Safety of Nonfederal Dams: A Review of the Federal Role (1982)

Pages
65

Size
5 x 9

ISBN
0309328675

Committee on Safety of Nonfederal Dams; Assembly of Engineering; National Research Council

SAFETY OF NONFEDERAL DAMS
A Review of the Federal Role

Committee on the Safety
of Nonfederal Dams

Assembly of Engineering

National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C. 1982

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors, according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Research Council was established by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and of advising the federal government. The council operates in accordance with general policies determined by the Academy under the authority of its congressional charter of 1863, which establishes the Academy as a private, nonprofit, self-governing membership corporation. The Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in the conduct of their services to the government, the public, and the scientific and engineering communities. It is administered jointly by both Academies and the Institute of Medicine. The National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970, respectively, under the charter of the National Academy of Sciences.

This report represents work supported by Contract Number EMW-C-0756, work unit number 6311F between the Federal Emergency Management Agency and the National Academy of Sciences.

COMMITTEE ON THE SAFETY OF NONFEDERAL DAMS

Robert B. Jansen, Chairman
Consulting Civil Engineer
Mead, Washington

Harl P. Aldrich
Haley & Aldrich, Inc.
Cambridge, Massachusetts

Charles Boothby
National Association of Conservation Districts
Washington, D.C.

Noble J. Campbell
Texas Water Rights Commission
Austin, Texas

Kenneth Dunn
Idaho Department of Water Resources
Boise, Idaho

James Doody
Department of Water Resources
Sacramento, California

Joseph J. Ellam
Pennsylvania Department of Environmental Resources
Harrisburg, Pennsylvania

James Murphy
Fred. S. James & Co.
Arlington, Virginia

Robert Sokolove
Ford, Farquhar, Kornblut & O'Neill
Washington, D.C.

Bruce A. Tschantz
University of Tennessee
Knoxville, Tennessee

Erik Vanmarcke
Massachusetts Institute of Technology
Cambridge, Massachusetts

Homer B. Willis
Consulting Civil Engineer
Bethesda, Maryland

Liaison Representatives

Buell M. Ferguson
Soil Conservation Service

Joseph S. Haugh
Soil Conservation Service

Harry E. Thomas
Federal Energy Regulatory Commission

Jack Thompson
U.S. Army Corps of Engineers

Technical Consultant

Charles F. Corns
Consulting Civil Engineer
Springfield, Virginia

Staff

Charles R. Malone, Executive Secretary
Sheila D. David, Staff Officer
Jeanne Aquilino, Administrative Secretary

Workshop Participants

Denis Binder
Western New England College
Springfield, Massachusetts

Lawrence Bowden
Civil Defense Department
Montgomery, Alabama

Robert A. Burks
Southern California Edison Company
Rosemead, California

Francis Haley
McGriff & Seibels, Inc.,
Birmingham, Alabama

George Koch
New York State Department of Environmental Conservation
Albany, New York

Edward C. Scheader
Department of Environmental Protection Administration
New York, New York

Leon Smothers
Booker Associates
Lexington, Kentucky

Arthur G. Strassburger
Pacific Gas & Electric Co.
San Francisco, California

Agency Representatives

William Bivins
Project Officer
Chief, Federal Dam Safety
Federal Emergency Management Agency

Brian Cowan
State and Local Programs and Support
Federal Emergency Management Agency

Melinda Hulsey
State and Local Programs and Support
Federal Emergency Management Agency

CONTENTS

PREFACE

The safety of dams and reservoirs is of vital public concern and entails large responsibilities. While the primary duty rests with the owner, the need for governmental supervision is widely recognized.

At the federal level, U.S. government agencies conduct comprehensive dam safety programs for federally owned dams. These have been subjected to periodic review and are generally regarded as effective. However, many states lack similarly effective programs for nonfederal dams. Approximately half of the states have inadequate dam safety programs. Even fewer have provided enough funding for proper supervision of dam safety. Yet, many dams do not meet accepted standards, and there are therefore important hazards that require attention.

The problem is nationwide and calls for a cooperative effort involving the U.S. and state governments and the owners of dams. Although its regulatory authority over the safety of nonfederal dams is limited, the national leadership is unavoidably involved. The economic and environmental damage, not to mention loss of life, that could result from a dam failure warrants concern at all levels of government.

Recognizing the states' fundamental responsibility for public safety, the federal role must be guiding and supportive. It must encourage awareness of the states' duties and facilitate measures that reduce risk.

A principal purpose of the Committee on Safety of Nonfederal Dams has been to consider this role of the

SUMMARY

The National Research Council organized the Committee on the Safety of Nonfederal Dams, at the request of the Federal Emergency Management Agency (FEMA), to study issues related to the safety of nonfederal dams. The committee's primary objective during the phase of the work reported here was to determine the proper role of the United States government in enhancing the dam safety programs of the individual states. A second phase will address technical issues pertinent to dam safety and is scheduled for completion by March, 1983.

The committee held a workshop in Washington, D.C. from November 30 through December 2, 1981 that addressed complex issues underlying the need for a federal role in the safety of nonfederal dams. The main issues discussed were questions of responsibility and liability for nonfederal dams; state dam inventories; risk classification of dams; emergency preparedness planning; technical, funding and training assistance to the states; post-failure investigations; liability insurance for dam owners; data on the true cost of dam failure; and dam terminology. The committee also identified technical issues that could be addressed in the second phase of its study. The plan for the second phase is described in Section VI.

LIABILITY

Although common law doctrine holds that dam owners are liable for damages resulting from failures of their dams, several judicial decisions have confused the issue

by suggesting that the person in control of a dam must be negligent to be held liable. The committee believes that this issue should be clarified by the enactment of state legislation assigning liability for dam failure or misoperation to the owner, where existing statutes or case laws are lacking, and that the U.S. government should encourage the states to enact such legislation.

Also, the committee is aware of at least one case in which the court ruled that state employees responsible for the state's dam safety program were not immune from liability. The committee believes that engineers who inspect and evaluate the safety of existing structures, as well as the regulatory employees of the states, should be immune from personal liability for dam safety activities, except in instances of malfeasance or misfeasance.

- The committee recommends that the U.S. government, through FEMA, encourage the states to enact legislation assigning liability for dam failure or misoperation to the owners and also accompanying legislation to relieve the engineers and regulatory personnel involved in dam safety activities from personal liability, except in instances of malfeasance or misfeasance.

STATE SUPERVISION

Since regulatory authority over nonfederal dams should lie with the states, all states need adequate laws regulating dam safety. However, many states have no dam safety legislation, and others have legislation that is inadequate. Therefore, the committee believes that a need exists to promote state legislation comparable to the Model Law for State Supervision of Safety of Dams and Reservoirs; published by the United States Committee on Large Dams (USCOLD) in 1970.

Also, the committee believes that the solution to the problem of poor state supervision of dam safety would be aided by a national perspective on dam safety provided by either a governmental or nongovernmental entity.

- The committee recommends that the U.S. government, through FEMA, encourage states to enact legislation comparable to the USCOLD Model Law and assist the states in forming a national association or forum for discussing common problems and assessing adequacy of state programs.

FEDERAL INVOLVEMENT IN NONFEDERAL DAMS

Many nonfederal dams were initially engineered and constructed with federal assistance. Although some continuing federal technical assistance is available to owners of such dams in cases of latent defects, inadequate or faulty design, and improper hazard classification, the committee believes that more should be done to assist owners in dam safety activities. Accordingly, the committee recommends that the U.S. government should take the following actions:

- Prepare guidelines for emergency preparedness plans for nonfederal dams initially engineered and constructed with federal assistance
- Maintain a central inventory of such dams
- Guide current and potential dam owners on the adverse consequences of changes in downstream land use on hazard classification
- Insist on strict compliance with operation and maintenance agreements.

IMPERATIVE NEEDS

The committee also agreed that the U.S. government should help mitigate existing impediments to effective state dam safety programs by:

- Helping the states establish and maintain up-to-date inventories of dams
- Developing methodology for risk assessment and promoting its use in state dam safety programs

- Providing a supportive, nonregulatory role to help the states obtain technical guidance material

- Studying the feasibility of providing some federal funding assistance to dam owners for repairing unsafe dams

- Developing and offering to conduct suitable dam safety training courses for personnel of the states and owners

- Providing federal insurance assistance, in conjunction with a benefit program, to states and dam owners who are committed to effective dam safety procedures

- Developing guidance for emergency preparedness planning

- Developing data on the real cost of dam failure, to help state officials set proper funding levels for dam safety activities

- Helping the states, upon request, to investigate causes of dam failures

- Developing common terminology to facilitate communication in dam safety activities.

