001).

1.2.2 Legal situation concerning tailings dams in some of the European countries

In the **European Union** there is still no specific legislation concerning waste from mining operations, although the process of creating and adopting such legislation is ongoing. On June, 2nd 2003 the European Commission published a "Proposal for a Directive of the European Parliament and of the Council on the management of waste from the extractive industries" (see paragraph 5.1.4). At the moment, the members States have their own mining and environmental legislation which covers the mining branch and is applicable to the tailings management facilities.

Tailings dams in **Finland** are included in the scope of the Mining Act and Mining Decree and regulated mainly by paragraphs 56 & 57. It is required in the Mining Law that suitable and applicable parts of the dam safety guidelines should be taken into account and the safety requirements stated in the Mining Law correspond to those of the Dam Safety Act. Both the Act and Decree are to be revised within a few years time. Other laws applying to tailings storage facilities are: the Environmental Protection Act (86/2000) and the Waste Act (1072/1993).

The Dam Safety Act and the Dam Safety Decree were enacted in 1984 to improve the safety of all dams including waste dams in different industries. Both the Dam Safety Act and Decree and the Dam Safety Code of Practice have to be applied to dams not less than three metres high. However, the Act should also be applied to a lower dam, if the volume of the substance in the basin impounded by the dam is so large or if the substance in the basin is of such a type that in the event of an accident it manifestly endangers human life or health or manifestly seriously endangers the environment or property. The Dam Safety Act concerns both water bodies and waste dams. Tailings and other waste dams are classified into four categories in the following way:

- P: those, which in the case of an accident, will endanger life of health or cause serious damage to the environment or property.
- N: those which do not belong to categories P, O or T.
- O: those which present only minimal danger.
- T: those which are temporary structures as defined by law.

In the **UK** tailings dams are regulated by the Reservoir Act 1975. It applies to tailings dams which still contain water and are capable of holding more than 25,000 m^3 of water above natural ground level. Spoil heaps and lagoons of liquid wastes at mines and quarries are subject to the Mines and Quarries (Tips) Act 1969 and the related 1971 regulations, which

lay down detailed requirements concerning their stability and safety. However, no tailings dams guidelines or codes of practice exist. Other laws applicable to tailings management facilities are the Health & Safety at Work Act 1974, the Mines & Quarries (Tips) Act 1969, the Mines & Quarries (Tips) Regulations 1971, the Environment Act 1995 and the Record of refuse deposited on active classified tips, Regulation 14 'A'.

In **Poland** the following laws are applicable to tailings dams:

- The Construction Law & Polish Norms (design, construction)
- The Water Law Act (licence to operate)
- The Act on Environmental Protection (EIA, monitoring)
- The Act on Waste (payments for discharge of water)

The Geological and Mining Law does not apply to tailings facilities. Tailings dams are classified in the same way as water retention dams and constitute four classes. All oversurface/raised tailings dams which impoundment size is more than 10 ha are subject to The Act of 9 Nov 2000 on Access to Information on the Environment and Its Protection and on Environmental Impact Assessment. According to this law, granting a decision whether to permit a proposed project which may have significant impact on the environment requires an environmental impact assessment procedure to be carried out. The EIA needs to be performed also when a tailings dam is modernized or extended. The local EIA commissions include: a Marshall of a Voivodship (main administrative unit of Poland), representatives of science and non-governmental organisations related to environmental protection. The EIA should contain, *inter alia*:

- a concise description of the project (nature, size, location, type of technology, etc) and the conditions for site use at the stages of construction, operation and closure
- the determination of the impact of the project on the environment, including the case of an emergency hazard to the environment
- a description of measures to prevent and reduce the impact on the environment
- a comparison of the proposed technological solutions with other available solutions applied in national or world practice from the point of view of cleaner production
- a concise summary of the information contained in the audit in a non-technical language

In **Germany** the following laws are applicable to tailings dams:

- Mining Law; however not all tailings ponds in Germany are amendable to the Mining Law
- each state has its own "Water Act" - the Water Act defines planning, construction, maintenance and operation of tailings dams

German Industry Norms (DIN-Normen) are applicable in all the Federal States:

- DIN 19700-15 for the construction of tailings ponds
- DIN 4149 for the construction in seismic activity/earthquake areas
- DIN 4084 for slope slide calculations
- ATV-DVWK (technical association on water issues) regulation for the controlling and reconstruction of tailings ponds

WISMUT-owned tailings ponds are also subject to:

- Radiation Protection Regulation and Waste Pile Regulation: both under the Atomic Energy Act
- The Waste Pile Regulation which is a still valid GDR (German Democratic Republic) regulation (fixed in the Reunification Contract).

In **Hungary** the Act no. XLVIII. of 1993 on Mining (Mining Act) indirectly defines the category of “mine tailings”. This term is not used in the Act but it can be deduced on the basis of other terms. According to the Mining Act, the mining activities include the prospecting, exploration, mining, preparation and primary processing of mineral raw materials and the subsequent mine closing and reclamation activities (article 49). The mining law definitely applies to tailings resulting from the physical mineral enrichment methods (washing, mechanical or radiometric sorting, etc.). In this case construction, operation and abandonment (reclamation) licensing is performed according to the Mining Act requirements and under the supervision of the mining authority. However, for tailings resulting from general mining activities – an Environmental Protection License (EPL) is also required. The Act no. LIII. of 1995 defines the general rules of the environmental protection. The Government Decree no. 20/2001. (II. 14.) contains the principles of environmental impact assessment and the procedure of environmental protection licensing. The next important regulation is the Government Decree no 193/2001. (X. 19.) which defines the rules of the integrated pollution prevention control licensing procedure. However, none of the mentioned regulations contains the term “mine tailings” or even “tailings” – they refer to mineral processing. It also has to be mentioned that these regulations do not use the term of mining in the same way as in the mining law. In practice the environmental authorities consider all mineral processing methods (including chemical treatment) as mining activities.

A part of the legislation on water also applies to the tailings facilities: the Government Decree no. 132/1997. (VII. 24.) on the tasks of water quality remediation and the Decree no. 21/1999. (VII. 22.) of the Minister of Transport, Telecommunications and Water containing the rules of the preparation, maintenance and modernisation of the operational plans for the water quality remediation (Barabás 2005).

Tailings storage facilities in **Ireland** are subject to the following laws:

- Environmental Protection Agency Acts (Part IV IPPC Licensing)
- Waste Management Acts 1996-2003
- Water Pollution Acts 1977-1990
- Minerals Development Acts 1940-1999
- Irish Planning and Development Act 2000

No specific legislation concerning tailings dams exists but Ireland has adopted the UK legal System. The UK's Reservoirs Act 1975 works as an operational law, although it is not legally binding. ICOLD recommendations concerning safety of tailings dams has had an impact on the practice in Ireland as well as the Canadian and Australian guidelines. All instructions and issues connected to safety of the TMF are included in the operational permit of a mine.

The authorisation process for mining activities includes, inter alia, the Integrated Pollution Control Licence (IPC). Since 1994 this licence has been required to be obtained from the Irish Environmental Protection Agency (EPA) for most large industrial activities in order to commence or continue operations. The requirements of the IPC licence corresponds to the requirements of the 1996 European Union Integrated Pollution Prevention and Control Directive (Council Directive 96/61/EC of 24 September 1996). The integrated permit replaced previous national legal requirements to obtain multiple authorisations for Air, Water and Waste emissions. Derham (1999) points out that the Irish IPC legislation is stricter than the current European Union one as it brings the mining as well as the processing of minerals into the IPC licensing net. One of the documents central to the licence decision process undertaken by the Local Government and EPA officials is the Environmental Impact Statement. The requisite scope and content of the EIS is laid out in the 1985 EU Directive (85/337/EEC) and in Guidelines on the Information to be Contained in Environmental Impact Statements published by the Irish EPA.

In 1995 an inventory of the **Swedish** tailings dams was ordered and performed for the Swedish Mining Association. In 1997 one of the mining companies initiated a dam safety programme including the development of a Operation-Supervision-Maintenance manual meant for tailings dams. This example was soon followed by other mining companies. At the moment the mining industry is using the applicable parts of the guidelines for water retention dams – RIDAS 1997. The possible need for creating a special appendix or separate guidelines for tailings dams has been investigated by a committee appointed by the Swedish Mining Association (Benckert 2003).

1.2.3 Closed mining sites

The effects of abandoned mines have a lasting influence on the environment. An abandoned mine is a reminder of potential hazards, and a powerful evidence of the weak regulations which fail to provide vital solutions for the present and future.

There are no European regulations existing today for closed mines and closure procedures. On the other hand, mine sites can be identified under Landfill Directive (1999/31/EEC), which specifies the closure conditions. However, in future this problem will be regulated by the new directive "on the management of waste from the extractive industries" once it is legally binding. The emphasis will be on the whole life-cycle management of waste and closure and after-closure will be of equal importance to the other stages. A waste management plan will be a part of the licensing process and after closure the operator will be obliged to provide monitoring to minimise the possible adverse effects on the environment. Moreover, a financial guarantee should be included in the licensing process. However, it should be noted that the BAT document does not cover abandoned sites.

According to Panagiotis (2004), the new legislation should be viewed as a challenge for the member countries to develop new efficient policies, dealing with a number of difficult issues such as the abandoned mines, and for the mining industry to adopt new flexible strategies, enhancing simultaneously its competitiveness as well as its corporate social responsibility.

At the moment, before a mine is to be closed in the **United Kingdom** it must follow statutory requirements on closure planning and implementation of an agreed closure plan. For closure planning it is usual to produce an initial mine feasibility closure plan that encompasses the need for progressive rehabilitation and monitoring of the restored mine site. Regular updates of the closure plan after discussion with entities such as the Coal Authority (CA), Her Majesty's Inspector of Mines (HMIM) who are part of the Health & Safety Executive (HSE), the Environment Agency (EA), and often Local Authorities take the form of a strategic review for closure and eventually result in a final closure plan. Once this has been agreed the actual mine closure is implemented starting with decommissioning and demolition and both active and passive care rehabilitation of the surface. In the industry the terms closure and abandonment are used for different purposes but legally they are essentially the same. The mining industry uses closure to mean the ceasing of mining activities, i.e. no coal is won and no underground development takes place and employment stops. Rather like stopping the production at a factory, the infrastructure is still in place. Abandoning is the further step of 'walking away' where the mine owners or operators wish to divest themselves of any liability associated with the closed and abandoned mine.

There is no unifying code that sets out the legal requirements. Instead a mine operator must look to a raft of legislation starting with the Management and Administration of Safety and Health at Mines Regulations 1993 (MASHAM). Part VI of the Regulations refer to the appointment and duties of surveyors and the requirement for various mine plans. These plans must accurately show the workings of the mine so the area to be closed can be

defined. A mine operator must also give notice to the EA 6 months before they wish to abandon the mine in accordance with the requirements of the Mines (Notice of Abandonment Regulations) 1998 and needs the agreement of the EA in respect of the proposed treatment and fill materials. The mine operator must submit a satisfactory condition report to the CA under the terms of the lease. This is to ensure that no liability transfers to the CA and ultimately to the public purse. The regulations are contained in s58 Environment Act 1995 which amends the Environmental Protection Act 1990 inserting two new sections, namely s91A and 91B. It is important to note that it is the operator and not the owner of the mine who is responsible for carrying out the procedure for mine closure (Dixon-Hardy 2004).

In the **new EU member countries** there exist detailed regulations on mining safety, but closure is not regulated in the same detail as the opening of mines. The mining license is usually based on the approval of a closure plan. The reclamation and post-closure monitoring are covered by the mine closure licensing procedure. If reclamation requirements are concerned, in most countries there are specific provisions. However, this is not the case for post-closure monitoring. This is usually laid down by the authorities in their resolutions. However, in lots of cases no safety procedures for reclamation apply to the abandoned mines. Orphan mines do not have an operator or a legal successor and therefore they pose a high risk to the environment. In most cases this problem is tackled in the mining act. The solutions vary and depend, among others, on the ownership of the given mineral commodity and the type of extraction technology. For instance, in **Poland** if the mine operator disappears without a legal successor, the landowner is responsible for the reclamation of open pits. In **Slovenia** the reclamation of orphan mines is taken care of by local communities which look for financial support from government funds. In **Hungary** the mining rights of the bankrupted mining company without a legal successor are to be announced for tender by the Hungarian Mining Office. If the transfer of the rights and obligations remains unsuccessful for a year, the licence is removed from the register and necessary measures to cover the costs of closure, reclamation, etc., are initiated. If the reserved financial guaranties of the company do not cover the total cost, the obligation for reclamation and environmental clean-up is eventually shifted to the State who is the original owner of the minerals. The status of the orphan mines is not regulated in **Estonia** and **Latvia** at all (Hamor 2002).

One of the most important obligations that shall be imposed by the new Directive concerns drawing-up inventories of closed hazardous waste facilities. For instance, **Ireland** has already created a register of closed facilities including inventory and risk ranking. Such sites are in the jurisdiction of the municipal authorities and the costs of any works performed there are met by the tax payers.

In general the administration of abandoned mines is a complicated and a sensitive affair which requires many issues to be addressed in order to achieve a desired result. In spite of the improved technological tools to deal with environmental pollution, such restoration projects usually face the lack of funding (Panagiotis 2004).

In the **USA** the Reclamation Branch issues permits to exploration and mining operations to reclaim (rehabilitate) the disturbance to a safe and stable condition that ensures a productive post-mining land use. An operator must obtain a Reclamation Permit prior to any exploration, mining or milling activity that proposes to create disturbance over 5 acres or removes in excess of 36,500 tons of material from the earth.

Picture 1: Open pit in non-operating Magcobar mine in Silvermines, Ireland. The mining activities in this area ceased in the late 1980s without post-closure activities.

Picture 2: The Gortmore Tailings Management Facility in Silvermines, Ireland. In 1999 there were cases of cattle deaths from lead poisoning on a farm adjacent to this site.

1.2.4 Financial guarantee

One can find many examples where tailings dam failures have been the initiative behind the implementation of formal stewardship programmes and improved management procedures.

