Dam Safety

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Module 1: An Approach to Dam Safety

Learning Objectives

By the end of this section, you will be able to:

- **Evaluate** the legal and moral responsibilities inherent in dam ownership.
- **Identify** the historical trends and increasing complexities of dam safety risks.
- **Determine** direct and indirect methods for establishing a comprehensive dam safety program.

Executive Summary: Legal and moral responsibility for dam safety rests primarily with the owner. Successful ownership requires integrating safety costs into project budgets as a non-expendable item to mitigate the high risks of life loss, property damage, and strict liability.

Design Fundamentals

There is a critical and continuing need for dam safety because of the thousands of dams now in place and the many new dams built each year. Although these dams are essential elements of the national infrastructure, the risks to the public posed by their possible failure are great; large and growing numbers of lives and valuable property are at stake. Although there are many who are concerned about dam safety, **legal and moral responsibility essentially rests with the dam owner.**

Urgency for Safety

World and national statistics on dam failures show an unacceptable record of losses in both lives and property. The International Commission on Large Dams (ICOLD) reports that more than **8,000 people have died** so far this century because of the failure of major dams.

The record for U.S. losses from major dam failures is significant. Note that actual national losses are much higher than indicated because statistics often omit small dam failures or combinations of dam failure and natural flooding events. Over an 18-year period (1965-1983), thirty lesser failures or serious incidents occurred in Colorado alone. The potential for future catastrophes remains strong, requiring a cooperative effort in dam safety involving owners and communities.

Dam Ownership and Safety Management

This course applies to dams owned and operated by state and local governments, public/private agencies, and private citizens. Typical reasons for construction include:

- **Water storage** for human consumption
- **Agricultural production**
- **Power generation**
- **Flood control**
- **Soil erosion reduction** and recreation

Dam owners serve society by meeting important national needs and may personally profit from operations. However, these factors do not justify ownership if the owner cannot provide safety for people and property in potential **inundation zones**.

💡 **Design Tip:** Investment in dam safety should be accepted as an integral part of project costs and not viewed as an expendable item that can be eliminated if a budget becomes tight. The costs of safety are small in comparison to the liability costs following a failure.

The Increasing Complexity of the Dam Safety Problem

The overall safety problem is becoming more difficult due to several intensifying factors:

- **Increased Construction:** More dams are being built to meet water needs.
- **Aging Infrastructure:** Many existing dams are reaching or passing their **design life spans**.
- **Downstream Development:** Continued human settlement near dams increases public exposure to hazards.
- **Suboptimal Sites:** Builders are increasingly forced to use poorer sites for new construction.

⚠️ **Safety Constraint:** In most states, dam owners are held **strictly liable** for losses or damages resulting from dam failure. This legal burden exists regardless of fault, contributing to rapidly rising liability insurance costs.

Table 1.1: Loss of Life and Property Damage from Notable U.S. Dam Failures, 1963-1983

Name & Location of dam	Date of failure	Number of lives lost	Damages
Mohegan Park, Conn	Mar 1963	6	$3 million
Little Deer Creek, Utah	June 1963	1	Summer cabins damaged.
Baldwin Hills, Calif.	Dec 1963	5	41 houses destroyed, 986 houses damaged. 100 apartment buildings damaged.
Swift, Mont.	June 1964	19	Unknown
Lower Two Medicine, Mont.	June 1968	9	Unknown
Lee Lake, Mass.	Mar 1968	2	6 houses destroyed. 20 houses damaged, 1 manufacturing plant damaged or destroyed.
Buffalo Creek, West Va.	Feb 1972	125	546 houses destroyed, 538. houses damaged.
Lake “O” Hills, Ark.	Apr 1972	1	Unknown.
Canyon Lake, S. Dak.	June 1972	33	Unable to assess damage because dam failure accompanied damage caused by natural flooding.