SECOND PHASE STUDY

The committee recommends that the following technical issues be addressed during the second phase of its study:

- Risk assessment: Develop a rational, practicable methodology for assessing risks in dam safety activities.

- Engineering methodology: Study and develop guidance on stability and hydrologic evaluations of dams (including but not limited to modes of breaching, stability parameters for overtopped dams, seismic stability, shear strength in weak

rock or in weak seams of strong rock foundations, and potential for piping at dams).

- Instrumentation and warning systems: Study and develop guidance on types of instruments appropriate for dam surveillance.

- Emergency preparedness planning: Develop a model plan for voluntary use by the states.

COMMENTS

Section VII of this report contains a detailed list of the committee's recommendations. In view of FEMA's assigned responsibility for coordinating and promoting dam safety (sub-section 2.2), the recommendations, for the most part, were formulated for the response of that agency. The committee recognizes, however, that the federal role defined by the committee would involve the support of other federal agencies, particularly in the technical areas. The committee also recognizes that implementing its recommendations would have significant impacts on the staffing and financial resources of FEMA. Therefore, it is incumbent on FEMA not only to use the assistance of other agencies, as appropriate, but also to improve its own capabilities to the extent necessary and possible. A necessary next step is for FEMA to evaluate the recommendations in light of its mission and objectives, possible similar efforts already underway, anticipated costs, and the capabilities of the federal agencies.

I. INTRODUCTION

1.1 PURPOSE

In October 1981, the Federal Emergency Management Agency (FEMA) asked the National Research Council (NRC) to undertake a study of technical and policy issues related to the safety of nonfederal dams. FEMA asked the NRC to identify impediments to state-run programs for dam safety, to suggest federal actions to remove or mitigate those impediments, and to define how the U.S. government could help make such nonfederal dams safer.

FEMA's request followed completion of a four-year U.S. Army Corps of Engineers program of inspecting nonfederal dams, conducted under authority of the National Dam Inspection Act (Public Law 92-367) of 1972. Since the completion of the Corps' inspection program, in 1981, no agency of the U.S. government has had authorized funds for monitoring or encouraging state programs to supervise subsequent inspections and investigations, or to ensure that deficiencies are corrected.

In response to FEMA's request, the NRC created a Committee on the Safety of Nonfederal Dams to review and discuss the involved issues. This report presents the results of the committee's effort.

1.2 SCOPE

FEMA and the NRC agreed that the committee's study would be a two-phase effort. The first phase was to consider the proper role of the U.S. government regarding the safety of nonfederal dams. It was an opportunity for the technical community to comment on

policy and administrative aspects of dam safety. Unlike the initial policy and planning phase, the second phase, to be completed by March 1983, will address technical issues pertinent to dam safety.

Operating under a February 28, 1982 deadline for the first phase of the study, the committee held a three-day workshop in Washington, D.C., from November 30 to December 2, 1981. Participants included committee members and staff, representatives of federal agencies involved in dam construction and supervision, and other experts with a variety of experience in dam safety. The workshop participants discussed such issues as legal liability, risk assessment, and the role of the U.S. Government, as well as the second phase of the study. The participants developed a list of "imperative needs," or actions necessary to eliminate existing impediments to an effective effort for improving the safety of nonfederal dams, and discussed possible solutions for each problem. From these discussions, the committee reached the conclusions and recommendations presented in this report.

Nonfederal dams are those that are not owned by the U.S. government. Of 67,451 dams listed in the National Inventory (dams over 25 feet in height or impounding 50 acre-feet or more of water if 6 feet or more in height), 64,566 are nonfederal, and are owned by state or municipal governments, or by individuals or other nongovernmental entities or organizations. Some nonfederal dams are under the regulatory authority of federal agencies whose dam safety programs are monitored by FEMA. The scope of the committee's study and the recommendations in this report concern the enhancement of state dam safety programs. However, it will be recognized that some of the recommendations, such as the use of risk classification and emergency preparedness planning, are equally applicable to the safety supervisory programs of federal agencies.

II. BACKGROUND

2.1 THE NATIONAL DAM INSPECTION ACT

Following a series of events that focused the public's concern on the hazards created by water storage dams, the Congress passed the National Dam Inspection Act (Public Law 92-367), which was signed by the President on August 8, 1972. These events were the near failure of the Lower Van Norman Dam during the February 9, 1971, San Fernando, California, earthquake; the failure of the Buffalo Creek, West Virginia, mine refuse embankment on February 26, 1972; and the dam failure at Rapid City, South Dakota, in June 1972. Also in June 1972, Hurricane Agnes caused extremely heavy rainfall in the northeastern United States, resulting in unprecedented flooding that seriously threatened a large number of dams, some of which were overtopped and damaged, adding to the property damage otherwise caused by the flooding and further intensifying the public's concern.

The Act required the U.S. Army Corps of Engineers to carry out a program of safety inspection of all dams in the United States, except those under the jurisdictions of specified federal authorities and certain other classes of dams. It also required the Corps to compile an inventory of all dams in the United States. Prior to fiscal year 1978, however, Congress funded only the inventory work.

Immediately following the November 6, 1977, failure of the Kelly Barnes Lake Dam at Toccoa, Georgia, President Carter directed the Corps to inspect all "high hazard" dams (those whose failures would cause loss of life or substantial property damage). He also encouraged state governments to cooperate in the program

and to implement effective safety programs for nonfederal dams. At the same time Congress funded the inspections.

Between December 1977 and October 1981, the Corps of Engineers inspected some 8,800 dams. About one-third, or more than 2,900, were judged to be unsafe by federal standards; that is, they had deficiencies that if left uncorrected could result in dam failure with consequent loss of life and/or substantial property damage. Less than 5 percent of the unsafe dams had been repaired by October 1981. Dam owners' inability to finance the work is the primary reason for their failure to perform the remedial measures.

Many states participated in the dam inspection by the Corps and helped compile inventory data for the dams within their boundaries. The capabilities of these states to administer dam safety programs were enhanced by their participation in the inspections. At the end of the inspection program, the Corps found that 25 states were adequately supervising both inventory and inspection activities. Some state officials, however, have said that without federal funding, they cannot continue effective dam safety programs.

About half of the states failed to implement effective dam safety programs due to lack of state funding, adequate legislation, regulatory practices, or technical staff. Some could not assist the Corps' inspection program in a meaningful way because of inadequate staff. Some of these states have inadequate legislation regarding dam safety; others have adequate laws but lack the necessary funds and personnel.

At the end of the four-year inspection program, the Corps of Engineers had inspected all of the high hazard dams. From now on, the states will have to rely on their own dam safety programs and mitigate the problems of the unsafe dams identified by the Corps.

The Corps of Engineers is preparing a report, scheduled to be published early in 1982, covering the inspection program carried out under the authority of the National Dam Inspection Act. In December 1980 the Corps issued a progress report, "Inspection of

Nonfederal Dams, Summary for Fiscal Year 1978-1980" which covers program activities through October 1, 1980.

2.2 FEDERAL EMERGENCY MANAGEMENT AGENCY

Following the failure of the federally owned Teton Dam in Idaho, the President on April 23, 1977, directed federal agencies to review their dam safety practices and to convene an ad hoc interagency committee to coordinate dam safety programs. On June 25, 1979, the ad hoc committee issued a set of management guidelines for the planning, design, construction, operation, and regulation of dams by U.S. government agencies. The ad hoc committee later evolved into the Interagency Committee on Dam Safety (ICODS), which is chaired by FEMA.

Under Executive Order 12148, dated July 20, 1979, President Carter assigned responsibility for coordinating and promoting dam safety to the Federal Emergency Management Agency (FEMA), including the task of monitoring the implementation of the management guidelines. FEMA is responsible for policy guidance, development of programs to prevent or respond to dam failure, coordination of federal dam safety programs, and encouragement of nonfederal programs to reduce the public hazard of unsafe dams. The goals of these efforts are accomplished primarily through coordination and information exchange among organizations sharing common problems and having responsibilities for dam safety.