In the **USA** a surety is to be filed prior to engaging in the activities authorised by the permit. The surety may be a trust bond, irrevocable letter of credit, corporate guarantee or a combination of these mechanisms. The surety is reviewed every 3 years to determine if the amount is still adequate to execute the approved plan for rehabilitation.

In **Ireland** the Integrated Pollution Control Licence requires the lodging of a bond (financial security) to underwrite the Closure Plan and a bond to finance the Perpetual Aftercare Plan prior to commencement of operations. All the older mines had to raise a fund in order to receive a new licence.

In the **European Union** the adoption of the new Directive on mining waste shall bring new requirements towards financial guarantees. Prior to the commencement of new mining operations a guarantee in the form a financial deposit or equivalent will be required. This is to ensure that all obligations including after-closure provisions are discharged, as well as there are funds available at any given time for the rehabilitation of the land affected by the waste storage facility. Within the period of six years from the date of adoption of the new legislation, mining waste storage facilities operators shall be obliged to provide a financial guarantee as part of the licensing process (Commission of the European Communities 2003).

1.3 Legislation applicable to tailings dams in the European Union

1.3.1 Legislation on waste or tailings

The Waste Framework Directive 75/442/EEC of 15 July 1975 (amended by Directive 91/156/EEC of 18 March 1991) lays down general provisions and principles for the handling of waste. The Directive states that Member States must take necessary measures to ensure that "the wastes are covered or disposed of in such a manner that they have no impact on human health or cause any environmental damage". This Directive applies to "…waste resulting from prospecting, extraction, treatment and storage of mineral resources" in the absence of specific Community legislation on mining waste (issue clarified by the Commission in its Communication on "Safe operation of mining activities: a follow-up to recent mining accidents").

The Directive concerning Landfill of Waste (1999/31/EC of 26 April 1999) outlines surveillance programmes for water, leachates and gases and requires that the results of monitoring must be shared with authorities. This directive also applies to waste "resulting from prospecting, extraction, treatment and storage of mineral resources" except if they are non-hazardous and inert (Article 3.2). Certain mining wastes are covered by the list of hazardous wastes (European Waste Catalogue, decision 2001/118/EC, an amendment of the earlier Directives 2000/532/EC and 94/3/EC). Because the Landfill Directive is meant to deal with general and common aspects of landfill management, some of its provisions are not compatible with best management practice or do not deal with management issues specific to the extractive sector, like for instance, stability of dams in tailings ponds. The following provisions are problematic in the case of extractive industries waste:

- a ban on the disposal of liquid waste into landfill
- a general ban on the co-disposal of non-hazardous with hazardous waste or with inert waste
- a requirement to install a barrier and a liner to be put under a landfill site in order to prevent groundwater pollution (Commission of the European Communities 2003)

This situation requires a necessity to create an appropriate legal framework that would exempt waste from the extractive industries from the scope of the Landfill Directive and establish tailor-made rules.

1.3.2 Legislation on industries/IPPC

Activities listed in Annex I of the IPPC Directive (96/61/EC) concerning integrated pollution prevention and control are required to obtain an operating permit issued by the competent authorities. The IPPC Directive stipulates, *inter alia*, that the operating permits must be based on environmental quality standards considering the requirements of the best available techniques (BAT).

In general, extraction activities as such are not specifically addressed by the IPPC Directive. According to the Communication from the European Commission COM(2000)664 on the Safe Operation of Mining Activities, most sites in the European Union where tailings management facilities are used are not covered by the IPPC Directive. However, activities such as mineral processing, certain metallurgical activities, chemical activities and landfill activities which involve waste other than inert waste are covered by the Directive. Thus, if extraction can be considered as a "directly associated activity" to any of the activities listed in Annex I of the IPPC Directive, it will require an IPPC permit.

1.3.3 Legislation on water

In the EU, the management of water is based on an integrated management system depending mainly on quality standards and limit values for emissions. Directives also concerned with tailings sites are, for example:

- Discharges into Water, Directive 76/464/CEE with other Directives on discharges of dangerous substances
- Groundwater Protection Directive 80/68
- Water Framework Directive 2000/60/EC

The aim of the Water Framework Directive is to provide a general framework for the protection of all waters. Although not explicitly mentioned, point sources of water pollution such as, for instance, acid drainage generated by tailings ponds will have to be covered by the characterisation of pressures and impacts in a river basin. The requirements of the Water Framework Directive apply also to the pollution originating from abandoned facilities of the extractive industries.

Picture 3: The Lisheen TMF, Ireland. The Irish tailings management facilities are required to obtain an authorisation called an Integrated Pollution Control Licence which is similar in most respects to the requirements of the 1996 European Union Integrated Pollution Prevention and Control Directive.

1.3.4 Legislation on environmental issues

The Environment Impact Assessment (EIA) Directive (85/337/EEC) (amended by Directives 97/11/EC and 92/104/EEC) is an integral part of the laws on mining operations for most of the EU countries. The primary objective of the EIA is to ensure that projects which are expected to have significant effects on the environment are subject to an assessment of their likely impacts. In particular, quarries, open-cast and underground mining and drillings are included in the scope of this Directive.

EIA is a process for anticipating the effects on the environment by an activity. An Environmental Impact Statement (EIS) is the document produced as a result of that process. The EIS provides information which the competent authority uses in determining whether consent should be granted or not. This information is also available to affected parties in order to evaluate the acceptability of the development and its impacts.

1.4 Towards a new European Union legislation

1.4.1 Proposal for a directive on the management of waste from the extractive industries

The relatively recent mining related accidents, Baia Mare/Romania in 2000 and Aznalcóllar/Spain in 1998 and the pollution they caused have attracted the attention of the public to the environmental and safety hazards of mining activities.

The European Commission's response to these accidents was set out in a Communication on the "Safe operation of mining activities: a follow-up to recent mining accidents". The Communication sets out three key elements envisaged to improve the safety of mining operations:

- a revision of the Seveso II Directive (96/82/EC OF 9 December 1996) on the control of major-accident hazards involving dangerous substances to include in its scope tailings ponds and dams used in connection with mineral processing of ores,
- a Best Available Technique (BAT) Reference Document on tailings and waste-rock management to reduce everyday pollution and to prevent or mitigate accidents in the mining sector,
- a proposal for a Mining Directive.

Picture 4: The remains of the tailings dam embankment in Aznalcóllar, Spain.

In June 2001 the European Parliament adopted a Resolution on the Communication and expressed its strong support to the Commission's initiative. The aim of the initiative is to improve the way in which mining waste is managed by addressing potential environmental risks during the waste disposal phase. It focuses on:

- the safety of waste management facilities and in particular dam safety, and
- operational issues connected with waste management, including acid rock drainage and possible contamination of the environment.

The Commission launched the proposal of the new directive "on the management of waste from the extractive industries" on 2.6.2003. The aim of the proposal is "to set minimum requirements in order to improve the way in which waste from extractive industries is managed by specifically addressing environmental and human health risks that may arise from the treatment and disposal phases of such waste. By encouraging waste recovery in particular, the proposal aims to contribute to the conservation of resources in serving to reduce pressure on the exploitation of virgin natural materials. The promotion of recovery could also reduce overall environmental impact by lessening the need to open new mines" (Commission of the European Communities 2003).

The proposal contains:

- a range of conditions to be included in the operating permits
- a range of general obligations concerning waste management
- the obligation to characterise waste before disposal or treatment stages
- measures to ensure the safety of waste management facilities
- a requirement to create closure plans for waste management facilities
- an obligation to ensure an appropriate level of financial security (Commission of the European Communities 2003)

A copy of the proposal is available from the European Commission website at:
http://europa.eu.int/eur-lex/en/com/pdf/2003/com2003_0319en01.pdf

1.4.2 BAT

The Reference Document on Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities was launched in July 2004. The BAT document results from the information exchange between the European Union's Member States and the mining industry.

The objective of the BAT document is to both reduce everyday pollution and prevent or mitigate accidents. The BAT document concentrates on:

- waste-rock management
- mineral processing relevant to tailings management
- tailings management, e.g. in ponds/dams, heaps or as backfill
- topsoil and overburden if they are used in the management of tailings

The aim of the BAT document is also to promote good management principles and life-cycle management. The BAT document, however, does not address abandoned sites. One of the main roles of BAT is to provide reference information for the competent authority to take into account when determining permit conditions.

The BAT document can be downloaded at the following address:
http://www.antenna.nl/wise/uranium/mdiss.html
http://eippcb.jrc.es/cgi-bin/locatemr?mmr_bref_0704.pdf

1.4.3 Seveso II Directive

The control of major accident hazards involving dangerous substances is covered by the Seveso I and II Directives (82/501/CEE and 96/82/EC) for preventing industrial accidents. However, the exploitation of minerals in mines and quarries is excluded from the scope of this directive. The Proposal to amend the Seveso II Directive (COM(2002) 540 final) suggests the changes (Article 4, point (g) and (e)) to ensure that "active tailings disposal facilities, including tailings ponds or dams, containing dangerous substances as defined in Annex I of this Directive and used in connection with the chemical and thermal processing of minerals (Commission of the European Communities 2002) fall within the scope of the Directive and are no longer excluded.

1.4.4 Permit

Article 9 of Directive 75/442/EEC states that no waste facility is allowed to operate without a permit granted by the competent authority. The permit may be combined to form a single permit to avoid unnecessary duplication of information and the repetition of work by the operator or competent authority. The application for a permit should contain, *inter alia*: the waste management plan; if applicable, a document proving that a major-accident prevention policy and a safety management system for implementing it have been put into effect; financial guarantee arrangements. The permit can be granted only under condition that all requirements under the new directive are met by the operator, and that the management of waste is in line with the relevant waste management plan. The public must be informed about the application for a waste management permit at an early stage so that there is possibility to participate in the procedure for the permit granting. The information contained in the permit has to be also available to the competent national and Community statistical authorities for statistical purposes (Commission of the European Communities 2003).

1.4.5 Classification of waste facilities

Under the new Directive waste management facilities have to be classified into two groups according to their hazard potential. Category A is to include any facility that in case of a failure or incorrect operation would present a significant accident hazard; and Category B is to include all others.

1.4.6 Adoption of the new legislation

Once the proposal for a *Directive on the management of waste from the extractive industries* is adopted by the deputies and ministers of member states it will become a binding law. It shall be implemented by the member states within 24 months following the date of its publication.

The member countries will face a problem of transposition and consequently of enforcement of this act. This will require a plan of implementation including the work to be done by the law-makers and the administrative tasks. New obligations will be faced by mining

entrepreneurs and mine supervision authorities which represent the state in the mining issues.

In **Poland** mining waste management is regulated by several legal acts such as the Act on the Environmental Protection, the Act on Waste, the Construction Law, the Act on Geological and Mining Law with executory acts. Amendments will have to be introduced into the current laws applicable to mining waste management. Since there is no legal act that regulates all aspects of mining waste, such an act will most likely have to be created when the directive on mining waste is adopted and Poland will be obliged to implement this act into its national legislation.

Some of the legal instruments proposed in the draft of the directive such as a permit for a construction of a waste facility, internal and external emergency plan are already present in the Polish legislation. However, waste management plans drawn up by the mine operators or a classification system waste facilities depending on their hazard potential as well as proposed definition of the waste facility are a novelty in the Polish legislation (Dulewski, Madej 2004).

Slovenia has started the process of preparation for the adoption of the new directive since the publication of its official proposal. The European Waste Catalogue and its amendments have been transposed the Slovenian legislation in the form of an annex to the Rules on waste management. Tailings are managed according to technical documentation consisting of mining projects, long-term and annual programmes of exploitation of mineral resources and documents on the environmental impact of mining operations. The mining operator is obliged to ensure an adequate level of environmental impact monitoring.

At the moment there is no information available on the costs of the mining waste management in Slovenia. However, in future the costs will increase when new obligations brought by the new directive will have to be met. According to Marc et al. (2004), these costs may be divided into three groups:

- one-off costs arising from the adjustment to the new requirements and operating conditions for the operating and planned mining waste management facilities
- additional costs arising from the operation of the mining waste management facilities
- additional annual costs when the exploitation of mineral resources ceases or the mining waste management facilities are closed.

The new requirements concerning design, construction and operation will greatly contribute to the increased costs of mining waste management. Additional costs will also arise when the action plan for mining waste prevention and reduction of its danger potential is implemented. Additional funding will also be needed for the preparation, implementation and upgrading of the existing accident prevention programmes (Marc et al. 2004).

1.5 Tailings Dam Guidelines and Codes of Practice

General dam safety guidelines which also include aspects concerning tailings dams exist in many countries. In 1989 ICOLD published Bulletin 74 "Tailings Dam Safety – Guidelines" which contains information about the unique aspects of tailings dams and general provisions for guidance on design, construction, operation and rehabilitation.

The Canadian Dam Association (CDA) updated their dam safety guidelines in 1999. The guidelines include recommendations concerning responsibilities for dam safety, scope and frequency of dam safety reviews, operation, maintenance and surveillance and also

emergency preparedness. These guidelines state that conventional earthfill dams for water storages and tailings dams for mining residues are in many cases similar, for instance if design criteria for stability of the dams are concerned.

In **Canada** “A Guide to the Management of Tailings Facilities” (Mining Association of Canada, 1998), presents a full life cycle management framework for a tailings storage facility. The guidelines give recommendations for planning, design, construction, operation and finally for decommissioning and closure. The framework is expanded into a series of checklists addressing various stages of the tailings dam life cycle. The guide identifies six key elements for effective implementation of the dam operation and management. These elements are 1) Management Actions, 2) Responsibility, 3) Performance Measure, 4) Schedule, 5) Technical Considerations and 6) Other References.

In 2003 the Mining Association of Canada completed another guide "Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities" in order to help mining companies apply tailings management systems that include environmental and safety criteria. The purpose is also to improve the consistency of application of sound engineering and management principles to tailings and water management facilities through their full life-cycle.

In 1994 the **US** Environment Protection Agency (USEPA) published a Technical Report titled “Design and Evaluation of Tailings Dams”. Sections of the document are based on the book “Planning, Design and Analysis of Tailings Dams” by Steven Vick (1990). The report provides an overview of the methods of tailings disposal and the types of storage facilities. General information is presented on the design of tailings dams, including a discussion on design variables, such as site-specific factors, site location, hydrology, geology, ground water, foundations and seismicity. Water control and management are also presented, including discussions on hydrology, management of storm flows, infiltration and seepage control and tailings water treatment.