Bear Wallow, N.C.	Feb 1976	4	1 house destroyed.
Teton, Idaho	June 1976	11	771 houses destroyed, 3,002 houses damaged, 246 business damaged or destroyed.
Laurel Run, Pa.	July 1977	39	6 houses destroyed, 19 houses damaged.
Sandy Run and 5 others, Pa.	July 1977	5	Unknown.
Kelly Barnes, Ga.	Nov 1979	39	9 houses, 18 house trailers and 2 college buildings destroyed; 6 houses, 5 college buildings damaged.
Swimming Pool, N.Y.	1979	4	Unknown.
About 20 dams in Conn.	June 1982	0	Unknown.
Lawn Lake, Colo;	July 1982	3	18 bridges destroyed, 117 businesses and 108 houses damaged. Campgrounds, fisheries, power plant damaged.
DMAD, Utah	June 1983	1	Unknown.

Source: Graham, 1983.

Safety Program Implementation

An owner must utilize both direct and indirect means of achieving dam safety.

Indirect Influence

- Influencing **governmental policy** and statutes (e.g., zoning laws).
- Understanding the roles of Federal and state governments.
- Analyzing the dam's **social environment** and developing human settlement patterns.

Direct Influence

Owners must develop their own safety programs including:

1. **Inspection** (Regular visual assessments)
2. **Monitoring** (Use of instrumentation)
3. **Maintenance** (Routine and preventative)
4. **Emergency Action Planning** (EAP development)
5. **Proper Operation** (Adhering to design parameters)

Checkpoint Quiz

1. **Under the legal standard of strict liability common in many states, when is a dam owner responsible for downstream damages caused by a failure?**
   a) Only if the owner was proven to be negligent in maintenance.
   b) Only if the failure was caused by a natural disaster.
   c) Regardless of fault or the specific cause of the failure.
   d) Only if the dam was classified as a High Hazard structure.

Answer: (c). Strict liability holds the owner responsible for damages regardless of fault, negligence, or the specific trigger of the failure.

2. **Which of the following is considered an indirect means of achieving dam safety?**
   a) Implementing a monthly visual inspection program.
   b) Working for positive change in statutes such as zoning laws.
   c) Installing piezometers to monitor internal seepage.
   d) Developing a routine maintenance schedule for debris removal.

Answer: (b). Zoning influence is an indirect method; the other options are direct technical/operational actions performed on the structure itself.

3. **According to the text, why is the dam safety problem becoming more difficult for owners?**
   a) Federal funding for private dam maintenance has been eliminated.
   b) The use of poorer construction sites and increased downstream settlement.
   c) New technologies have made older instrumentation obsolete.
   d) International standards have replaced local state regulations.

Answer: (b). The text notes that as prime sites are taken, builders use poorer sites, and the growing population continues to settle in potential inundation zones.

Module 2: Introduction to Dams

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the primary components of various dam types and their functional roles in water impoundment.
- **Evaluate** the mechanisms of water retention and the critical risks associated with seepage and piping.
- **Select** appropriate release structures, including principal and emergency spillways, based on operational and safety requirements.

Executive Summary: A dam's primary function is the safe and effective impoundment of water. Understanding the interplay between construction materials (embankment vs. concrete), seepage control (filters and cutoffs), and release mechanisms is essential for maintaining structural integrity and preventing catastrophic failure.

Design Fundamentals

The purpose of a dam is to **impound (store)** water for various applications, including flood control, human water supply, irrigation, energy generation, and recreation. While several materials are used in construction, this course concentrates primarily on **earthen dams**, which constitute the majority of structures currently in place and under development.

The Watershed System

The **watershed system** refers to the drainage process where gravity collects rainfall or snowmelt into a particular stream valley. Dams constructed across these valleys impound runoff and release it at a controlled rate.

- **High Runoff:** Reservoir storage increases; overflow through a spillway may occur.
- **Low Runoff:** Reservoir levels typically decrease.
- **Downstream Impact:** By controlling the quantity of water flowing, owners can mitigate the extremes of floods and droughts.

Types of Dams

Man-made dams are classified by construction materials, methods, cross-sectional design, and how they resist hydrostatic pressure.

Component Parts

Nearly all dams possess standard features for water retention and release.

Purchase this course to see the remainder of the technical materials.