2.3 INTERAGENCY COMMITTEE ON DAM SAFETY

Several federal agencies are involved in dam safety. In addition to FEMA, these include the Departments of the Army, Agriculture, Interior, and Labor; the Federal Energy Regulatory Commission (FERC); the Tennessee Valley Authority (TVA); the U.S. section of the International Boundary and Water Commission, and the Nuclear Regulatory Commission (NRC). Their principal coordination mechanism is the Interagency Committee on Dam Safety (ICODS).

ICODS was created ".....to encourage the establishment and maintenance of effective federal and state programs intended to assure dam safety for protecting human life and property." (From ICODS Charter and Operating Rules, adopted April 20, 1980.) This is achieved primarily through the coordination and exchange of information among federal agencies. ICODS provides a permanent forum in which the agencies can advise FEMA, in its role as coordinator of interagency activities and to identify, discuss, and recommend solutions to dam safety problems.

ICODS has created six subcommittees to address various issues involved in dam safety efforts: Technical Guidelines, Research, Funding for Dam Safety, Training, Emergency Action Planning, and Interagency Communication. The subcommittees on Research, Funding, Training, and Interagency Communications have completed their work and will issue final reports that will be parts of the FEMA/ICODS biennial report on dam safety. Because of the bulk of the report of the Research Subcommittee, it will be published separately by FEMA. These reports were not available in time for the meeting of the Committee on the Safety of Nonfederal Dams.

The Technical Guidelines Subcommittee has undertaken to establish consensus guidelines for inflow design floods and design earthquakes. Due to the magnitude of the effort, a completion date has not yet been set.

The Emergency Action Subcommittee is addressing questions of dam failure and mapping, notification guidance, evacuation planning, and repairs. A draft subcommittee report is scheduled for submission to ICODS in October 1982.

2.4 FEDERAL ASSISTANCE AND REGULATORY FUNCTIONS

The U.S. government has varying degrees of responsibility relating to some nonfederal dams. Following is a brief summary of the involvements of the principal federal agencies.

2.4.1 U.S. Department of Agriculture

Five agencies within the Department of Agriculture are involved with nonfederal dams.

The Agricultural Stabilization and Conservation Service (ASCS) provides cost-sharing assistance for the construction of dams designed to conserve or safely dispose of water, protect against soil erosion or flood damage, or prevent agricultural pollution of water. The ASCS has no responsibility or capability with respect to dam safety. Administratively and procedurally, the technical engineering responsibility for dams is assigned to the Soil Conservation Service (SCS).

The Farmers Home Administration (FmHA) provides loans and grants funds to rural landowners and public organizations for construction to enhance land and water resources and to improve living and working conditions in rural areas. Where water resource developments, including dams, are required, FmHA ensures that loans for construction are financially sound. FmHA has no engineering expertise related to the safety of dams.

The Forest Service (FS) issues special-use permits to private entities building and operating dams either in National forests or on private land if National forest lands are affected in some way. It has some degree of administrative control over more than 17,000 dams, most being small, low hazard structures. However, over 1,300 of the nonfederal dams are of such a size and height as to be included in the National Dam Inventory. The Forest Service reviews and approves the owners' activities related to dam safety and maintains a staff of engineers trained in design, construction and operation of dams.

The Rural Electrification Administration (REA) makes loans and loan guarantees for rural electrification in certain areas. The loans are for constructing and operating facilities that include hydroelectric dams. The REA has limited technical expertise in dam safety.

The Soil Conservation Service (SCS) assists land users and owners in the conservation, protection, and enhancement of soil, water, and related resources. It

provides technical assistance to individuals and groups for dams installed under some programs, and technical and financial assistance in the case of dams constructed under federal cost-sharing programs such as those authorized by the Watershed Protection and Flood Prevention Act and some of those of the Resource Conservation and Development authorities. Under the cost-sharing programs, SCS agreements with project sponsors require inspections for the life of the agreement (usually the economically evaluated project life). SCS has assisted in the construction of more than 8,000 nonfederal dams in upstream watershed protection and flood prevention projects.

2.4.2 U.S. Department of the Interior

The Bureau of Land Management (BLM) is a land managing agency and prescribes procedures under which others receive authorization to construct dams on BLM public lands. No federal funds are involved in the design, construction, operation, or maintenance of these dams. The BLM has no requirements and provides no supervision relating to the safety of the structures.

The Office of Surface Mining (OSM) administers programs regulating surface coal mining operations and the surface effects of underground coal mining operations. The dams regulated by OSM are used in conjunction with mining operations in order to control the surface runoff of water and to dispose of waste products. Planning, site selection, design, construction, maintenance, and operation of these structures are the responsibilities of the mining companies. However, OSM regulates and inspects the dams or monitors and supports the state regulatory programs.

2.4.3 U.S. Department of Labor

The Mine Safety and Health Administration (MSHA) inspects the nation's mines and enforces regulations for the protection of the health and safety of persons working in those mines. MSHA's dam safety responsibilities lie in enforcing its regulations governing coal waste impounding structures. Its inspection and enforcement jurisdiction is limited,

applying primarily to the prevention and elimination of hazardous conditions that could adversely affect the lives of those working in the mines and on mine property.

2.4.4 Department of the Army

Under the authority of Section 404 of the Federal Water Pollution Control Act of 1972 (Public Law 92-500) and Section 9 of the River and Harbor Act of 1899 (30 STAT. 1151; 33 USC 401), the Corps of Engineers issues permits for the construction of nonfederal dams on the nation's waterways. Permit applicants furnish documentation on the designs, but the Corps does not provide an independent engineering review. Unless another federal agency requires inspection of the dam, the permit requires the permittee to operate and maintain the structure properly to ensure public safety. Such dams are not included in the Corps' dam safety program, because their safety is considered to be a state responsibility.

2.4.5 Nuclear Regulatory Commission

The Nuclear Regulatory Commission (NRC) issues permits and operating licenses for nuclear facilities, including dams. The licensing process addresses only dams where failure could result in a radiological risk to the public health and safety. These are dams (20 in number) that impound water required for the safe shut-down of nuclear power plants. The NRC imposes no explicit dam safety requirements on approximately 31 other dams associated with nuclear power plants.

2.4.6 Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC) supervises a dam safety program under Section 10(c) of the Federal Power Act. It issues rules and regulations to ensure that licensed projects are adequately constructed, operated, and maintained to protect life, health, and property. FERC's jurisdiction covers dams at hydroelectric projects that are located on navigable streams, occupy federally owned lands, use surplus water or water power from a federally owned dam, or affect the

interests of interstate or foreign commerce. The FERC dam safety program involves about 1,200 dams, of which about 350 are in the high hazard category. FERC is a member of the Interagency Committee on Dam Safety and pursues its dam safety activities in general conformance with the Federal Guidelines for Dam Safety.

III. LIABILITY

3.1 DISCUSSION

English common law, still the basis for nonstatutory law in the United States, traditionally has held that the capture or collection of large amounts of water on one's land constitutes a hazardous activity and that the collector operates at the risk of all subsequent occurrences related to that capture. Thus, to this day, most states hold dam owners liable for damages that result from the failures of their dams.

This is not always the case, however, since statutory law and judicial decisions have somewhat confused the certainty of liability. For example, the results of some cases* have suggested that dam owners must be negligent before they can be held liable for damages resulting from the dam's failure. In at least one case (Gibson et al. vs Commonwealth of Pennsylvania, Department of Environmental Resources, and Goddard and Ellam, 1978) the court held that a state official responsible for inspecting a dam was not immune from liability. Following a dam failure during the 1977 Johnstown flood, downstream residents filed suit against the State of Pennsylvania and individual employees responsible for the state's dam safety program. The State Supreme Court ruled that the state employees were not immune.

*Turner vs Big Lake Oil Co. 96 S.W. 2D 221 (1936) (Texas); Walsh vs East Butte Copper Mining Co. et al. 214 P. 641 (1923) (Montana); and Van Alstyne vs City of Amsterdam 197 N.Y.S. 570 (1922) (New York).