The **Mexican** Official Standard (1997) stipulates the compulsory requirements for site selection, construction, operation and monitoring of a tailings storage facility. These requirements include:

- environmental impact study
- compliance with laws governing the preservation of historical or cultural heritage
- assurance that there will be no percolation of toxic leachates to the nearest aquifer or surface water body within 300 years
- approved plans for surface and groundwater monitoring
- detailed characterisation of the underlying geological structure and the mechanical properties of rock formations and soil deposits
- land surveys of the site to delineate elevations and features such as roadways and pipelines
- compliance with civil work design standards for dams issued by the Federal Electricity Commission
- monitoring instrumentation for a tailings facility over 50 m in height.

In **South Africa** a policy of “self management” is applied that requires mines to prepare an Environmental Management Program Report (EMPR) at the planning stage. Thereafter, the requirements of the "Code of Practice for Mine Residue" (SABS 0286-1998) apply to a tailings storage facility during its life cycle stages of design, construction, operation and closure. The Code of Practice addresses the life cycle of a TSF in terms of safety, construction, operation and environmental impact. It contains objectives, principles and minimum requirements for good practice and its aim is to ensure that no unavoidable risks,

problems and/or legacies are left to future generations. A process of continual management and continuous improvement throughout the life cycle is envisaged. The Code of Practice requires that each TSF be assigned a Safety and Environmental Classification. In terms of safety each TSF is classified as having a high, medium or low safety hazard. The TSF is environmentally classified according to the spatial extent, duration and intensity of its potential impacts and is considered as either “significant” or “not significant”. These classifications determine the minimum requirements for investigation, design, construction, operation and decommissioning of the TSF (see Appendix 2).

For all mining projects in Western **Australia** a Notice of Intent (NOI), a document addressing the environmental issues associated with the mining project has to be submitted in accordance with the “Guidelines to Help you get Environmental Approval for Mining Projects in Western Australia” (DME 3, 1998). The NOI should contain a Design Report that documents the design of the TSF.

In October 1999 the **Australian** National Committee on Large Dams prepared "Guidelines on Tailings Dams Design, Construction and Operation". The purpose of the guidelines is to provide a single base document directed to all relevant government authorities, national and international companies involved in tailings dams development. The guidelines do not provide a design, construction or operation code, and dam personnel are expected to apply their own considerations, judgements, and professional skills when designing and maintaining tailings dams (Guidelines on Tailings Dam Design, Construction and Operation, 1999).

In the People’s Republic of **China** tailings storage facilities must be designed and constructed in accordance with National Codes (Design Standards). Provincial authorities are responsible for issuing a license to construct and operate the tailings facility. Code ZBJ 1-90 (1991) Design Standard – Tailings Facility for a Mine, addresses the design of a TSF for a mine and classifies a TSF into one of five classes according to storage capacity and dam height. The Code specifies the minimum factor of safety for various operating conditions. Tables are presented stipulating the minimum freeboard and storage (beach) length for different classes and types of construction (upstream and centreline), minimum crest widths and downstream slope angles.

2. Authorisation and responsibilities

2.1 Different authorities for dam and tailings dam safety

The purpose of the authorisation is to minimise all the risks concerning tailings dam. This target is mainly achieved by involving different sections and levels of different ministries. However suggestions made by Golder Associates (2001) state that all tailings storage facilities should be assessed, licensed and monitored by a single authority.

A comparative study made by Bradlow et al. (2002) revealed that from the 22 studied countries 11 jurisdictions have designated a regulatory authority that is exclusively dedicated to dam safety. In some of these countries the specifically designated authority may share jurisdiction over some aspects of dam safety with other regulatory bodies. In 15 countries the regulatory authority deals with dam safety as part of the other responsibilities and as an exception Australia has a system where the regulatory framework identifies a specific individual to be responsible for dam safety issues.

In **Finland** dam safety authorities are as follows: The Ministry of Agriculture and Forestry has the supreme supervision and guidance, issuing guidelines for dam safety. The supervision of dams subject to the Mining Law is undertaken by the Safety Technology Authority of the Ministry of Trade and Industry. The Regional Environment Centres are responsible for official decisions, supervision of observance of rules and regulations issued in and by virtue of the Dam Safety Act excluding rescue services. The Ministry of the Interior and its authorities (provincial governments and municipal rescue authorities) are responsible for rescue services and emergency action planning. The role of the Finnish Environment Institute is to give expert opinions to regional environment centres on the safety monitoring programmes for P dams (dangerous) and hazard risk assessments, to improve dam safety and to participate in preparation of the dam safety code of practice.

In **France** the authorities concerning dam surveillance are divided into three different sections: the Ministry of Transport has the supervision for the reservoirs that supply the canals. The Ministry of Industry has the supervision for major hydroelectric power stations and tailings dams and the Ministry of Environment for the remaining dams.

In **Germany** the supervision of the tailings dam belongs to the State Mining Authorities.

In **Romania** the administrative organisation is governed by several laws which are planned to be modified. The coordination of the administration is the National Commission for the Safety of Dams which is a part of the Ministry of Water, Forest and Protection of the Environment. The supervision of the dams is performed at a central level or by local authorities. The Department of Mines has a particular responsibility for tailings dams.

2.2 Responsibilities of the authorities

According to Bradlow et al. (2002), the authorities have many responsibilities and powers in the dam safety issues. They are in charge to develop norms and standards. They have the power to issue licenses and permits. Considering the surveillance of the dam, the authorities are monitoring and conducting the inspections and/or giving the approval of the inspectors.

Regulators should also establish and maintain a database on all tailings dams, operating and others (closed). Information databases are collected by making the inventory of dams and by maintaining the register. In **Canada** there have been a few quite recent tailings dam incidents, which were partly caused by the lack of relevant and accessible historical database and/or inadequate appreciation of that database (Martin et al. 2002).

The authorities may have the responsibilities of advising dam owners and lower authorities. In addition some state or country carry also the requirement to issue periodic reports on dam safety.

In **Finland** Regional Environmental Centres must supervise the fulfilling of all requirements on the dam safety legislation including procedures of applied permissions, surveillance for the demands of the permissions and roles in emergency situations.

In **France** a specific regulation covers water dams in operation with possible consequences for public safety. The local service of the administration in charge of the dam keeps up to date a file comprising all useful documents (final drawings, inspection reports, monitoring reports etc.). The administration inspects the dam every year. Five years after the first filling and every ten years, the reservoir is, in principle, emptied in order to inspect the upstream face of the dam. Underwater inspections are only exceptionally carried out.

In the **UK** the local authorities are required to keep a register of all raised reservoirs in the area and submit regular reports to the Secretary of State detailing the steps they have taken to ensure that undertakers observe and comply with the requirements for all reservoirs in their area. If the Secretary of State is concerned that the local authority is not meeting its obligations, an inquiry into the matter can be ordered. From 1st October 2004, the responsibility for enforcement of the Reservoirs Act passed from the local authority to the Environment Agency (Bradlow et al. 2002).

2.3 Responsibilities of other persons in charge of dam safety

The responsibilities for dam safety are shared with the different parties, which are dam owners, dam operators, designers (and constructors) and stakeholders. Stakeholders should be involved already during the environmental impact process of the tailings storage facility.

2.3.1 Tailings dam owners

The primary responsibility for dam safety rests with the owner of the plant including appropriate monitoring, maintenance and provision for emergency measures. The owner must ensure that the dam is designed by a competent and experienced person. In addition, the owner must recognise the importance of good management principles and practices. Responsible management of tailings might be expensive, but expenses are incomparably higher, if the tailings facility fails and causes enormous damage to humans and the environment. The owner must implement means of detection and, if possible, repair of the defects that can occur in the dam. The owner of a dam is obliged to make himself acquainted with the regulations concerning his dam, and, on his own initiative, ensure that they are observed. The owner must also have a detailed file with all the documents concerning the dam.

As an example of the different responsibilities of a dam owner the items of dam safety for dams in general are in **Switzerland** the following (BETGCB 2001):

- the control of the working order of the outlet gates and the spillway gates.
- the visual surveillance and the reading of the monitoring system. Data must be immediately analysed (control of the behaviour of the dam).
- the annual inspection by a experienced professional (regular control of the state).
- publication of annual reports about the results of surveillance and monitoring. These reports are intended for the Authority of Surveillance.
- expert evaluations of the dams (at least every five years) by confirmed experts in the field of dams (engineers, geologists). These evaluations include an opinion on the condition of the dam, an analysis of its behaviour, an examination of the monitoring system with a proposed programme of monitoring. A special evaluation can be required (for instance safety in the case of flooding).
- setting up the register of the dam.

In the **UK** the Reservoirs Act makes the owners legally responsible for the safety of their reservoirs. They are required to employ suitably qualified civil engineers to make regular checks on safety in between the Panel Engineers' inspections. According to the Reservoir Act, a reservoir cannot be constructed or modified unless a qualified engineer is employed to design and supervise its construction. The Act defines clear procedures for issuing the certificate to fill and operate the dam. A qualified engineer has to be certain that a dam under construction is ready for filling and then issue a preliminary certificate specifying the level to which the dam can be filled. A final certificate is issued after three years if the engineer is satisfied that the dam is sound and satisfactory and may safely be used for storing water. An annex to the final certificate should detail the issues that the Supervising Engineer believes need to be watched in any inspection of the dam. If a final certificate is not issued after five years, the engineer must provide a written explanation (Bradlow et al. 2002).

2.3.2 Operators

The operators of the dams have to ensure that the tailings facility has an Operation Manual for guidance in tailings management. Operators must maintain the contacts with designers and, most importantly, they must ensure that the design work is closely combined with operator's active participation. The operators have to guarantee that the dam is operated by a qualified staff.

In **France** the operator of a dam keeps a register for all the events, incidents, maintenance activities, etc. The operator must carry out periodical visual surveys and implement suitable monitoring. The regulation indicates (but does not impose) frequencies of inspections and monitoring. Every fault must be reported to the administration. The operating instructions for exceptional events are established by the operator and approved by the administration. The operator publishes an annual report of the surveillance, the monitoring and the operation of the dams. Every two years, the report includes a detailed analysis of the results given by the monitoring (BETGCB 2001).

In **Spain** the operating director must be a qualified engineer. The operating instructions must include the following items:

- procedures in the case of exceptional events
- programme of monitoring and periodical inspections
- information procedure for water releases
- alarm system.

These instructions are included in the file of the dam. The operator keeps up to date a register of the dam (BETGCB 2001).

2.3.3 Designers

Special qualification of engineers who are in charge of dams is considered important. However, almost in every country there is no formal approval of them, in spite of a few exceptions for the "Dams Safety Engineers". The dam designers must have a good knowledge of their own skills and resources, in other words, designers must know their limits and be sure that they are "not assuming that they will be able to manage to design all the sites just because they got the contract".

First of all, design consultants should have appropriate educational and engineering experience directly applicable to tailings dam design. In addition, the history of design projects of construction and operation are of an extreme importance for such consultants. Dam design consultants are also recommended to have experience from different countries and different companies. Workshops, conferences, etc. give an opportunity to share and gather the knowledge of different experience.

The designer should participate in supervision of the dam by overseeing the most demanding work stages and inspecting the site records.

There is no formal approval for engineers dealing with dams in **Finland**. According to the Dam Safety Code of Practice, a body constructing a dam is responsible for ensuring that the dam was designed under the direction and responsibility of a competent and experienced person (MMM 1997).

In the **United Kingdom** there is in use a formal approval of civil engineer for dam construction. After consultation with the Institution of Civil Engineers, the Secretary of State for the Environment makes appointments to panels of qualified civil engineers for a five-year period. The four panels are 1) all reservoirs, 2) non impounding reservoirs, 3) service reservoirs and 4) supervising engineers.

3. Management of the tailings facility

According to the **Australian** Guidelines, "continuous management is a fundamental principle in the planning of tailings storage systems. Any TSF is a system which is developed and maintained over a long period of time in a dynamic environment. This requires a commitment to management at the appropriate level during all phases of its life" (ANCOLD 1999).

The management of the tailings storage facility begins after dam construction. The dam management starts with the commissioning and implementation of the dam (in relation to the plans and construction work descriptions etc.), and after that the filling of the impoundment basin can start. During the tailings dam operation and functioning, including water balances, increasing the height, emergencies and decommissioning, the importance of the surveillance, monitoring and inspections can never be underestimated.

The management and supervisory personnel should have sufficient experience in carrying out demanding earthworks, and the persons responsible for these works should have experience of previous works on embankment dams. The supervisory personnel and the management should not be dependent on each other, and the supervisor should have the right to halt construction should the conditions, materials used or work methods differ from those specified in the design documents.

3.1 Tailings Management Plan

A Tailings Management Plan should address the whole life-cycle of the facility starting from design and ending at closure and rehabilitation. Several issues should be addressed like for instance, lead times for design and construction of new storages to avoid risks of overtopping of the existing facilities or a plant closure if replacement facilities are not commissioned on time. As there usually come changes throughout the life-cycle of the facility, the Plan should be flexible and capable of modification. The **Australian** Guidelines on Tailings Dam Design, Construction and Operation, 1999 suggest that to this end the plan could be subdivided into Short, Medium, and Long Term Plans.

The Long Term Plan should consist of the overall planning criteria, control issues and goals for achieving satisfactory tailings disposal over the remaining life of the project. The Medium Term Plan includes information on management, detailed schedules of the planned construction and necessary costs for maintaining the tailings facility for a given period of time, typically 3 to 5 years. Finally, the Short Term Plan consists of month to month operating framework which can be modified to suit operating conditions provided they are in line with the goals specified in the longer term plans (ANCOLD 1999).

3.2 Operational Safety Manuals

A operational safety manual (OSM) should be prepared for the documenting operation, maintenance and surveillance. The OSM should be implemented, followed and updated at appropriate intervals. The manual should also contain suitable and sufficient information in order to operate the dam safely, to maintain it in a safe conditions and to monitor its performance.