Because of the uncertainty engendered by such decisions, the issue of liability needs to be clarified so that the appropriate parties know they will be held responsible for dam failures. This certainty of outcome would serve two major purposes. First, it would encourage the responsible government agencies or other parties to inspect and correct deficiencies that could lead to dam failures. Second, it would establish an incentive for the parties to obtain insurance quickly to cover damage claims that could result from dam failures.

The U.S. government assumes liability for federally owned dams. However, it disclaims liability for nonfederal dams, including those regulated by federal agencies. With respect to the Corps of Engineers inspections of nonfederal dams from 1977 to 1981, the law specifically excluded the federal government and its officers or employees from any liability.

3.2 CONCLUSIONS

3.2.1 Dam Owners

In states that lack laws governing liability for dam failures, the legislatures should be encouraged to pass strict liability standards for the ownership of dams. In essence, the owners of dams, as the parties most directly in control of potentially hazardous conditions, should be primarily responsible for ultimate failures. Any uncertainty as to who would be liable for a failure would hamper dam safety and appropriate liability coverage.

3.2.2 Engineering and Regulatory Personnel

Conversely, state legislatures should consider a form of immunity for engineers who assess the integrity of existing dams and for state regulatory employees. Because of the real or imagined fear of potential liability, many qualified engineers and engineering firms are reluctant or refuse to become involved in assessing dam safety. Engineers must be able to provide their best professional opinion without fear of legal liability for any consequences. Similarly, the employees of state regulatory agencies should be free to

discharge their responsibilities without fearing personal liability should a dam fail. Such legislation should be carefully drawn so as not to affect the ordinary liabilities of the engineers for work over which they have full control or to conflict with professional registration laws, and to except instances of malfeasance or misfeasance.

3.2.3 Federal Role

The encouragement of states to enact such legislation is a proper function for the U.S. government and could be coordinated through FEMA.

IV. RESPONSIBILITIES

4.1 STATES

4.1.1 Discussion

State governments are responsible for protecting their residents from loss of life or property by the unsafe action or inaction of others whenever and wherever possible.

While some states have adequate statutory and regulatory authority over nonfederal dams, others lack any such authority and many fall somewhere in between. Since it is widely accepted that dam owners are responsible for the safety of their dams and that regulatory authority should lie in the states, all states need laws regulating dam safety. Six states have enacted such legislation in the past five years. However, many others need to enact legislation or improve existing legislation, and the U.S. government should assist and encourage the states in this matter.

4.1.2 USCOLD Model Law

The United States Committee on Large Dams (USCOLD) has issued a "Model Law for State Supervision of Safety of Dams and Reservoirs." USCOLD is the United States Member of the International Commission on Large Dams, an organization of professional engineers, geologists, other individuals, and organizations concerned with the design, construction, operation, and maintenance of dams and reservoirs. The model was prepared as a public service for the consideration of state governors and legislatures. The objective was to promote states' awareness of their dam safety responsibilities and to help the states begin or improve supervisory programs.

It would be helpful to the promotion of adequate legislation if FEMA or some other U.S. government agency or private organization would compile a detailed description of the laws and regulations of all states with regard to dam safety. While the Corps of Engineers, for the 1975 report to the Congress, "National Programs of Inspection of Dams," surveyed the states to determine what their supervisory practices were and whether or not they had statutory authority over dams, it made no detailed analysis of the laws and regulations. The USCOLD model could be used to compare state programs. Such a compilation should be updated periodically, perhaps every two to five years. Further, it might be useful to poll the states periodically to determine what problems they see in their programs. (Such a poll could maintain the anonymity of the responding parties if found desirable).

4.1.3 National Perspective

Because of inadequate state supervision and the magnitude of the consequences of widespread dam failures, a national perspective on dam safety is needed. The problems will not be solved entirely without a nationwide perspective or the impetus that a broad-based group can offer. This could be provided by either a government agency or a nongovernmental entity, such as FEMA, an association of state dam safety officials, or a combination of these in a cooperative forum like the U.S. Committee on Large Dams or the American Society of Civil Engineers (ASCE).

4.1.4 Conclusions

FEMA, in coordinating dam safety, should encourage states to assume and discharge competently their rightful supervisory responsibilities for dam safety. FEMA, for example, could promote state legislation comparable to the USCOLD model law and help formulate a national association or forum for discussing problems of dam safety. FEMA should also establish means for impartial assessments of state programs and disseminate the results of such assessments appropriately.

4.2 FEDERAL GOVERNMENT

4.2.1 Discussion

Responsibilities of the federal agencies for nonfederal dams differ widely and involve dams built with federal technical and/or financial assistance and dams subject to permits and licenses. Section 2.4 contains a summary of each agency's involvement with nonfederal dams.

Except for some of the dams falling under federal regulatory authority, the U.S. Government does not attempt to supervise nonfederal dams in the interest of public safety, not even those that may have been constructed under its programs. The states are expected to provide safety supervision for these dams. Only in the case of nonfederal dams engineered and constructed with federal assistance (principally under the USDA Small Watershed Program and Resource Conservation and Development Program), is a degree of federal responsibility for safety clearly defined and accepted. In this case, the U.S. government corrects deficiencies involving (1) latent conditions not discovered during original investigations or construction, and (2) inadequate or faulty designs, including improper hazard classification at the time of construction. Also, the U.S. Government has, to varying degrees, helped dam owners with plans and inspections to facilitate operation and maintenance, development of emergency plans, and recognition of land use changes that could alter the hazard classifications of dams. It has also encouraged land use controls to regulate development in areas that could be affected by dam failures.

As a result of the Corps of Engineers inspection program, nonfederal dam owners have become aware of the very serious defects in some of their dams. These defects relate to (1) deterioration, primarily due to the dam's age and/or lack of maintenance; (2) dam constructed to meet a lower hazard classification than that applicable at the time of inspection (generally these changes in hazard classification have occurred as a result of actions by others over which dam owners have little or no control); and (3) changes in the criteria by which the adequacy of design and/or construction is judged.

Out of frustration and economic necessity, many owners of nonfederal dams have asked the federal agency that initially assisted with design and construction for help. Normally, the agencies lack the authority to provide more than technical assistance to the owners in upgrading the structure to meet current criteria.

4.2.2 Conclusions

Considering the technical involvement of the U.S. government in the initial construction, the federal government has a degree of continuing responsibility for such nonfederal dams. Either on its own or through the Interagency Committee on Dam Safety, FEMA should prepare guidelines for emergency preparedness plans that can be used by dam owners and state regulatory agencies in preparing for possible failures of dams initially engineered and constructed with federal assistance.

To assist in planning related federal activities, FEMA should maintain a central inventory of nonfederal dams that fall under federal permit, assistance and regulatory programs. Some agencies presently have inventories of nonfederal dams falling under their programs; these would facilitate the compilation of a central inventory.

Federal agencies should advise dam owners and potential dam owners on the hazard-classification consequences of downstream land use changes. (This information should also be furnished to state and local zoning authorities.) Further, they should insist on strict compliance with operation and maintenance agreements and work with state governments in designing and instituting dam safety programs.

V. IMPERATIVE NEEDS

The committee identified and discussed existing impediments to effective safety efforts on nonfederal dams. In the course of these discussions, the committee developed a list of "imperative needs" and addressed the question of federal involvement in meeting those needs. These needs are listed below and are discussed in the remainder of this section.

- Dam inventory: Data on the ownership, characteristics, conditions, and hazard classifications of dams should be kept current to facilitate supervision of safety programs.

- Risk classification: A comparative risk classification of dams is needed to serve as a basis for determining which dams are most in need of inspection and remedial measures.

- Technical assistance: Assistance is needed in many cases to upgrade states' technical capacities to conduct dam safety programs effectively.

- Funding assistance: Many dam owners are unable to fund investigations or repairs to improve the safety of dams.

- Training assistance: Many states lack adequately trained personnel for inspections and other safety activities.

- Insurance: Many dam owners lack insurance to cover their liabilities for loss of life and/or damage to property in the event of dam failures.

- Public safety planning and awareness: Emergency preparedness plans, for warning and evacuating downstream residents in case of failure or imminent failure of a dam, and alerting the public to potential hazards associated with dams, are needed.

- Costs of dam failure: The lack of knowledge by federal and state officials and elected representatives of the real costs of dam failures precludes their rational determination of proper funding levels for dam safety activities.

- Post-failure investigations: A need exists for conducting and coordinating investigations of why a dam failed.

- Dam terminology: A common terminology for dam safety activities is needed.

These needs will now be discussed in detail.

5.1 DAM INVENTORY

5.1.1 Problem Description

The National Inventory Program has effectively defined the scope of the inspection problem. It has also helped shape policy decisions. However, the federal inspection program for nonfederal dams has ended and the states continue to have primary governmental responsibility for nonfederal dam safety; therefore, the need for inventories appears to be primarily at the state level. In fact, up-to-date information is vital to: the hazard classification and inspection processes, effective emergency planning, flood plain management programs, and to informing and assisting the public.

While 40 states have current inventories, the others depend on the Corps of Engineers' inventory. With the termination of the Corps' program, many states

will not maintain their own inventories because of budgetary, personnel, and other problems. However, if an orderly transfer or phase-out (over perhaps 3 to 5 years) of the federal inventory is arranged, states would have time to plan and budget for maintaining their own inventories. The alternative would be to provide each state a printout of the current inventory, which could be updated when and if the state so decided.

The federal government, and particularly FEMA and its regional offices, would benefit from a national inventory kept current. Up-to-date state inventories would help federal agencies identify special flood hazard areas below dams, prepare flood insurance study reports, site federal facilities located below dams and determine compliance with federal regulations such as those of the National Environmental Policy Act.

5.1.2 Conclusions

The committee did not reach unanimous agreement on continued federal support of dam inventory activities. A minority view was that the federal government should do no more than furnish each state a copy of the current inventory.

The majority, however, concluded that the national inventory should be maintained by FEMA for a specified period of time and then phased out. All states would be advised that they would have this period in which to take responsibility for their own inventories if they wished. Together with other ICODS agencies, FEMA should use the phase-out period to develop a clear policy on issues pertinent to nonfederal dam safety. Specifically, FEMA should take the following steps:

- Take the lead and share the financial responsibility with the states for transferring the Corps' inventory program to the states
- Assist and guide, when requested, in setting up state-run inventory programs that are consistent with the Corps' inventory file system but fit the needs of individual states
- Investigate the feasibility of updating the file during the phase-out period with data on new

federal and nonfederal dams (presuming the availability of data from state inventories)

- Study the need for continuing a national inventory of nonfederal dams before the end of the phase-out period.

5.2 RISK CLASSIFICATION

5.2.1 Problem Description

The analysis of risk involves consideration of two basic elements: these are the probability and the consequences of failure (hazard potential or potential losses in the event of failure). Combining these two elements in a rational manner produces a measure of risk.

While the consequences of failure can be realistically estimated, the probability of an individual structure's failing is difficult to assess. Although the basic principles for making such assessments exist, the methodology has not been applied in practice to dams except in isolated instances and in very simplistic forms. A risk assessment for dam safety would have to consider such information as historical data on dam failures; the uncertainties about loads (including earthquakes), structural resistances, and geological factors; overtopping probabilities and their structural consequences; and the existing conditions of structures. Estimates of risk and the reliability of risk predictions change with time since the amounts and quality of information about site conditions and structural properties usually increase with time.

By applying risk assessment to dam safety, engineers and safety officials would at least obtain a priority list for inspections, maintenance, and remedial work. Together with pertinent cost data, risk assessment would facilitate the better allocation of financial and personnel resources for mitigating dam failure hazards. In the process, the trade-off between cost and risk would have to be considered. All structures, no matter how well engineered, embody some risk. Risks can be lowered by upgraded design, more intensive inspection, rehabilitation, or effective emergency warning systems and evacuation plans; and the

benefit can be expressed as reduced likelihood or severity of losses. Quantification of risk and the degree of risk reduction achieved by a dam safety program are necessary if the benefit of such a program is to be demonstrated.

In analyzing choices among alternatives in design, inspection, maintenance, or repair of dams, it is seldom necessary to deal with absolute probabilities. What is needed is an assessment of relative or fractional risks, together with the differences in cost associated with each alternative. This greatly facilitates decisions that involve the allocation of limited resources.

On the other hand, cost and risk assessments are often controversial. Different parties (owner, downstream resident, and contractor, for example) are affected differently by the outcomes of such assessments. Thus, they tend to assess costs and risks differently, and they may select different criteria on which to base the decision. In light of these conflicts, the main value of such methodologies may be in providing a framework for organizing factual information about cost and risk, for structuring the decision making process, and for promoting communication among opposing parties.

5.2.2 Conclusions

The federal government should encourage states and dam owners to use risk assessment as a tool for balanced resource allocation to mitigate dam failure hazards.

The inspection reports compiled by the Corps of Engineers contain important information about deficiencies that present dangers of dam failures. This information could be combined with data about failure consequences in an analysis to identify which dams (for example, in a given jurisdiction) should have priority for further investigation or to help in choosing among alternative strategies for providing added protection for a single dam or group of dams. The U.S. government should provide guidance to the states for such use of the inspection data.

Risk analysis can quantify the benefits of upgraded technical standards, inspection programs, or instrumentation programs for dams. Although some progress has already been made in developing the necessary methodology, meaningful applications to dam safety will require further research. Federal involvement in the further development of such methods, and education and training in their use, is highly desirable.

Objective information about the probabilities and consequences of structural failure is needed to help in assessing the need for dam insurance, to allow setting reasonable premium levels, and to clarify questions of liability. The reduction of risk offered by a variety of protective actions also needs to be understood. The U.S. Government should sponsor research aimed at developing background information of this type and should provide for the timely dissemination of the findings through education and training programs.

5.3 TECHNICAL ASSISTANCE

5.3.1 Problem Description

Every state agency responsible for dam safety needs a technical staff acquainted with currently accepted and recommended engineering practices. However, there are no universally recognized technical standards relating to dam safety. In fact, a number of state agencies have opposed setting national standards. Many states lack the funds to provide adequate staffs. Any action by the U.S. government to assist the states in dam safety must take these variations in expertise into account.

Information on technical and institutional aspects of dam safety is widely scattered in the publications of technical societies and government agencies, and in state and national laws and regulations. It is difficult for technical personnel to acquire complete, up-to-date information in this area. Federal assistance is needed to provide state agencies access to technical and regulatory material.

5.3.2 Alternative Solutions

Two basic approaches could be taken to help the states acquire effective guidelines for dam safety programs:

- FEMA could, by operating a reference service or clearinghouse, make available to the states material from the world's technical literature.

- FEMA could develop a comprehensive set of technical guidelines for dam safety, with assistance from a number of possible sources.

Regarding the clearinghouse approach, various agencies and groups have already developed a considerable volume of material that could be helpful to state agencies. In addition to technical guidelines, this material includes the USCOLD Model Law, dam safety legislation from various states and other countries, and various regulations promulgated to regulate dams. Thus, FEMA could provide a useful reference service for such material. FEMA could also provide training programs and research to develop computer programs and methods for the application of new techniques.

If FEMA decided to issue guidelines, it could do so in a variety of ways:

- Encouraging technical societies to set standards similar to those established by such groups as the American Society of Civil Engineers, the American Society for Testing and Materials, the American Concrete Institute, and the National Association of State Highway and Transportation Officials

- Sponsoring conferences of state dam safety agencies to draw up guidelines, using the appropriate existing standards

- Having ICODS develop and suggest engineering guidelines for use by state agencies

- Encouraging the establishment of a technical group of state supervisors of dam safety programs to promulgate standards.

A number of problems are foreseen in any effort by FEMA to promulgate national standards for dam safety. Traditionally in the United States, technical standards have been developed by nongovernmental groups. Governmental agencies have issued such standards only where required by government-financed activities or for regulatory purposes. Because FEMA lacks both a regulatory and a financing function related to nonfederal dams, it does not seem appropriate for it to establish safety standards, or to seek compliance with them. Also, it is unrealistic to expect agreement on a set of national guidelines at this time.

5.3.3 Conclusion

FEMA should establish a technical clearinghouse with appropriate supportive activities relating to dam safety. In this way, FEMA would aid states that need help in developing their own technical guidelines. No attempt would be made to involve those states that do not desire such assistance.

5.4 FUNDING ASSISTANCE

5.4.1 Problem Description

To date, very slow progress has been made in remedying the deficiencies found by the Corps of Engineers. As of October 1, 1981, repairs had been completed on less than 5 percent of the 2,900 dams judged by federal standards to be unsafe. Many dam owners lack the financial resources to undertake correction of major deficiencies.