There are countries (for example **Finland** and British Columbia in **Canada**), where operation manuals and annual inspections/reviews by specialists are a regulatory requirement. The

Canadian operation and maintenance manual contains general information of the dam, operational procedures and emergency preparedness plan.

According to Martin et al. (2002), the Operation Manual (OSM) for a tailings facility might be the most important measure in implementing good stewardship practices for tailings. The recommended elements of the OSM are as follows:

- project administration, responsibilities of operation, safety and review roles of the corporation
- design overview and key design criteria
- tailings deposition and water management plans
- planning requirements
- training and competency requirements
- operating systems and procedures
- dam surveillance (checklists, signs of unfavourable performance, responses to unusual observations)
- reporting and documentation requirements
- emergency action and response plans
- construction and quality assurance/ quality control requirements
- standard formats for status reports in certain times, performance reviews
- reference reports and documents

In **Poland** operational manuals for the tailings facilities are required by the Construction Law. Each tailings impoundment is required to have its own operational manual and files meant for the operator.

In **Sweden** the OSM manuals have been developed by the Swedish mining companies and follow RIDAS: Hydropower Industry Dam Safety Guidelines (1997). The Swedish OSM manuals cover the following issues: dam safety organisation, classification of dams due to hazard, Emergency Preparedness Plan (EPP), design and construction, hydrology and discharge facilities, environmental issues, monitoring, operation permits, filing register for reports, calculations, etc. It is required that the organisation and responsibilities of the staff must be well documented and established. Details about consultants, contractors, authorities etc., familiar and associated with the facility must be available. RIDAS requires also that one person ”responsible for dam safety” (RDS) & ”one technical expert on dam design” (EDD) must be appointed; their role is to assist the RDS and the local dam safety organisation. In general, all staff must have appropriate competence including education, training and experience specified in RIDAS (Benckert 2003).

In **Hungary** tailings facilities operation rules are included in a Technical Operation Plan (TOP) for a mining activity. The TOP has to be submitted to the mining authority for approval and is valid for 1-5 years depending on the type of the extracted mineral raw material, the production volume and the mining method (Barabás 2005).

3.3 Implementation and commissioning of the tailings dam

According to the Finnish Dam Safety Act, the construction of a dam has to be carried out in such a way that in structure and strength it meets the requirements that no safety risk would arise from either the dam itself or its use. From this point of view the commissioning inspection of a dam should be made in such a manner that all issues relevant to dam safety are adequately considered. The quality of the dam structures should also be assessed. The commissioning inspection is the responsibility of the chief dam designer or another

competent person. The commissioning inspection is based on data in the dam plans, the quality control programme and, if necessary, the hazard risk assessment.

The commissioning inspection begins with a written notification to the authority. Then the inspection continues with the necessary field inspections, which can be reviews of structures and foundations conducted during different stages of the work. The commissioning inspection is completed when all the structures are operationally ready, have been brought into full-scale use and have been approved to function as planned. At the closing of the commissioning inspection the records of the field inspections and the completion documents are collected, and a summary (final statement) and a proposal for dam qualification are compiled from them and included in the dam safety file.

As compared to water dams, there is no such thing as the first filling of the tailings dams.

3.4 The filling of the impoundment area

The management of the tailings facility requires the filling of plans including the amounts of solid substances and free water areas. In addition, the planned tailings deposition method and later the realized deposition must be documented during the operation of the TSF.

The tailings placement can be arranged by cyclones or spigots or the tailings deposition can be done by the paddock or mechanical placement systems (ICOLD 1995b). The technical parameters to be monitored are the width of the beach, discharges from the spigotting outlets and tailings coarseness and slurry density from the first and the last spigottings outlets from the main delivery pipe (ICOLD 1996c).

Picture 5: Spigotting outlet in Żelazny Most, Poland.

The report on the fillings of the tailings impoundment should contain the information about the planned and completed fillings and their effect on the stability and other properties of the dam and the tailings storage facility.

According to the German guidelines on tailings facilities, the geotechnical characteristics of the tailings can be considered as a function of the distance from the discharging place. The further one goes, the greater values one gets for percentage of fine materials, combined pore volumes, water consistence and inclinations for alleviation (sludging). On the other hand, increasing distance from the discharging place will decrease the values of dry density, shear strengths and water and air permeabilities (ATV-DVWK 2001).

3.5 Water balance of the tailings dam

The water coming to the tailings storage facility mainly originates from the tailings discharge, which can vary from 5-50% of sludge percentage. Other sources of water are the rainfall and the surface drainage from the dam levees.

The waters leaving the tailings storage facility are due to seepage, decantation, overflowing in the planned and unplanned situations and the evaporation. The amount of the seepage can be measured by weirs of V-notch, rectangular or trapezoidal type (ICOLD 1996c).

The operational manual should include the description of overflow spillways (during the use of the dam and the different stages of construction) and of reserve basins and/or ditch systems for diverting the waste substance if its surface exceeds the safety level. Also the description of the methods of by-passing the water from the surrounding area should be added to the management procedures.

As a fluid management plan the monitored items of the tailings impoundments should be 1) normal size and depth of supernatant pond, 2) anticipated dimensions of pond after design storm event, and 3) leak detection or vadose monitoring well locations (Bureau of Mining Regulation and Reclamation 1994).

3.6 Increasing the height of the tailings dam

One of the typical features of the tailings dams is the continuous need for increasing the height of the dam. The different methods for that are upstream, downstream and centerline methods. When evaluating the effects of the increasing of the dams on the stability and other properties the items to be considered and reported are:

- planned increasing of height
- planned time schedule for the increasing of height
- method of construction
- materials used in the increasing of height

The increase of the dam height cannot be performed during the frost period. The materials used as a building material are usually the tailings itself, and in order to evaluate the effects on stability the operator must know the geotechnical characteristics of the tailings.

During increasing the height of the waste areas, the quality control and surveillance have to be carried out. The constructions mentioned above are to be observed especially during extreme conditions such as heavy rains or freezing temperatures.

Picture 6: Increasing the height of the tailings dam in Żelazny Most, Poland.

3.7 Emergency situations

Tailings dam failures are typically caused by poor water management, overtopping, foundation failure, drainage failure, piping, erosion or earthquake. The potential effects caused by the tailings dam failures are loss of life, contamination of water supplies, destruction of aquatic habitat and loss of crops and contamination of farmland. In addition, tailings dam failure may threaten the protected habitat and biodiversity and lead to loss of livelihood. Guidance have also been given for the mining industry in raising awareness and preparedness for emergencies at local level (see Appendix 3, UNEP 2001).

In **Finland** the dam safety guidelines recommend reporting and evaluating the possibility of failures and other problems endangering the structures of the reservoir, their causes and consequences. Also the plans for future prevention of such failures or other problems in the use of the dam must be documented.

The Dam Safety Act requires an Emergency Action Plan to be created for any dam which in the event of an accident may manifestly endanger human life or health or seriously endanger the environment or property. The plan is based on a dam-break flood analysis (hazard risk assessment). The municipal rescue authority is responsible for the emergency action planning. The dam owner is obliged to assist the rescue authorities in drawing up the plan, to draft the relevant assessments and necessary action plans for his part. The dam owner bears also the responsibility to acquire and maintain the facilities and materials referred to in the action plan and to take other measures to safeguard people and property against the risk posed by the dam and to participate in the implementation of the action plan. The Regional Environmental Centre, when this is considered necessary, can require that a dam breach hazard analysis is prepared for a waste dam. A dam breach hazard analysis for a tailings or other dam can be prepared by supplementing the evaluation of dam failures (MMM 1997).

The precautions against a dam accident are to be taken according to the instructions for the tailings or other waste dams, as well as the possible harmful and toxic nature of the waste material which must be reported at all waste dams. This can be done on the form for evaluating the environmental consequences of a dam failure. For the most dangerous dams (P dams), the reports and plans for accident prevention are prepared according to instructions in the Dam Safety Code of Practice. For the assessment of a danger to human health or to the environment, the following details of the impounded substance are to be provided:

- the nature of the impounded substances, the substances harmful or dangerous for health and environment, and their content in the impounded material.
- the total volume of the impounded substance and an estimate of the amounts of harmful or dangerous components likely to be washed out into the environment in the case of an accident.

Additional materials to be presented are an estimate of the magnitude of the risk of danger to human health and to the environment (see Appendix 4), an estimate of the consequences, and an action plan for the prevention of these dangers in the case of a dam accident. If there are people living so close to a dam in a potential downstream hazard area that an alarm given by the rescue services could not possibly reach them in time, the area at particularly high risk must be provided with a system capable of sounding the alarm in time. The normative time limit for an area at particular high risk is two hours from a dam failure. The need for such a system has to be ascertained by the rescue authority.

In **Poland** the Environment Protection Law stipulates that Emergency Action Plan is needed for tailings storage facilities. The EAP needs to include:

- maps of the potential pollution caused by a dam breach
- flood simulations
- rescue action plan
- warning system
- evacuation routes

In **Germany** an Emergency Action Plan is legally required for operating tailings dams and during the time of remediation. It is no longer required when a dam slope is flattened or stabilized. In the Federal State of Saxony, it is the Saxon Ministry of the Interior that bears responsibility for EAPs.

In **Sweden** Emergency Preparedness Plan is required by RIDAS (Hydropower Industry Dam Safety Guidelines 1997). The EPP should cover plans for:

- critical situations, incidents and dam failure
- mobilisation of staff, equipment and material
- working systems for information and alarms
- information on responsible staff members (Benckert 2003).

3.8 Decommissioning and remediation of tailings dams

The method of decommissioning the tailings facility depends on the characteristics of the impounded material. The different alternatives are tearing down the dam, surface cover structures and preventing the environmental impacts caused by the tailings facility. In every case the area need to have a surveillance programme for the environmental emission and water levels.

According to discussion paper for guidelines in Victoria, Australia (NRE 2002), the mining industry in Peru has used The Mine Closure Guide prepared by Golder Associates Ltd. to provide an outline of closure objectives, approaches and technical issues for the planning of closure of mines or mine facilities including tailings storage facility. The guide contains the following issues relating to tailings storage facility:

- perpetual disruptive forces and control technologies
- chemical stability of soluble minerals, acid drainage and chemical reagents, and control technologies
- design methodologies, including treatment and encapsulation
- guidelines for the design of covers
- closure alternatives including water management and landfill stability
- closure plans for waste materials that address potential environmental issues, typical closure technologies and typical design elements
- post-closure performance monitoring.

In the **UK** the abandonment of reservoirs must be approved by a qualified engineer. After closure the responsibility of monitoring is passed over to the local authorities. The only requirement on the owner is to ensure the dams are safe before closure and that the water in the dams cannot pond – it must be able to flow/run out of the dam (Bradlow et al. 2002).

In **Poland** the owner is responsible for the remediation process of the tailings storage facility. In case of a bankruptcy the legal successor, the owner of the ground where the impoundment is situated, or finally the State is responsible for monitoring and sustaining of the existing tailings facilities and for the subsequent remediation process.

Picture 7: Wismut site under remediation, Germany.

In **Hungary** in usual conditions a tailings facility is remediated and reclaimed. The reclamation is approved by the authorities under a condition that a facility does not require a subsequent maintenance. Since generally the operator is the owner of the land, it is the owner's duty to perform land inspections and maintenance if still required. According to the Mining Act, the operator (the mining company) or its legal successor (if exists) is responsible for any damage that occurs in connection to the tailings facility after its closure. In case of uranium mining, the tailings ponds require monitoring after remediation and a state-owned company perform the required activities and bears responsibility for damages. The Mining Act requires a financial bond which depends on the volume of production that is supposed to cover the costs of remediation and reclamation. In case of bankruptcy, the State of Hungary uses the financial resources to cover the costs of remediation tasks (Barabás 2005).

In **Ireland** the IPC licence and the planning authority permission require the rehabilitation and aftercare plan for a TMF. A fund necessary to underwrite the perpetual aftercare elements of the closure plan is secured by the Environmental Protection Agency (Derham 1999).

3.9 Documentation

In order to improve the safety of existing tailings dams the documentation and filing the important documents are of great importance during dam operation. Documentation is established in forms of operating manuals, dam safety files, maintenance diaries, malfunctions reports and records/minutes of the inspections.

According to the dam legislation survey (BETCGB 2001), dams in **Germany** are operated with the help of the approved documents including 1) operating plan for the use of the water, 2) operational and maintenance instructions for the plugs, operating and measuring installations and 3) instructions for dangerous situations with the required communication.

In **Finland** the dam owner or holder is obliged to store all the documents relevant to dam safety in a special safety file. This also includes the control and measurement documents, which must be registered in the same dam safety file. A record is made of the annual and regular inspection and included in the dam safety file. The records can be made more graphic with drawings, photographs, videos, etc. A copy of the record is also sent to the authority (regional environment centre) and, for a dangerous dam, also to the provincial government, the regional fire commander and the municipal fire authority even if these did not participate in the inspection. Amendments and supplements to the safety file are sent to the regional environment centre (MMM 1997).

In **Finland** the Dam Safety Code of Practice requires that structural and operational disturbances affecting dam safety must be reported. The report must present the cause of the disturbance, the investigations conducted and the measures undertaken. The disturbance report has to be delivered to the dam safety authority.

In **Poland** documentation issues are regulated by the Construction Law. For instance, instructions for the workers describing their daily routines are to be created for each tailings facility. The report book of the tailings dam is required to be updated daily and includes such activities as sampling, monitoring and embankment control.

In the **UK** records on critical issues relating to the dam, such as its water level and leakages must be kept by the undertakers (i.e. owners and operators) of dams. The undertakers must also install instruments to measure these aspects of the dam's functioning (Bradlow et al. 2002).

4. Surveillance, monitoring and inspections

Safety surveillance, monitoring and inspections belong together when evaluating the safety of a tailings or other dam. The **Canadian** guidelines (MAC 1998) suggest that periodic inspections and reviews, audits, independent checks and comprehensive independent reviews are the main part of the surveillance programme.

The dam monitoring involves, *inter alia* 1) monitoring the height of water or other substance impounded in the basin, 2) inspection of the visible parts of the dam structures and the dam downstream area during each inspection visit, 3) the observations and measurements listed in the monitoring programme and other issues relevant to the dam and 4) other special items related to dam safety (especially of tailings and waste dams).

The risks of tailings impoundments are normally caused by seismic, hydrological or operational disturbances. Tailings dams are usually inspected annually by independent experts for various safety concerns. One might suspect that this kind of evaluation represents only an instant of time and does not tell how the facility is really being operated. From this point of view testing and evaluation of possible failure scenarios should be added to the annual inspections (Glos 1999).

As a result of the surveillance to the operational manual, the description of the possible problems at the tailings dam should be documented, for example excess filling, overflow, their causes and measures for preventing similar problems in the future.

The **Swedish** dam safety guidelines RIDAS (1997) which are also applicable to tailings dams require that all tailings facilities have appropriate instrumentation to:

- register changes
- control the operation of the facility
- check the stability and
- evaluate the status of the dam (Benckert 2003)

4.1 Safety surveillance programmes

The safety monitoring programme has to be drawn up well in advance of completion of a dam so that it can be approved for compliance before starting the filling. According to Hurndall (1998), the dam safety programme should include as a minimum:

- some form of legislation, regulation and /or guidelines
- an inspection programme for dams with significant hazard potential
- an operation, maintenance and surveillance programme in place
- regular independent review of the safety of dams
- an audit programme in place.

The **Finnish** procedure for reducing the risks of dam damage includes a safety monitoring programme, which has to be drafted for each dam referred to in the Dam Safety Act. The dam safety monitoring programme has to be drafted by the dam owner. The programme has to be drafted in such a manner that all the issues relevant to dam safety are subjected to surveillance and inspection. The programme may include rules concerning the monitoring proper, annual inspections and the inspections made at regular intervals (not exceeding five

years). A safety monitoring programme or its amendments are approved by an authority (MMM 1997).

In **Finland** the safety surveillance programme of a tailings or other dam is prepared in accordance with the Dam Safety Code of Practice. According to it the safety surveillance programme includes regular inspections (every 5 years) by a competent expert, annual inspections (in the intermediate years) by maintenance personnel and surveillance between inspections according to the programme defined in the basic inspections.

In safety surveillance, special attention is to be paid to the observation of a) intake pipes of the waste material, pumping and transfer lines and discharge pipe systems, b) inspection wells and collecting wells, and c) quality of work in constructing and increasing the height of waste dams and drainage areas.

In **Finland** seasonal surveillance of the dam is to be carried out by the schedule required in the safety surveillance programme. In addition, surveillance is required when the structures come or may have come under special strain after the break-up of ice, during a flood, or because of heavy rains or a storm. During the surveillance the following observations should be made (whether to until stated and agreed date or alternatively for the time being):

- Investigation of the visible parts of the dam structure
- Observation of the internal inspection galleries and wells
- Visual observation of the collection wells and discharge points of the dam filter system (function of drains and colour of seepage)
- Reading of the stand pipes, measuring weirs and other monitoring instruments
- Inspection of the drains in the downstream area and abutments
- Inspection of the inflow pipes, pumping lines and outlet channels
- Checking the inspection of the monitoring and collecting wells
- Quality control of the building and work to increase the height of the dams and the waste areas
- Evaluation of environmental impacts

4.2 Parameters of monitoring and inspections

The general information collected for the further evaluation of the dam safety includes the sections of dams, their types and materials with the stationing of length of the sections, widths of the top and the greatest heights of the dams. In addition, the lowest elevation of top dam and lowest level of core belong to the same category. The smallest freeboard, safety margin and inclinations of the wet and dry slopes also have great effects on dam safety.

4.2.1 Stability and settlements

According to the Finnish dam safety guidelines, the total safety of dams, i.e. dam stability in a state of constant seepage flow should be at least 1.5. At the final stage of construction and on a sudden fall in water level (HW-NW) total safety should not be less than 1.3.

Stabilities are calculated for different cross-sections. The calculation can be made either using the total safety method or partial safety coefficients. Total safety is the ratio of shear strength to the shear stress prevailing in the assumed fracture plane. It is noticeable that in

some cases calculations of the total safety or the limit state of failure may give too favourable picture of dam stability.

Sampling and soil mechanics laboratory tests should be done in order to determine for example the dry densities, frictions and shear strengths. *In situ* determinations of soil mechanics properties can include volume density, total pressure and water permeability, which can be affected by freezing and thawing cycles.

Dam settlements are evaluated by monitoring the vertical and horizontal movements and differential settlements in the embankment. In unstable areas seismicity also must be monitored.

4.2.2 Seepage and pore water pressure

Seepage discharge is the most important factor which has to be measured, because it provides evidence of any serious failure in the tailings dam. The measurements of the seepage discharge should be automated and the readings recorded separately from each drain and place without interruptions. By doing so the location of any increase of seepage and the possible occurrence of internal erosion can be observed. For safety reasons the properly drained tailings dam is essential in order to keep the *phreatic* surface as far away as possible from the downstream slope, to reduce pore water pressures and to decrease the danger of liquefaction (ICOLD 1996c).

Monitoring and reporting the seepage of the tailings dam include items and information of the outflow channels for the seepage, methods of measuring the seepage water (amount and measuring interval) and changes in the volume or nature of seepage water during recent years. With the help of this information the assessment of the danger to the structures caused by seepage and the plans for preventing dangerous seepage is made.

The height and the position of seepage surfaces may be deduced by measurements of stand-pipe piezometers or piezoprobes. It is usually recommended to install stand-pipe piezometers once the dam has reached a certain height and continue their extension as the height increases. In order to determine the seepage surface accurately a sufficient number of stand-pipes must be installed. Seepage flow can be estimated by calculations of discharge quantities and/ or monitored by measuring and recording the rates of discharge of the collector drains beneath or above the liners (ICOLD 1996b).

Objects subject to visual surveillance of seepage are springs, wet areas in the downstream area, changes in vegetation (e.g. proliferation of willow) and areas that remain ice-free in winter or become snow-free early in spring. In areas where the tail water extends to the dry slope of the dam it is not usually possible to measure seepage water flow. To determine the quality of seepage waters the inspections should be made when there is no flow in the downstream channel (MMM 1997).

Pore pressure includes the hydrodynamic pore pressure (the difference between upstream and downstream water levels) and excess pore pressure generated during undrained loading, if the consolidation is not complete, and it can be very high in the internal part of tailings dams. Dynamic pore pressure develops in the tailings and liquefaction might occur, if the induced pore pressures become so high, that it starts destroying the structure of the fine and silty sands, which is the case in the earthquakes (ICOLD 1996c).

Picture 8: Seepage in Siilinjärvi TMF, Finland.

4.2.3 Freeboards and safety margin of dam

The maintenance of adequate freeboard is essential to the safety of every tailings dam. The operating freeboard should be measured and recorded by accurate survey methods on a monthly basis (ICOLD 1996b). Items to be monitored can also be the impoundment freeboard variations corresponding to the area, the average freeboards and the lowest observed freeboards of the tailings storage facility.

The Finnish dam safety guideline (MMM 1997) states that the freeboard of dams (the difference between the dam crest and the HW level) is deduced from the maximum wave height at HW or the depth of frost penetration based on design freezing index. The freeboard should, however, always equal the depth of frost penetration that occurs at least once in ten years (in general the dominant factor of the freeboard). For the dams with minor impacts (O dams) the freeboard is determined by the maximum wave height or depth of frost penetration occurring once in five years. The impact of traffic as a factor augmenting frost depth must be taken into account separately when dimensioning the freeboard of dams with a public road running along the crest. For dams without regular traffic, freeboard determined on the basis of frost penetration can be reduced by ensuring that the upper part of the dam is sufficiently watertight down to the frost penetration depth estimated as above.

Should the freeboard only just meet the dimensioning requirements, the frost depth on the dam crest should be monitored regularly in a few cross-sections. After a winter harsher than that corresponding to the design cold content used in determining the depth of frost, inspections during the spring thaw should be intensified.

Safety margin is the difference between the top level of the dam core and the highest technical water level. According to Finnish guidelines (MMM 1997), the safety margin should be at least 0.4 m for dams with normal and high risks. The low risk dams can use 0.3 m for their safety margin. Allowance must also be made for settlement of the structure and formation.

4.2.4 Structures in the dam

In order to monitor the structures built for the handling of the impounded tailings the surveillance programme must include wells and pipes. Wells built in the tailings dam, pipes through the dam and wells within the waste area are monitored by their condition and compactness and their effect on the stability and other properties of the dam. Inspection of dam structures includes checking the internal inspection galleries and wells and visual inspection of collection wells and discharge points of the dam-filter system (performance of drains and colour of the seepage water).

The purpose of the drainage system in tailings dam is to decrease the phreatic surface, to reduce pore pressure and hydrodynamic pressure deforming the flow net and to control seepage and migration of tailings particles. Designing the drainage system starts with careful study of the seepage by taking account to the heterogeneity, anisotropy and irregularity in shape of the tailings dam (ICOLD 1994).

The filtering structures and the drainage system should be so dimensioned that they are capable, in all circumstances, of protecting the core against erosion and of discharging the waters seeping through, under or around the dam and to smooth any peaks in flow gradients. The filtering structures must meet the grain size criteria, and their permeability must be 100 times that of the protected structure. The drainage system must be able to put through a volume which is ten times that of the calculated total seepage water (MMM 1997).

Monitoring includes the reading of the standpipes, measuring weirs and other gauges and inspection of drains in the downstream area.

4.2.5 Condition of the dam

The condition of the tailings dam should be inspected regularly and the defects and deformations, which can be observed visually are the possible cracks parallel or transverse to the crest or the slopes or the cracks in the soil at the toe of the slope. In addition visible displacement or distortion of solution or drainage trenches and visible sagging and bulging at the toe of the slope must be inspected (ICOLD 1996b).

The Finnish guidelines (MMM 1997) state that the width of the top of the dam i.e. the crest width of dams should be at least 4 m. The width must be increased by 0.5 m if the height of the dam exceeds 10 m, and by a further 0.5 m for each successive 10 m. For special reasons the crest width of smaller risk dams (N dams) less than 4 m high can be 3.5 m. The crest of minor risk dams (O dams) should be no less than 3 m wide. The crest should be passable over its entire length.

Vegetation is not the most important issue for the tailings dam, because in many cases the tailings do not provide the optimal circumstances for it. But there are also the kind of tailings, where vegetation can occur. According to the Finnish guidelines (MMM 1997), trees and bushes on the dam slope should be so sparse that there is an unimpeded view of the dam for inspection purposes. The area of dam and background subsurface drains that are part of

drainage systems should be kept free of trees and bushes for a width of at least 5 m. In the dam background, trees at the foot of the dry slope must not prevent maintenance or inspection. The following recommendations are given to different parts of the dams and should be inspected regularly:

- the top of the dam: the amenity of the dam area and its impact on the landscape can be enhanced with trees, bushes and ground vegetation. Vegetation prevents erosion of the dam surface. The vegetation must not endanger the structure or impede dam maintenance.
- wet slope: as a rule, no trees with trunks are allowed on the wet slope. Bushes growing between the wet slope and the crest are advantageous for the accumulation of snow.
- dam crest and dry slope: trees are not as a rule permitted on the dam crest. Low bushes may grow at the bend between the slope and the crest. On the dry slope, trees with trunks may grow down slope from a height corresponding to high-water level as long as they do not endanger the structure.
- levees: on levees, trees and bushes can be on the wet slope as well as the dry slope, chiefly in the freeboard area. Vegetation must be removed from the water fluctuation area to the extent it interferes with water flow in the channel.

Picture 9: Siilinjärvi tailings dam slope, Finland.

4.2.6 Impounded tailings

In addition to the structural safety and stability of the dam, the environmental impacts have become a more and more important issue in dam inspections. The evaluation of

environmental impacts should include information about the type and amount of impounded tailings. The characteristics of the tailings are also relevant information for the estimation of the consequences of possible tailings dam failure. The report on the characteristics of the impounded substances should include the nature and the origin of the waste, the geotechnical properties of the waste and the effect of the impounded substance on the dam stability.

The amount of the impounded tailings can be measured by collecting the data of discharging equipment (for example pumping systems). From the impoundment area the average depth of the impounded substance (m) and the average thickness of sludge on the bottom of the dam should be monitored on a regular basis. In addition to the monitoring programme the following features should be included: critical height of water level in the basin (HW), lowest technical or planned water level (NW) and the basin storage capacity (flood HW - NW).

4.3 Frequency of monitoring and inspections

The normative periodicity of the inspections depends on the dam classification. Deviations from the normative periodicity are allowed if a system replacing the inspections is in use (e.g. remote monitoring cameras, telemetric apparatuses and computers with the alarm systems based on them). The use and function of the replacement systems should be described in the draft monitoring programme.

The annual inspection should establish the state of the structures and changes in them visually and by means of equipment test runs. The structures should be inspected in spring or early summer after the flood and thaw. In addition, and if necessary, during floods and after exceptionally heavy rainfalls and storms, inspection visits should be made to dams which are or may have been subject to extra strain.

The conditions of the structures and facilities, and for waste and tailings dams, the type of impounded material, and changes in them that affect dam safety should be established by regular inspections (to be held at intervals not exceeding five years) with measurements, analyses of observational data, test runs of the equipment, and other investigations considered necessary.

In **Hungary** the mining authority is obliged to perform an annual inspection of tailings dams. According to the Mining Act, the mining company has to appoint an expert called a responsible technical leader to perform weekly inspections.

In **Poland** annual inspections of tailings dams are to be performed, as well as regular inspections should take place at least every five years.

4.3.1 Annual inspection

The annual inspection of a dam should be made when the soil is not frozen. In the course of the annual inspection the measurements and observations made during the year are reviewed, taking into account the changes that have occurred, the operational state of the measuring devices is checked and the parts of the dam and the associated facilities requiring repair are investigated in the field.