While the responsibility and liability for unsafe dams rest with the owner, the U.S. government is unavoidably involved from a financial standpoint. The failure of a nonfederal dam could threaten federal facilities, including dams in the same watershed. Waters released by failure of one dam could cause a series of dams along a river to collapse like dominoes, no matter who owns or is responsible for them. The consequences may be further compounded if the watershed extends across state lines, which would not be unusual. Also, the U.S. government would have to pay for disaster

relief, interest subsidies, unemployment compensation, and defaulted loans in case of such dam failures. All of this is in addition to the government's proper interest in the safety of all of its people no matter where they may reside.

5.4.2 Conclusions

The U.S. government should, if necessary, help owners repair unsafe dams. Therefore, FEMA should thoroughly investigate the magnitude of the existing problem and determine what federal, state, and local programs or resources are available for upgrading the safety of nonfederal dams. FEMA should also determine the adequacy of the current funding mechanisms, considering the numbers and types of nonfederal dams.

FEMA should also study the feasibility of establishing revolving funds that could be used to upgrade nonfederal dams. These would make large enough sums available to upgrade the worst dams first; then, as the money is paid back into the fund, it could be loaned out to less serious cases. Such funds could be established at either the state or federal level.

In addition, FEMA should study possible alternatives to structural rehabilitation such as changes in operating procedures, emergency plans, flood plain zoning to minimize downstream impact, and enhanced public awareness of dangers (perhaps through inundation mapping). The committee did not reach unanimity on this conclusion. The minority opinion is that such operational procedures should not be used as an alternative to structural modification. However, there appears to be sufficient justification for a study of this question in view of the possible expeditious mitigation of a potentially unsafe condition by such means. For example, many of the dams called "unsafe" have insufficient spillway capacity by federal standards to avoid overtopping during maximum flood conditions. Conceivably, in some cases, the normal pool could be regulated at a low enough level that the dam could pass the flood without overtopping. Also, the question of dam failure under flood conditions where the downstream flooded area is not significantly increased needs to be

addressed. In many cases, the downstream area should be evacuated due to flooding even before the dam fails.

5.5 TRAINING ASSISTANCE

5.5.1 Problem Description

There are too few trained personnel with expertise in dam safety. Most states lack enough trained individuals to carry out in full an adequate dam safety program. Moreover, states that have experts in dam safety frequently lose them to the private sector. In light of the budget crises experienced by most state governments today, these problems are unlikely to be corrected in the near future. Consequently, special training programs are needed to enable states to use available personnel and enhance their capabilities. While these programs alone would not develop experts in the field of dam inspection and analysis, such training provides an appreciation of the involved problems and instructions for performing duties within the limits of capabilities and recognized responsibilities.

In the past, the Corps of Engineers, through its inspection program, has helped by arranging on-the-job training for state employees and specialized short training courses in such areas as hydrologic analyses, dam-break analysis, use of LANDSAT imagery, and maintenance of the computer-based dam inventory. The Corps also conducted a series of week-long training courses on safety inspection of dams. This program is no longer available and there is no other source of suitable training at present.

To remedy this situation, the U.S. government could encourage states to adopt their own training programs, offer to help fund those programs, or create its own training programs for nonfederal personnel. On the other hand, the U.S. government could leave training to the states and do nothing itself.

5.5.2 Conclusions

FEMA currently offers a broad training program for emergency operations and has trained professionals for

special tasks (for example, the fallout shelter analysis program). Considering its responsibility for promoting dam safety, the U.S. government should make training programs for dam safety personnel available to states, dam owners, and others. To carry out this responsibility, FEMA should develop and offer to conduct suitable training courses on dam safety, and should develop a manual and offer to conduct short training courses for owners and operators on dam operation, maintenance, and emergency action plans.

5.6 INSURANCE

5.6.1 Problem Description

Insurance for dams is generally not available at reasonable rates. Many owners of nonfederal dams have either no insurance or insufficient amounts to cover their liabilities in case of dam failures. Thus, insufficient financial resources may be available to settle damage claims arising from dam failures. For almost any other type of risk, insurance is affordable to meet such personal and social needs. In some instances, such as automobile insurance, states require owners to obtain insurance.

The U.S. government spends a lot of money as a result of dam failures. Generally paid in the form of disaster assistance, the money comes from the Small Business Administration, Veterans Administration, Federal Housing Administration (defaulted loans), Federal Emergency Management Agency, Environmental Protection Agency, and other agencies. Also, a dam failure invariably requires the payment of flood insurance. Thus, federal money could more constructively and effectively be spent on a program to reinsure or guarantee any insurance obtained by dam owners, provided such benefits depended on the owner's meeting minimum safety standards. Those standards could be monitored by state safety programs.

5.6.2 Possible Solutions

A federal benefit program, similar to the National Flood Insurance Program, could promote dam safety and

save the U.S. government millions of dollars in disaster assistance, while helping to eliminate the loss of human life and property associated with dam failures. As with flood insurance, where Congress recognized that the mere offer of insurance would not induce communities to take advantage of the program, a number of states will simply refuse federal assistance for dam liability insurance if it is offered in return for their compliance with model guidelines and enforcement of dam safety. Thus, a range of voluntary, but stringent, measures should be considered as ways to encourage states to enforce dam safety.

At one end of the spectrum, the approach could be similar to that taken by FEMA in its enforcement scheme for flood insurance. That is, any state that fails to adopt or effectively maintain a dam safety program would not be eligible for any financial assistance from the U.S. Government. This includes disaster assistance and flood insurance, and would not be limited merely to denial of financial assistance related to a disaster caused by dam failure.

On the other hand, this denial could be limited to disaster assistance that would be reasonably related to dam failure. Of course, states that may believe the risk of a failure is so small as not to require action may not be persuaded by this.

There is little question that a federal benefit program designed similar to the flood insurance program would have some distinct advantages. These include, but are not limited to, the following:

- FEMA staff is already familiar with the enforcement mechanism and "incentives" already in place with the flood insurance program.

- Because enforcement would take place at the state level, few federal resources or funds would be required.

- The program would still be legally "voluntary" (see Texas Landowner's Rights Association v. Harris 453 F. Supp. 1025, Affirmed 598 F. 2d 311, Cert. Den. 100 S. Ct. 267, 444 US 927, 62 L. Ed. 2d 184, 1979), thus avoiding any

challenge under the Tenth Amendment to the U.S. Constitution.

- There would be a reasonable relationship between the risk of dam failure, the mitigation of that risk, and savings in federal dollars and the reduction in loss of life and property.

5.6.3 Conclusions

In the past, many states have chosen not to address the very serious matter of potential dam failures. For those states that have already adopted workable dam safety programs, the suggested federal benefit program would not impose any new burden. It would, especially if run in conjunction with joint (or separate) federal and private insurance, encourage states to comply with minimum dam safety requirements so as to be eligible for federal disaster and insurance assistance.

Until now, some states have lacked sufficient commitment to dam safety to avoid catastrophic loss. A program supported by the U.S. government, enacted and enforced by the state governments, and buttressed by the insurance industry should help ensure commitments to dam safety. Thus, federal insurance assistance, in conjunction with a benefit program, should be provided as an incentive to states and dam owners who are committed to effective dam safety.

5.7 PUBLIC SAFETY PLANNING AND AWARENESS

5.7.1 Problem Description

Effective planning can minimize loss of life and property when a dam failure occurs or becomes imminent. It can also alert downstream residents to the hazard involved. Given their responsibilities, public officials need to be prepared for any potential disasters. Such preparedness requires the development of appropriate emergency plans, and the direction and control of emergency operations when disaster strikes.

There is little experience on which to base emergency preparedness plans for dam failure, but they

should include communication and warning systems, inundation mapping, operator training for emergency responses, and evaluation procedures. The Corps of Engineers, Bureau of Reclamation, and Federal Energy Regulatory Commission, among others, have developed guidelines for dams that are their responsibilities. Also, USDA's Soil Conservation Service may require the development of emergency plans on future projects that it assists.

Although the states must deal with the consequences of the failures of nonfederal dams, most have not developed effective warning and evacuation plans, or issued the appropriate public information for areas downstream from potentially hazardous dams. Furthermore, federal agencies have not provided suitable guidance or funding in this regard to state and local governments.