During the annual inspection special attention should be paid to checking the condition, performance and alarm systems of the dam. In addition, the checking measures taken by the

operating personnel during sudden heavy rainfall are reviewed. The filling and discharge channels of the basins and associated structures should be inspected when the spring flood has subsided. Correspondingly, the structures and facilities of waste dams, such as the inflow and outflow systems, are inspected once a year. A record is made of the annual inspection and test runs and included in the safety file of the dam owner.

Picture 10 and 11: Annual inspection in Harjavalta TMF, Finland.

4.3.2 Regular inspection

In **Finland** a regular inspection is made at intervals not exceeding five years. The date of the first regular inspection is counted from the date of the commissioning inspection. A representative of the dam owner or holder, authority and a competent person participate in the regular inspection. In the regular inspection the agenda is usually as follows:

- the compiled observational data and other results are gone through
- repairs made and the reasons for them are checked
- structures are inspected as considered necessary and the working conditions of the facilities important for dam safety are checked
- trees and other plants are checked for dam safety
- it is verified that the hazard risk assessment is up to date
- it is checked that the assessment of the impact on health and the environment is up-to-date
- the site plan and the associated action plans are inspected and the viability of the arrangements required by them is evaluated and the site plan revised if necessary
- it is established whether changes have taken place in conditions or in the type of impounded substance affecting the dam class
- the dam classification is verified, which may imply that the existing hazard risk assessment has to be supplemented or, if the situation so requires, the authority (regional environment centre) may have to order a hazard risk assessment to be made for the dam
- the dam safety monitoring programme is checked and necessary changes, if any, recorded,
- it is verified that the safety file is up-to-date in every other respect and that any amendments needed are recorded
- if necessary, decisions are made on the follow-up measures and investigations.

4.4 Methods of monitoring

The surveillance and monitoring of the features for evaluating the dam safety are done by periodical visual inspections, sample taking and different kind of measurements. Periodical measurements and data acquisition on site are carried out by operators or attendants of the inspections. Non destructive techniques (NDT) are recommended for the existing dams to prevent any harms caused by the measurements, which could be the case with the drillings, sample takings, etc. An example of the monitoring programme is presented in Appendix 5.

Monitoring equipment for continuously measuring (which is suited to the importance of the dam) is installed in order to measure the deformations of the dam and its foundation, the seepages, the uplifts, the temperatures, the pore pressures, and, possibly, the phreatic surface in earth fill dams. Automatic acquisitions, transmissions and processing of significant behaviour data are constructed for generating data alarms, if data exceed allowable reaches. Continuously operating monitoring methods need also periodical calibration and testing of automatic monitoring systems (alarm tests). In addition the periodical tests of appurtenant devices (operational equipment like spillway and outlet gates) must be done at least once a year.

Satellite surveillance can be used as a monitoring method for tailings facilities. Satellite images provide an effective method to check such features as pool size and position, wetness of slopes, etc. Evaluation of tailings dams by these images should be made on a regular basis (ICOLD 1996b).

4.4.1 Monitoring of the structure

The structure can be monitored with measurements (levelling, settlement observations, frost depth measurements etc.) and visually. The visual monitoring should concentrate above all on changes that have taken place (settlements/cracks in the crest or slopes, state of facing, unusual frost heaves etc.). The embankment dams should be kept free from vegetation, so that any deformations or waterlogged sites in the dam slope are readily visible. The drainage ditches in the background area in particular should be kept clean (MMM 1997).

4.4.2 Monitoring of seepage waters

Seepage waters can be monitored with pore water pressure gauges, groundwater wells, drain structures or drainage ditches. Special emphasis should be placed on changes in pore water pressure, water level or rate of water flow, and on water quality (colour, turbidity, etc.). After completion of the dam (by the first regular inspection at the latest) alarm limits should be set for pore water pressure, the water level in groundwater tubes and/or the measured water volumes, which would call for inspection by an expert.

The concentrations of seepage flows can be studied with ground-penetrating radar. The first such radar study should be made as soon as the dam has been completed and thereafter in conjunction with the regular inspections. The radar results enable the monitoring instruments (pore water pressure gauges, groundwater wells etc.) to be placed more accurately in dam cross-sections, which improves the quality of monitoring.

4.4.3 Monitoring of pore pressures

Pore pressure can be measured by standpipe piezometers if the water level does not rise too high. If the piezometric level exceeds the top of the standpipe and overflows, a Bourdon tube pressure gauge can be attached to the top of the standpipe as a temporary measure. The recommended way to measure the excess pore pressure component due to incomplete consolidation is by remote reading piezometers, which are available in four different types: hydraulic, pneumatic, vibrating wire and electrical piezometers (ICOLD 1996c).

4.5 Requirements for the inspectors

The personnel participating in the commissioning and regular inspections in addition to dam owners are the head designer and other competent persons. It is also recommended that the dam designer or a person with the corresponding expertise should participate in the annual inspections (at least for dangerous dams). The personnel undertaking the monitoring proper should be trained at the dam, appropriate attention being paid to the special features of each dam.

The persons undertaking monitoring and surveillance should be instructed adequately so that they are aware of the likely dam damage and hazards and their manifestations. They should also be made aware of the measures they have to take if factors endangering the safety of the dam are noted. The dam owner should train his operating and maintenance staff to watch the changes that occur in structures in dam areas and dams and make sure that they know whom they should inform about the changes observed. The member of the dam owner's staff responsible for dam safety decides whether or not the changes observed are significant for dam safety. The surveyor who undertakes measurements should be well informed about the

limits of the normal values and, if these limits are broken either upwards of downwards he should immediately inform the person responsible for the dam. A record should be kept of the monitoring and observations (MMM 1997).

In the **United Kingdom** there is a qualified supervising engineer, who is appointed by the dam operator to check the safety level and inform the owner of dangerous events. To this end, one or several inspections are made every year. At least every ten years, a qualified inspecting engineer makes an expert evaluation. The creation of a panel of qualified engineers is required by the law in the United Kingdom. The panel can be applied to by any engineer with the requisite qualifications, which are set by the regulatory authority. The inspections of the dams are conducted then by the members of this panel (Bradlow et al. 2002).

In **Germany** inspections are performed by the state authorities for mining, geology or radiation protection in cooperation with some consulting firms. Specially qualified persons are called *Experts for slope stability*. Qualifications are obtained on the basis of experience in this field and by passing a special test.

In **Hungary** a member of the inspection body has to be a mining engineer. The responsible technical leader can also use the help of other experts.

In **Poland** there are no specific regulations defining the qualifications of the inspecting body members. However, a degree in water construction engineering and experience in the field is required.

4.6 Independent audits

Auditing of tailings facilities by independent parties has become more and more known to the mining industry. In **Australia** there is a complementary document called "Tailings Dam HIF Audit", which describes the components of an independent audit (see Appendix 6). There are also some mining companies in **Canada**, which retain a board of geotechnical consultants to provide independent review and advice for design, operation and management of the tailings facilities (Martin et al. 2002).

5. Suggestions for efficient implementation of mining waste regulations and maintaining them

5.1 Legislative framework

The stability of hydrological construction as well as water and soil pollution issues have already been regulated in most of the EU Member States. However, it has to be stressed that the legislation governing the safety of Tailings Management Facilities (TMF) is not consistent between the Member States. In some of the European countries there are strong mining traditions with well developed legislation, in others water retention dam safety regulations are applied to tailings dams, while other countries lack an effective control system. In general, the variety of licence requirements, different control systems coupled with a diversity of the extractive industry, including facilities of multi-national companies and SMSs result in a challenging situation at the EU level.

There have occurred considerable changes in the mining sector throughout the whole of Europe during the past decades. These changes were caused by economic and political factors and resulted in the cessation of traditional mining activities in several regions, the introduction of new mining activities in areas with a weak mining tradition as well as an increased importance of the large international mining corporations. In some cases there have been opportunities to improve mining waste management systems by applying international experience and high safety standards but the history of the latest major mining accidents in Europe proved that strong adequate national legislation and an efficient control system are indispensable in order to avoid or diminish a risk of an accident. The new EU Mining Waste Directive has been drafted in order to set minimal requirements in the area of management of waste produced by the extractive industry. By specifying and improving requirements on the design, operation, closure and after-care of TMFs the new directive is supposed to ensure the long-term stability of tailings disposal facilities and to prevent or minimise water and soil pollution.

5.2 The role of national, regional and local administration

The adoption of the Mining Waste Directive shall impose a demand on national administrators to either create or adapt and then maintain regulatory, inspection and enforcement systems meeting the obligations established by the new Directive. Article 249, paragraph 3 of the EC Treaty states that a Directive shall be binding, as to the result to be achieved, upon each Member State to which it is addressed, but shall leave to the national authorities the choice of form and methods. Thus a Directive leaves the Member States room for manoeuvre and enables them to adopt the most appropriate measures to reach the objectives laid down. This means that certain elements such as, for instance, content or scope of the waste management plan and some technical issues remain as a subject for further specific deliberation by the relevant national competent authority. Local conditions must be taken into consideration while drafting or adapting the national legislation to meet the Directive requirements.

In order to have the new national regulations efficiently implemented they need to be supported by more effort that deals with developing and publishing model plans, policies and technical guidance to which operators and individual officials can refer to.

5.3 Availability of information

There exists a plethora of international knowledge and experience concerning safety of mining waste storage facilities and the role of the authorities would be to utilise them in the form of guidelines and standards. Such guidelines and standards should be available in the local language as only that can guarantee its full availability to all the operators involved in mining and mining waste storage activities.

The same concerns apply to the Best Available Technology (BAT) document which is expected to provide technical information and increase the clarity of the responsibilities of the operators and supervising authorities. Since the BAT is a bulky document, the translation of the whole text might be too time consuming and partially unsatisfactory if it covers mining activities that do not occur in a given country. However, at least parts of this document that are most adequate in a given country should be available in the local language.[2]

A web-site devoted to mining waste issues and tailings dam safety created and administrated by the adequate national authorities might prove to be the best way of information dissemination. It could also enable successful networking and improve the clarity of the authority system by offering updated information on possible changes.

5.4 Dam safety regulations

Although the standards and procedures in dam safety legislation vary considerably in the European countries they are usually considered to be of a very high level. However, tailings dams are often regarded as, so to speak, "lower level dams". This unfortunately means that laws do not include clear requirements for safety procedures, inspections etc. for this type of dam. In addition, these unclear circumstances in legislation may have effects on responsibilities of inspections and requirements of tailings dam safety procedures.

It would benefit the safety of tailings dams if they were included in the scope of dam safety regulations in force for water retention dams. Regulations concerning safety of the tailings dams could be either added to the existing water retention dam safety regulations or drafted separately using the applicable provisions of the dam safety legislation. It is also crucial that dam safety experts are involved in the supervision and inspections of the tailings impoundments.[3]

5.5 Qualification requirements

[2] During a training course devoted to the tailings and waste dams in Finland held in Kuopio in September 2005, the representatives of the mining industry and consulting agencies expressed their opinion that since the BAT document is supposed to play such an important role in the management of this stream of waste, it should be available in Finnish. The representatives of the authorities pointed out that the translation of this document would be very work- and time-consuming. It was suggested then that if necessary recourses are found parts of this document might be translated.

[3] On the international level, in 1989 the ICOLD (International Commission on Large Dams) made an effort to provide various recommendations on how tailings dam statutory legislation could be arranged. These contain, *inter alia*, provisions for commissions, registers, permit procedures for design, construction, operations and maintenance, supervision, authorities, inspections and rehabilitation.

In case of new tailings storage it is essential to ensure that the design is based upon the highest possible safety standards. This can be achieved only if the design work is performed by adequately qualified persons.[4]

Also for the successful implementation of regulations into practice and therefore improving the safety of tailings facilities qualification requirements of personnel have to be specified. In some countries the qualification requirements exist in the form of guidelines. However, it seems that the requirements will be most effective if developed in a separate regulation with requirements to the dam owner and to consulting engineers. It is the role of the authorities to introduce qualification requirements in the form of regulations. An official body responsible for the appointments of specialists should also be established.

The training and qualification requirements of the personnel employed by the dam owner should be directed to the company manager, dam engineer and the staff involved with safety inspection of the dams. It is crucial that the company manager completes some form of education (e.g. a course) that concentrates on legal aspects of dam safety, emergency action planning and dam safety awareness.

5.6 Education system qualifications upgrading for engineers and involved authorities

The introduction of qualification requirements for engineers involved in design, construction, consulting and safety inspections should be simultaneous with the creation of an education system for such specialists. Specialists dealing with tailings dams need not only appropriate education but also sufficient degree of interdisciplinary knowledge and experience. In some countries there is a lack or a shortage of personnel fulfilling such requirements. Aging of the professional staff is one of the reasons for this situation and is often the result of the temporary recession of different branches of the mining industry. For instance, in Finland there are several new mining sites but once some of the specialists retire in the near future there might be an acute lack of experienced stuff needed to assure the safety of construction and management of the tailings facilities.

The educational opportunities for the tailings dams specialists might be organised on the international level under the auspices of the EU and lead to professional certification. This would enable an efficient dissemination of know-how and experience from different countries and create an international network of experts who could utilise their new skills and experience on the national level.

A similar educational system and networking possibilities should be created for the members of the national and local authorities involved in the licensing process for the TMFs and their inspections. This can be performed on the national level but some form of international education and cooperation between the authorities would be in line with the Article 15 of the

[4] Some of the EU Member States have adopted a system of formal approval for engineers qualified for designing, constructing and supervising dams and reservoirs. In the United Kingdom specialists in dam construction are appointed to panels of qualified civil engineers for a five-year period by the Secretary of State for the Environment. The four panels are: 1) all reservoirs, 2) non impounding reservoirs, 3) service reservoirs and 4) supervising engineers. Outside the EU, Norway has strict requirements for engineers responsible for planning and reassessment of dams. There are 2 approval classes: overall safety (project manager) and dam specialist. The approval class for the dam specialist is subdivided in four main areas: 1) concrete dams, 2) embankment dams, 3) gated spillways and diversion works, 4) flood calculations. For high hazard dams the consulting engineers are required to hold a masters degree in engineering and at least 8 years experience from each of the approval areas.

Directive on exchange of information among the neighbouring countries about waste facilities that could have negative consequences on their environment.

5.7 Raising dam safety awareness

In most cases tailings dams are operated by mining companies and supervised by State Mining Authorities. Tailings dam safety might be considered a minor issue in comparison to say mine production and worker safety. Many involved with the design, operation and maintenance of tailings dams might not fully realise their legal responsibilities. Therefore, it is the role of the authorities to demand a high level of knowledge and dam safety awareness from the managers and the operators of the TMFs. A company should demonstrate sufficient internal knowledge and awareness should be raised among all the personnel involved in the operation and maintenance of the TMFs. A high level of dam safety awareness is crucial for maintaining sound professional standards.

6. Disclaimer

The views and comments expressed in the text are those of the authors only and not the official views of the Finnish Environment Institute or any other bodies mentioned in the paper. Legal issues are by their very nature complex and professional legal advice should always be obtained.

7. References

ATV-DVWK. 2001. Grundlagen zur Überprüfung und Ertüchtigung von Sedimentations-becken. Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, Merkblatt M 503, ISBN 3-935669-43-7, 60 p.

Australian National Committee on Large Dams. Guidelines on Tailings Dam Design, Construction and Operation, ANCOLD October 1999.

Barabás, A. 2005. Mine tailings in Hungary: Legislation, operation and supervision.

Benckert, A. 2003. Tailings Dam Safety in Sweden. In: Proceedings of the International Symposium on Major Challenges in Tailings Dams, Montreal, 35-45.

BETCGB (Bureau d'Etude Technique et la Contrôle des Grands Barrages). 2001. European Club – Dam Legislation, February 2001, 80 p.

Bradlow, D.D., Palmieri, A. & Salman, S.M.A. 2002. Regulatory Frameworks for Dam Safety. A Comparative Study. The World Bank, Washington DC, ISBN 0-81´213-5191-5, 159 p.

BRGM. 2001. Management of mining, quarrying and ore-processing waste in the European Union. BRGM/RP-50319-FR. Study made for DG Environment of the European Comission TENDER DC XI E3/ETU/980116, Co-ordination by P. Charbonnier, 83 p.

Bureau of Mining Regulation and Reclamation. 1994. Guidance Document for Preparation of Operating Plans for Mining Facilities. 3 p.

Canadian Dam Association. 1997. Dam Safety Guidelines.

Derham, J. 1999. The Regulation of a World Class Zinc-Lead Mine Under the Integrated Pollution Control Licensing System. In: Proceedings of the REWAS 99: Global Symposium on Recycling, Waste Treatment and Clean Technology, San Sebastian, 13-26.

Dixon-Hardy, D.W., Kreft-Burman, K. 2004. Closing and abandoning mines in the United Kingdom. In: Proceedings of the International Conference on Sustainable Post-Mining Land Management, Krakow.

Dulewski, J., Madej, B. 2004. New developments in the Polish mining industry – waste management rules now and in the future. In: Sustainable Post-Mining Land Management, Wroclaw, p. 205.

Environment Protection Agency. 2001. Integrated Pollution Control Licence, Licence Register Number 516, Tara Mines Limited, 41 p.

Glos, G.H. 1999. Using administrative controls to reduce tailings dam risk. Mining Engineering, September 1999, 31-33.

Golder Associates Pty Ldt. 2001. Report to United Nations Environment Programme Giving Guidance for Developing Tailings Regulations. Report no. 01640072, 9 p. + Appendices.

Hamor, T. 2002. Legislation on Mining Waste Management in Central and Eastern European Candidate Countries. European Communities, p. 1-20.

Hurndall, B. 1998. Dam Safety Guidelines. In: Proceedings of the Workshop on Risk Management and Contingency Planning in the Management of Mine Tailings. Buenos Aires, Argentina. ICME/ UNEP, p. 276.

ICOLD 1989. Tailings Dam Safety - Guidelines. Bulletin 74, Paris, ISSN 0534 8293.

ICOLD 1994. Tailings Dams Design of Drainage – Review and Recommendations. Bulletin 97, Paris, ISSN 0534-8293.

ICOLD 1995a. Tailings Dams and Seismicity – Review and Recommendations. Bulletin 98, Paris, ISSN 0534-8293.

ICOLD 1995b. Tailings Dams. Transport Placement and Decantation – Review and Recommendations, Bulletin 101, Paris. ISSN 0534-8293.

ICOLD 1996a. A Guide to Tailings Dams and Impoundments. Bulletin 106, Paris, ISSN 0534-8293.

ICOLD 1996b. Tailings Dams and Environment – Review and Recommendations. Bulletin 103, Paris, ISSN 0534-8293.

ICOLD 1996c. Monitoring of Tailings Dams –Review and Recommendations. Bulletin 104.

MAC (Mining Association of Canada) 1998. A Guide to the Management of Tailings Facilities. Ottawa, Ontario.

Marc, D., Kortnik, J., Bajželj, U. 2004. New EU Mining Legislation: What does it bring to Slovenia in the future? In: Sustainable Post-Mining Land Management, Wroclaw, 121-126.

Martin, T.E., Davies, M.P., Rice. S., Higgs, T. & Lighthall, P.C. 2002. Stewardship of Tailings Facilities. AMEC Earth & Environmental Limited & AMEC Simons Ltd. Mining, Minerals and Sustainable Development, Report no 20, April 2002, International Institute for Environment and Development, 35 p.

Mine Metallurgical Managers' Association of South Africa 1995. The Management of Gold Residue Deposits - A Code of Practice. 30 March 1995.

MMM 1997. Dam Safety Code of Practice. Ministry of Agriculture and Forestry.

MMSD 2002. Mining for the Future, Appendix A: Large Volume Waste Working Paper. Mining, Minerals and Sustainable Development, Report no 31, April 2002, International Institute for Environment and Development, 55 p.

MODAM 1999. Tailings Dam HIF Audit. Mining Operations Division Audit Management System, The Department of Industry and Resources, Western Australia.

http://notesweb.mpr.wa.gov.au/modams/MDWebAnalysisReps.nsf/

NRE (Department of Natural Resources and Environment) 2002. Discussion Paper: Tailings Storage – Guidelines for Victoria. State Government Victoria, Readable at: http://www.nre.vic.gov.au/).

Panagiotis T. 2004. The contribution of mining industry to the management of abandoned mines. In: Sustainable Post-Mining Land Management, Wroclaw, 109-110.

Penman, A.D.M. 2001. Tailings Dams: Risks of Dangerous Occurrence. In: Köngeter, J. (ed.), Mitteilungen des Lehrstuhls und Instituts für Wasserbau und Wasserwirtschaft der Rheinisch-Westfällischen Technischen Hochschule Aachen. 124, 229-247.

Sol, V.M., Peters, S.W.M. & Aiking, H. 1999. Toxic waste storage sites in EU countries. A preliminary risk inventory. IVM Report E-99/02, 59 p.

UNEP. 2001. APELL for Mining - Guidance for the Mining Industry in Raising Awareness and Preparedness for Emergencies at Local Level. Technical Report No 41, United Nations Environment Programme, Division of Technology, Industry and Economics, ISBN 92-807-2035, 67 p.

Appendices

Appendix 1: Summary of dam safety measures (Finland, MMM 1997)
Appendix 2: Five phases in the life cycle of a TSF according the *Code of Practice for Mine Residue,* South Africa (2000)
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Appendix 1: Summary of dam safety measures (Dam Safety Code of Practice, MMM 1997)

1 Design

- under the direction and responsibility of a person with a sufficient competence and experience (chief designer)
- determination of dam class
- hydrological specifications
- hazard risk assessment if necessary
- structural design

2 Construction

- advance notification to the regional environment centre on the date construction is to begin
- good construction practice and quality control

3 Commissioning inspection

- starts with advance notification of the beginning of construction to the regional environment centre
- all items affecting dam safety are assessed
- at least one field inspection before starting to raise the water or other impounded materials
- final statement and proposal for dam qualification

4 Safety monitoring programme

- proposal in three copies to the regional environment centre, months before the dam is taken into use
- proper monitoring
- annual and regular inspections
- the regional environment centre approves the monitoring programme
- for the monitoring programme of a high risk dam the regional environment centre acquires an expert opinion from the Finnish Environment Institute

5 Dam safety file

- three copies of it are sent together with the proposed monitoring programme to the regional environment centre
- missing items are added to the file at the commissioning inspection
- the file is kept up-to-date by supplementing it at regular inspections and in special cases

6 Prevention of and precautions against a dam accident

A high risk dam (before starting to raise the water or other impounded materials):

- hazard risk assessment (dam owner or holder)
- other accounts and actions plans as stated in the Dam Safety Act Section 9 and the Dam Safety Decree Section 4 (dam owner or holder)
- site plan (fire authority and dam owner or holder)

Appendix 2: Five phases in the life cycle of a TSF according the Code of Practice for Mine Residue, South Africa

South Africa requires mines to prepare an Environmental Management Program Report (EMPR) at the planning stage. Thereafter, the requirements of the *Code of Practice for Mine Residue (SABS 0286-1998)* apply to a TSF during its life cycle stages of design, construction, operation and closure. The code aims to provide control of mining activities from "cradle to grave" and identifies five phases in the life cycle of a TSF.

- **Phase 1: Conceptualisation, Planning and Site Selection** requires mine management to consider alternatives, ensure a sustainable end land use, avoid unnecessary waste and minimise impacts. Alternatives are to be compared using analytical techniques. TSF of medium and high hazard classification, or one with a significant environmental impact component, require a Planning Report.

- **Phase 2: Investigation and Tailings Characterisation**. Activities include investigation of the site, characterisation of tailings, assessment of the pre-development environment and background environmental data and review of alternative impact management measures. Geotechnical and hydrogeological reports are to be prepared for medium or high-hazard TSF and baseline environmental data must be included in the mine EMPR.

- **Phase 3: Design**. The primary design objective is to ensure the reliability and sustainability of the structural design and the environmental mitigation measures. A Design Report, an Operating Manual, a Risk Management Report, and approved working drawings are mandatory. "Best Practice" standards are a minimum requirement. Specific environmental objectives must be set out and included in the EMPR.

- **Phase 4: Construction and Operation**. Objectives and personnel/management requirements are listed for four sub-phases – construction, commissioning, operation and monitorring and maintenance.

- **Phase 5: Decommissioning and Aftercare**. A Decommissioning and Aftercare Plan for the TSF must be documented in the EMPR. Aftercare management must include effective design and mitigation measures for extreme circumstances. Monitoring systems are to be maintained until the closure objectives are reached.

Appendix 3: 10 steps of the APELL process

(UNEP 2001. APELL for Mining, Guidance for the Mining Industry in Raising Awareness and Preparedness for Emergencies at Local Level)

1) Identify participants and their roles – Identify emergency response participants and their roles, resources and concerns.

2) Evaluate and reduce risks offsite – Evaluate the risks and hazards that may result in emergency situations in the community and define options for risk reduction.

3) Review existing plans and identify weaknesses – Have participants review their own emergency plan, including communication, for adequacy relative to a coordinated response.

4) Task identification – Identify the required response tasks covered by existing plans.

5) Match tasks and resources – Match tasks to resources available from the identified participants.

6) Integrate individual plan into overall plan and reach agreement – Make changes necessary to improve existing emergency plans, integrate them into an overall community plan and gain agreement.

7) Draft final plan and obtain endorsement – Commit the integrates community plan to writing and obtain endorsement for it and relevant approvals.

8) Communication and training – Communicate final version of integrated plan to participating groups and ensure that all emergency responders are trained.

9) Testing, review and updating – Establish procedures for periodic testing, review and updating the plan.

10) Community education – Communicate the integrated plan to the general community.

Appendix 4: Assessment of the health and environmental impacts of the tailings dam failure (MMM 1997)

In estimation of the environmental consequences of a tailings dam failure some general information is needed to give an overview of the case. Amounts of the tailings are evaluated by the beginning and ending times of the fillings, if the value of maximum volume of waste in the reservoir (m^3) is not available. Other relevant information is average inflow of sludge per day (m^3), recycling of process water (%) and impoundment volume (m^3) as a whole. In addition the proportion of liquid waste in the impoundment capacity (%) and also content and amount of different substances in the waste water discharged from the basin (according to the latest annual summary of observations) need to be investigated.

Quality of the impounded substance i.e. tailings are evaluated according to components which are harmful or dangerous to human health or the environment. The information needed of these harmful or dangerous substances are origins e.g. processes, amount contents (proportions), times and methods of dumping and proportions likely to be washed into the environment in a dam failure (%). Report on the degree of danger to human health and environment includes chemical and biological analysis of the impounded tailings and other waste material (to be conducted as necessary, if the health and environment risks of the dam cannot be assessed by other means). The measures to be taken are among other things:

- pH-value
- capacity to conduct electricity
- total nitrogen content and total phosphorus content
- chemical oxygen demand (COD Cr)
- heavy metals
- possible organic harmful substances or groups of substances
- acute toxicity (for example the effect to water fleas Daphnia magna EC50, 24 or 48 h)
- other possible chemical or biological analyses

A possible tailings dam failure may cause severe consequences to people, property and/or environment. A drawing of the spreading of the waste material in a failure (shown on a topographic map, scale of 1:20 000) and the risk targets of the area concerned will help in evaluating the danger of a failure to human health, property and the environment (if there are several possible failure routes, each one is to be investigated separately). Surface water areas on the route of the failure, their catchment areas, groundwater areas, surface and groundwater intakes, household wells, and other similar risk targets should be taken into account. The effects of the tailings dam on the water course and the environment in the case of a failure may cause for example bad smells or sights, shortage of oxygen, fish deaths etc. and for several failure routes individual reports are required. If flood wave calculations or model trials have been conducted, their results will be applied in this section.

It is also recommended that dam owners have made all the demanded precautions against accidents and advance measures for the protection of the risk targets in he case of the failure. The report can include for example information of ditches, valleys, and other points in the terrain where the spreading of the waste substance can be halted and the substance gathered up. In addition the plans and materials for erecting temporary dams in suitable spots in the terrain or for blocking ditches to stop the spreading of the waste substance and protective walls around the risk targets are desirable.