5.7.2 Possible Solutions

This problem might reasonably be left to the states to solve without federal involvement. Again, however, many states lack the resources to address the issue. Thus, the U.S. government could encourage, and where necessary help, states to enact emergency preparedness plans.

5.7.3 Conclusions

FEMA's responsibility for coordinating federal efforts to promote dam safety includes the development of plans to prepare for and recover from the consequences of dam failure. In this regard, FEMA has authority to take the following steps:

- Encourage states to enact laws or regulations that require effective emergency preparedness plans, including the development of inundation maps

- Develop emergency warning and evacuation guides for state and local governments and dam owners. This would include guidelines on training programs for emergency personnel.

- Emphasize emergency preparedness planning as part of FEMA funding for state and local programs.

5.8 COSTS OF DAM FAILURE

5.8.1 Problem Description

On June 5, 1976, the Teton Dam in Idaho gave way, reportedly causing at least $400 million in downstream damages. Damage estimates for other failures also have been based on downstream property damage only. In terms of disaster relief, unemployment compensation, interest subsidies, lost power production and/or other benefits, costs to rebuild dams, and environmental damage, the real costs of a dam failure have never been accurately quantified. Nor has an acceptable quantitative value for lives in jeopardy generally been used in formulas for determining costs relating to dam failure. Agency and elected government officials need such information to set proper funding levels for preventive programs. Such data would also help officials analyze the relative risks at dams to determine the priorities of inspection and maintenance procedures.

5.8.2 Conclusion

FEMA should undertake to quantify the real costs of dam failure in order to help define just what dam safety efforts are warranted.

5.9 POST-FAILURE INVESTIGATIONS

5.9.1 Problem Description

The evolution of engineering practice for structures has, in part, been based on the lessons learned from past failures. Such information helps not only to improve design but also to survey existing structures for safety. It should be recognized, however, that the investigation and analysis of dam failures must be done immediately after the occurrence, before critical evidence is lost or altered by post-failure operations. Therefore, there is a need for

an organized program to investigate dam failures or accidents as they occur and to issue the results for the benefit of all.

5.9.2 Conclusions

FEMA should coordinate the investigation of dam failures. In this role, FEMA should maintain a list of experts who could be called upon to move quickly if an emergency arises and if help is requested by the state. To do this, FEMA will need to establish the necessary preauthorization and the monetary resources. Such federally sponsored investigations should be done at the request of and in cooperation with state programs and should not interfere with rescue operations or efforts to rectify conditions.

5.10 DAM TERMINOLOGY

5.10.1 Problem Description

At the present time, considerable confusion occasionally arises over the use of different terms for various dam components and engineering procedures and concepts. For example, the Soil Conservation Service uses an alphabetized classification for the degree of hazard potential of dams, with "A" indicating a low hazard and "C" a high hazard. Others use a reverse order or a numerical system. Some use the word "hazard", in lieu of hazard potential, to convey the prospect for loss of life or damage to property should a dam fail. Others relate "hazard" or "risk" to the probability of dam failure. Properly, "risk" is the combination of probability of dam failure and the downstream consequences of the failure. Some organizations refer to the discharge facility as the "principal spillway", whereas others call it the "outlet works" or simply "outlet". Also, the terms "auxiliary spillway" and "emergency spillway" are often used interchangeably without regard to the true purpose. A listing of dam nomenclature would facilitate the communications between all involved with dam safety and would be beneficial for use in educational and public relations materials.

5.10.2 Conclusion

FEMA, through the Interagency Committee on Dam Safety, should develop common terminology for use in dam safety activities.

VI. SECOND PHASE STUDY

The Committee on the Safety of Nonfederal Dams, as part of its charge, was asked to identify technical issues critical to dam safety that could properly and constructively be addressed during the second phase of the NRC study. The second phase would be undertaken by specialized panels consisting of experts in the technical areas to be studied. After a review of the state of the art, the second phase study would develop and recommend procedures to improve the safety surveillance of dams.

Specifically, the second phase of the study would include the following engineering concerns important to dam safety:

- Risk assessment: Further study and research are needed to develop a rational, practicable methodology for assessing risks in dam safety activities.

- Engineering methodology: Practices applicable to stability and hydrologic and hydraulic evaluations of dams need to be studied. A study of this matter would include, but not be limited to, the modes of breaching due to overtopping of dams, stability parameters for overtopped dams, the evaluation of seismic stability, shear strength in weak rocks or in weak seams of strong rock foundations, and potential for piping at dams.

- Instrumentation and warning systems: The types and capabilities of instruments appropriate for

dam surveillance need to be assessed, including the use of computers to store, transmit, and process data, and to alert management to danger signals.

- Emergency preparedness planning: As stated in section IV, the committee recommended that FEMA should encourage states to establish emergency plans through, among other means, the development of suitable guidelines. A model plan could be developed in the second phase effort.

ICODS is now developing guidelines for hydrologic and seismic stability evaluations, and for emergency preparedness planning. The results of ICODS' efforts could be reviewed by the committee during the second phase to determine their applicability and suitability for nonfederal dams and to aid in the detailed study of technical issues.

VII. RECOMMENDATIONS

7.1 STATE LEGISLATION AND SUPERVISION

The U.S. government, through FEMA, should encourage states to:

- Enact legislation assigning liability for dam failure or misoperation to owners, and accompanying legislation to relieve from liability the engineers and regulatory personnel involved in dam safety, except in instances of malfeasance or misfeasance.

- Assume and competently discharge their rightful supervisory responsibilities by promoting state legislation comparable to the USCOLD Model Law and assisting in the formulation of a national association or forum for discussing problems and assessing adequacy of state safety programs.

7.2 NONFEDERAL DAMS INITIALLY ENGINEERED WITH FEDERAL ASSISTANCE

The U.S. government, through FEMA, should:

- Prepare national guidelines for emergency preparedness plans, with the assistance of the Interagency Committee on Dam Safety (ICODS), for nonfederal dams that were initially engineered and constructed with federal assistance.

- Maintain a central inventory of nonfederal dams that were initially engineered with federal assistance.

Also, all federal agencies involved with nonfederal dams built with federal assistance should:

- Advise current and potential dam owners on the adverse consequences that changes in downstream land use could have on hazard classifications
- Insist on strict compliance with operation and maintenance agreements
- Work with states in designing and instituting dam safety programs
- Provide periodic inputs to the central dam inventory.

7.3 DAM INVENTORY

Working with the Corps of Engineers and other federal agencies, FEMA should:

- Promote the transfer of the Corps' inventory program and file technology to the states as they become capable of carrying out the task, and share in the related costs with the states.
- Provide technical assistance and guidance to states, when requested, for setting up inventory programs that are consistent with the Corps' files, but fitting the jurisdictional sizes and needs of individual states
- Investigate the feasibility of updating the national file during the phase-out period with new dams built with or from private action (presuming the availability of states' inventories)
- Study before the end of the phase-out period, the future need for a national inventory of nonfederal dams.

7.4 RISK CLASSIFICATION

The U.S. government, through FEMA, should encourage and promote the use of risk assessment in dam safety programs by:

- Sponsoring related research to develop applicable and rational procedures
- Providing the necessary education and training to disseminate research findings
- Developing a system for establishing priorities for safety investigations and remedial works based on information regarding the deficiencies found in the Corps of Engineers' Phase I inspection reports, combined with data on the consequences of failure.

7.5 TECHNICAL ASSISTANCE

The U.S. government, through FEMA, should establish a technical clearinghouse to aid states that desire state-of-the-art guidance material and technical assistance.

7.6 FUNDING ASSISTANCE

The U.S. government, through FEMA, should:

- Thoroughly investigate how much money is needed to repair unsafe dams and determine what federal, state, and local programs or resources are available for assisting owners of nonfederal dams to upgrade the safety of their dams
- Study the feasibility of establishing revolving loan funds that could be used to upgrade nonfederal dams
- Study possible alternatives to structural rehabilitation, such as changes in operating procedures, emergency plans, flood plain zoning, and enhanced public awareness of dangers (by inundation mapping).