Other details to be taken into account are the type of the dam and the area affected by the failure (including scale of the maps, longitudinal profiles and cross sections), foundations and dam structures and the typical cross sections of the location with bottom reinforcements (including drainage, monitoring instruments).

Appendix 5: An example of the monitoring of tailings management facility (EPA 2001)

Location	Parameter	Monitoring Frequency	Analysis Method/ Technique
Piezometers in TMF embankment	**Water level**	Monthly	Dip meter
	pH	Monthly	Electrometric
	Conductivity	Monthly	Electrometric
	Pb, Zn, As, Fe, Cu, Hg, Co, Ca, Mg, Mn, Cd, Ni, CN, sulphide/sulfate	Bi-annually	Standard methods
	Standard walk-over condition & stability checks	Weekly	Visual
	Embankment settlement/movement	Quarterly	Survey of seven fixed movement monitoring stations
	Annual safety inspection report	Annually	Agreed standard
TMF embankment crest	**Tailings distribution system**	Daily	Visual
TMF	**Tailings settlement**	Bi-annually	Survey
TMF	**Volume of tailings disposed**	Continuous	Flow meter
	Tonnage of tailings disposed	Monthly	Dry density
	Used capacity	Annually	Agreed method
	Remaining capacity	Annually	Agreed method
TMF Perimeter	**Water level**	Monthly	Dip meter/gauge
Interceptor Channel (locations as per plan Surface Water Monitoring in Section 18 of IPC licence application)	**pH, SO_4, SS, temperature, conductivity**	Monthly	Standard methods
	Pb, Zn, As, Fe, Cu, Hg, Co, Mg, Mn, Ni, Cd, CN, Al	Quarterly	Standard methods

Appendix 6: Tailings Dam HIF Audit (MODAM 1999)

1. Hazard Rating

1.1. A hazard rating has been assigned to the Tailings Storage Facility (TSF).

1.2. The hazard rating has been derived by considering the potential environmental impact in the event of either a controlled or uncontrolled escape of material, seepage and/or abrupt failure of the storage embankment at any stage in its life.

1.3. The hazard rating has been derived by considering the potential impact in terms of safety on any nearby community infrastructure and/or mining developments (including the tailings storage operator) in the event of either controlled or uncontrolled escape of material, seepage and/ or abrupt failure of the storage embankment at any stage in its life.

1.4. The hazard rating has been derived by considering the potential impact in terms of economics on any nearby community infrastructure and/or mining developments (including the tailings storage operator) in the event of either controlled or uncontrolled escape of material, seepage and/or abrupt failure of the storage embankment at any stage in its life.

1.5. Changes in the operation of the TSF or the surrounding infrastructure have the resulted in a re-evaluation of the TSF hazard rating.

2. Design and Construction

2.1. The TSF has been designed in accordance with the applicable edition of the "Guidelines on the Safe Design and Operations Standards for Tailings Storages" issued by the Department of Minerals and Energy, Western Australia.

2.2. The TSF has been constructed in accordance with the design.

2.3. Annual operating audits are submitted as required by the Guidelines on the Safe Design and Operations Standards for Tailings Storages".

2.4. Changes from the original design were documented during construction.

2.5. Records of construction quality control checks are available.

2.6. The specified monitoring equipment is installed.

3. Dam Break Assessment

3.1. Category 1 TSF have a documented "Dam Break Risk Assessment".

4. Operation

4.1. There is a TSF Operating Plan.

4.2. The Operating Plan describes the deposition methodology.

4.3. The Operating Plan describes the pond control and water management.

4.4. The Operating Plan specifies the method of seepage control.

4.5. The Operating Plan specifies the pipeline management system.

4.6. The Operating Plan describes the TSF geometry at all stages of its life.

4.7. The Operating Plan includes provision for dust control.

4.8. Modifications to the Operating Plan are documented when they occur.

4.9. The actual operating characteristics of the TSF have been assessed against the original design assumptions.

4.10. Annual geotechnical and engineering reports are submitted as outlined in the "Guidelines on the Safe Design and Operating Standards for Tailings Storage".

4.11. The recommendation included in the annual geotechnical and engineering reports have been acted upon.

4.12. The TSF site is secured against inadvertent access by unauthorised personnel.

4.13. The TSF access roads are demarcated by windrows, railings or other such indicators of safe travel limits.

4.14. The TSF access routes are controlled by suitable signage indicating speed limits, direction etc.

4.15. Traffic control measures on the TSF are effective at night.
4.16. Where there is deep water in a TSF, rescue equipment is provided.
4.17. Access roads on the TSF are designed for the equipment using them.

5. Management

5.1. A responsible person has been appointed in writing to manage the TSF.
5.2. Individual roles and responsibilities have been documented for persons working on the TSF.
5.3. The TSF Operating Plan is available to the personnel working there.
5.4. There is a training program in place for personnel engaged in work on the TSF.
5.5. There is an incident reporting procedure for the TSF.

6. Monitoring and auditing

6.1. Routine inspections of the TSF are carried out daily.
6.2. Routine inspections are recorded.
6.3. Operating audits are conducted every year for Category 1 TSFs and every 2 years for Category 2 TSFs.
6.4. Groundwater monitoring is carried out as per the DEP licence for the TSF.
6.5. The monitoring equipment is kept in calibration.
6.6. The required frequency for the reading the monitoring instruments is specified.
6.7. The monitoring results are documented.
6.8. The action to be taken when monitoring results fall outside the expected range is specified.
6.9. A permanent survey monitoring grid is in place for the TSF.
6.10. There is a dam stability monitoring programme in place.
6.11. The results of the dam stability monitoring programme are documented.
6.12. The action to be taken is specified should the dam stability monitoring results fall outside the expected range.

7. Emergency Plan

7.1. There is a specific Emergency Plan for incidents that may occur at the TSF.
7.2. The TSF Emergency Plan contains details of any evacuations procedure that may be required in the event of failure, or impending failure of the TSF.
7.3. The TSF Emergency Plan contains a diagram indicating the whereabouts of an assembly point for all nominated personnel in the event of a failure or other event.
7.4. The TSF Emergency Plan contains a list of names and residential addresses of all nominated personnel and their home/emergency contact telephone numbers.
7.5. The TSF Emergency Plan contains a list of the telephone numbers of the local/ regional emergency services (fire, ambulance, police, etc.).
7.6. The TSF Emergency Plan contains a list of all personnel that are associated with operation of the TSF and evidence that they have attended and understood all relevant induction/ safety procedures.

8. Decommissioning

8.1. A Decommissioning Plan has been drawn up for the TSF.
8.2. Roles and responsibilities have been documented for key personnel involved in the decommissioning process.
8.3. A hazard analysis has been conducted for the long term stability of the TSF structure post decommissioning.
8.4. A risk assessment has been conducted for the long term stability of the TSF structure post decommissioning.
8.5. A rehabilitation plan is in place for the decommissioned TSF structure.
8.6. Where operational changes have been occurred the Decommissioning Plan has been revised to take the changes into account.

Appendix 7: Essential and desirable elements and trends of a regulatory scheme

Bradlow et al. (2002) have listed the following items of the essential and desirable elements and trends of a regulatory scheme in order to improve dam safety regulations mainly of the water storage dams. Many of them can also be applied to the tailings dam safety:

The essential elements of a regulatory scheme

1) The Form of the Regulation

The regulatory framework should be clearly spelled out in publicly available documents. The precise form of the legal instruments used in the regulatory framework will vary depending on the specific characteristics of the legal and administrative traditions in of each country.

2) The Institutional Arrangements

a) Identification of the regulatory authority that is responsible for dam safety and clarification of its powers and responsibilities.

b) The regulatory authority must be provided with adequate human and financial resources to perform its functions.

3) The Powers of the Regulating Entity

a) The power to identify and develop norms, standards and guidelines dealing with dam safety.

b) A voice in decisions to issue permits or grant licenses for the construction and operation of dams.

c) The power to monitor inspections conducted by others and the power to reject the findings of the inspection either because the inspector is not qualified to conduct the inspection or because the report of the inspection is inadequate.

d) The power to conduct its own inspections when it deems it necessary to do so.

e) The power to approve the party selected by the dam owner or operator to conduct the required safety inspection.

f) The responsibility to maintain an inventory/register of all dams in the country that are covered by the regulatory scheme.

g) The responsibility to advise dam owners and other interested parties, such as affected communities and industry, about dam safety issues and developments in the regulatory framework.

h) The responsibility to make periodic and public available reports on dam safety issues to both higher authorities in the executive branch of government and the legislature and to advise government on dam safety issues.

i) The power to enforce the dam safety regulatory framework.

4) The Content of the Regulatory Scheme

a) Establishment of clear and easily applied criteria for determining which dams are covered by the regulatory scheme. It is not essential that all dams be included in the scheme, but those that are excluded should be easily identified and should be too insignificant to cause harm to anyone other than owner if they fail.

b) Definition of the scope of the regulatory scheme. It should address dam safety issues mat all stages of the dam life cycle. Thus it should address dam safety considerations that arise during the design, construction, first filling, operation, alteration and decommissioning stages of the dam's life.

c) Clarification that it is the owner that has the primary responsibility for dam safety and can be held liable for any damage that results from a dam failure.

d) Stipulation of the dam safety standards and specifications with which the owner is expected to comply.
e) Establishment of the qualifications required of the person who does the safety evaluations for the owner.
f) Stipulation that the owners/ operators of the dam must make periodic reports to the regulators on the results of their reviews, inspections and monitoring of the dam's safety.
g) Stipulation of he frequency with which the dam owner/ operator should conduct dam safety inspections and reviews.
h) Stipulation that the owner/ operator must maintain complete records on the dam at a convenient location.
i) Requirement of all dams to have an operations, maintenance and supervision manual, and an adequate budget for operation, maintenance and supervision.
j) Imposition of fees that dam owners/ operators must pay to the regulatory authority.
k) Requirement of dams with the greatest hazard potential to have an emergency plan that is provided to the regulatory authority and to all other relevant authorities and downstream communities that could be affected by a dam failure. The regulatory authorities should provide dam owners with guidance on the issues to be addressed in the emergency plan.

Elements that would be desirable to include in a regulatory scheme

1) The Institutional Arrangements
a) The dam safety regulatory authority is exclusively devoted to dam safety.
b) Regulatory authorities appoint a dam safety advisory committee. The function of this committee would be to advise the authority on dam safety issues.

2) The Powers of the Regulating Entity
a) The dam safety regulatory authority is empowered, where appropriate, to coordinate dam safety regulation among all the agencies at the local, regional and national levels that are involved in or affected by the regulation of dam safety.

3) The Content of the Regulatory Scheme
a) Stipulation that the regulatory authority may make its own periodic inspections of all dams that have high hazard classifications. These inspections would be in addition to those conducted by the owner/ operator of the dam.
b) Stipulation that the regulatory authority be provided with a copy of the dam's technical archives/ records and for the highest hazard category dams, be required to review these records in its periodic inspections of the dam.
c) Stipulation that, as part of a process for obtaining a dam license, prospective dam owners are required to conduct a failure impact assessment.
d) The dam safety regulatory framework should establish a series of benchmarks that can be used to measure dam safety at all dams.
e) The regulatory authority requires the dam owner to conduct periodic safety reviews of all dams.
f) The regulatory authority is required to issue annual reports on the safety of the dams subject to its jurisdiction.
g) The regulatory authority undertakes activities designed to educate the public about dam safety.

Emerging trends in dam safety regulation

1) The Institutional Arrangements
a) There is a general trend toward making the owners responsible for monitoring dam safety and for conducting all the necessary inspections. This is linked to a trend toward

limiting the regulatory authority to developing standards and norms and to monitor the dam owner's performance.

2) The Contents of the Regulatory Scheme

a) There is a trend toward taking a life cycle approach to dam safety. This means that the dam owner is required to incorporate dam safety issues into its plans for the design, construction, maintenance, alterations and decommissioning of the dam.

b) There is a trend toward requiring dam owners to pay more attention to the funding of dam rehabilitation and maintenance. The funding mechanisms that can be used for these purposes include trust funds, bonds, insurance and sinking funds.

c) There is a clear trend toward paying more attention to the social implications of the dam safety, including health and environmental implications. This trend is likely to be strengthened, given the critical importance of social and environmental factors for sustainable development.

d) There is a significant trend toward using risk analysis in dam safety.

Appendix 8: Case study: Lisheen Mine – IPC Licence

In June 1997 the Lisheen Mine (a Zinc-Lead mine) was issued an operational permit under the Integrated Pollution Control.

The IPC Licence

Key aspects of the IPC licence for the Lisheen Mine are the requirements for:

- Development and operation of an Environmental Management System.
- Development and operation of a continuous environmental improvement programme.
- Comprehensive self monitoring and reporting of all emissions.
- Purchase of Environmental Liability Insurance.
- Provision of a Perpetual Aftercare Fund.
- Provision of a comprehensive Quality Control/Quality Assurance programme for the design and construction of the TMF including lining system.
- Certification of 'Fit for Purpose' of the completed TMF by an international Reservoirs Engineer retained by the operators.
- Ambient monitoring of groundwater, surface waters and air quality.
- Payment of an annual charge of Euro 40,000 to the EPA to cover agency's own monitoring and inspection costs.
- Submission of an annual report to the EPA detailing results of all monitoring and inspection, progress on environmental improvements, natural resource consumption, etc.
- Specification of emission limit values for air (particulates 1 mg/m^3; lead and zinc 0.7 mg/m^3; H_2S 0.01 mg/m^3); effluent (lead 0.0015 mg/l; zinc 0.1 mg/l; cadmium 0.0002 mg/l; suspended solids 700 mg/l; arsenic 0.01 mg/l, etc.); noise (general noise 55 dB(A) day and 45 dB(A) night, vibration 8 mm/sec day and 4 mm/sec night, air-overpressure 125 dB(lin) day and 105 dB(lin) night).
- The establishment during the operational life of the mine of a field test cell adjacent to the TMF to test and validate the closure solution.
- The provision of a public information service dealing with environmental aspects of the operations, to be available on site through the operational life of the mine (Derham 1999).

The IPC licence for the Lisheen Mine can be viewed and downloaded from the Irish Environmental Protection Agency web page at http://www.epa.ie/.