7.7 TRAINING ASSISTANCE

The U.S. government, through FEMA, should:

- Develop and offer to conduct suitable training courses for dam safety personnel
- Develop a manual and offer to conduct short training courses for dam owners and operators in dam operation, maintenance, and emergency planning.

7.8 INSURANCE

The U.S. government should offer insurance assistance in conjunction with disaster assistance as an incentive to states and dam owners who are committed to effective dam safety efforts.

7.9 PUBLIC SAFETY PLANNING AND AWARENESS

The U.S. government, through FEMA, should:

- Encourage states to enact laws or regulations requiring emergency preparedness plans, including the development of inundation maps
- Develop emergency preparedness (warning and evacuation) guidance for state and local governments and dam owners
- Emphasize emergency preparedness planning as part of the state and local government programs that receive FEMA funding.

7.10 COSTS OF DAM FAILURES

FEMA should study the feasibility of quantifying the real costs of dam failure to justify and define what should be done to make dams safe.

7.11 POST-FAILURE INVESTIGATIONS

FEMA should maintain a list of experts who could be called on quickly to investigate dam failures when requested by states, and should establish the necessary preauthorization and monetary resources to perform such missions.

7.12 DAM TERMINOLOGY

FEMA, with the help of ICODS, should develop a glossary of common terms for use in dam safety activities.

7.13 SECOND PHASE STUDIES

The following technical issues related to dam safety should be studied in greater detail:

- The methodology of risk assessment
- Engineering methodologies for stability and hydrologic evaluations (including but not limited to modes of breaching, stability parameters for overtopped dams, seismic stability, shear strength in weak rock or in weak seams of strong rock foundations and potential for piping at dams)
- Instrumentation and warning systems
- Model guide for emergency preparedness planning

APPENDIX A

BIBLIOGRAPHY

U.S. Congress. Aug. 8, 1972. "National Dam Inspection Act." 92d Cong., 2d sess.

Chief of Engineers. 1975. National Program of Inspection of Dams, vol. 1-5. Washington, D.C.: Department of the Army

Chief of Engineers. Dec. 1, 1980. "Inspection of Nonfederal Dams, Summary for Fiscal Years 1978-1980: A Progress Report." Washington, D.C.: Department of the Army. (Final report to be published early in 1982.)

Executive Office of the President. Federal Emergency Management (Executive Order No. 12148), July 20, 1979, 44FR143.

President Jimmy Carter (1977), memorandum of April 23, 1977, to all principal dam safety agencies within the government.

Section 10(c) of the Federal Power Act; Rules and Regulations (Part 12); and Order 122 revised part 12 of regulations, Regulations Governing Safety of Water Power Project Works, January 21, 1981.

Interagency Committee on Dam Safety. June 25, 1979. "Federal Guidelines for Dam Safety." Washington, D.C.: Federal Coordinating Council for Science, Engineering, and Technology.

Federal Emergency Management Agency. July 30, 1980. "Early Progress to Implement the Federal Guidelines

for Dam Safety and Recommendations to Improve Federal Dam Safety Programs." Washington, D.C.

National Research Council. 1977. Safety of Dams: A Review of the Program of the U.S. Bureau of Reclamation for the Safety of Existing Dams." Assembly of Engineering, Committee on the Safety of Dams. Washington, D.C.: National Academy of Sciences.

Committee on Model Legislation for Safety of Dams. 1970. Model Law for State Supervision of Safety of Dams and Reservoirs. New York: United States Committee on Large Dams (USCOLD).

Committee on Failures and Accidents to Large Dams. 1973. Lessons from Dam Incidents. Paris: International Committee on Large Dams (ICOLD).

Committee on Failures and Accidents to Large Dams. 1975. Lessons from Dam Incidents, USA. New York: American Society of Civil Engineers and U.S. Committee on Large Dams.

Committee on Risks to Third Parties from Large Dams. 1976. Committee on Risks to Third Parties from Large Dams Report. Paris: International Committee on Large Dams (ICOLD).

Engineering Foundation. 1974. Inspection, Maintenance and Rehabilitation of Old Dams. Proceedings of Engineering Foundation Conference, Asilomar Conference Grounds, Calif., September 1973. New York: American Society of Civil Engineers.

Engineering Foundation. 1974. Safety of Small Dams. Proceedings of Engineering Foundation Conference, August 1974, Henniker, New Hampshire. New York: American Society of Civil Engineers.

Engineering Foundation. 1975. Responsibility and Liability of Public and Private Interest on Dams. Proceedings of Engineering Foundation Conference, Asilomar, Calif., Sept.-Oct. 1975. New York: American Society of Civil Engineers.

Engineering Foundation. 1976. The Evaluation of Dam Safety. Proceedings of Engineering Foundation

Conference, Asilomar, Calif. Nov. 28-Dec. 3, 1976, New York: American Society of Civil Engineers.

Vanmarcke, E. H. 1974. Decision Analysis in Dam Safety Monitoring. Proceedings of the Engineering Foundation Conference on Safety of Small Dams, August 1974, Henniker, New Hampshire. New York: American Society of Civil Engineers.

Binder, Denis. 1979. "Dam Safety: The Critical Imperative." Land and Water Law Review XIV (2). University of Wyoming, College of Law.

APPENDIX B

BIOGRAPHICAL SKETCHES OF COMMITTEE MEMBERS

ROBERT B. JANSEN is a consulting civil engineer specializing in the engineering of dams. He has directed the design, construction, and dam safety programs of both the California Department of Water Resources and the U.S. Bureau of Reclamation. In 1963-64 he was chairman of the California State Engineering Board of Inquiry which investigated failure of the Baldwin Hills Dam. He was executive director for the Independent Panel to investigate the Teton Dam failure in Idaho in 1976. He holds an M.S.C.E. degree from the University of Southern California. He was chairman of the U.S. Committee of the International Commission on Large Dams in 1979-1981.

HARL P. ALDRICH is president and cofounder of the consulting engineering firm of Haley and Aldrich, Inc. He has been in charge of geotechnical engineering investigations for more than 1,000 projects, concentrating on the design and construction aspects of buildings and earth dams. He received a Sc.D. degree in civil engineering from the Massachusetts Institute of Technology (MIT) and taught undergraduate and graduate courses there in soil mechanics, foundations, and seepage and ground water flow. Dr. Aldrich chaired the National Research Council study on dam safety, A Review of the U.S. Bureau of Reclamation Program on the Safety of Existing Dams, published in 1977.

CHARLES L. BOOTHBY is with the National Association of Conservation Districts, where he analyzes proposed environmental and natural resource legislation and

prepares background papers for congressional testimony. He holds a B.S. degree in agronomy and a masters degree in public administration from the University of Maine. He has worked with the Soil Conservation Service helping landowners develop soil and water conservation plans for their lands, and providing technical assistance in implementing of conservation plans. Mr. Boothby was formerly executive director of the Maine Soil and Water Conservation Commission, where he helped draft that state's "Registration of Dams" and "Land Use Regulation" laws and administered construction contracts for federally-assisted dams.

NOBLE J. CAMPBELL is a member of the Dam Safety Unit of the Texas Department of Water Resources. He is responsible for supervising the structural review and inspection of existing permitted dams, a job involving the guidance, training, and supervision of staff engineers and technicians. He holds a B.S. in civil engineering from Texas A&M University and for 17 years was a senior staff engineer with Humble Oil and Exxon.

JAMES L. DOODY is chief of the Division of Safety of Dams with the California Department of Water Resources. The division supervises the safety of over 1,100 dams and reservoirs in California. Mr. Doody's division deals with owners of dams and reservoirs and with representatives of local, state, and federal agencies concerning dam safety. He holds a B.S. degree in civil engineering from the University of California and has previously served with the U.S. Army Corps of Engineers. While with the Corps, he held various positions involved in the design of multipurpose reservoir projects, including concrete dams and tunnels, earth-fill dams, and associated structures such as spillways and outlet works.

KENNETH A. DUNN is director of the Idaho Department of Water Resources, where he started as chief engineer in 1967. He was previously employed by the California Department of Water Resources and the U.S. Bureau of Reclamation. Mr. Dunn holds a B.S. degree in civil engineering from Sacramento State

University and is on the Western States Water Council.

JOSEPH J. ELLAM is chief of dam safety for the Pennsylvania Department of Environmental Resources. He is responsible for administering the Pennsylvania dam safety program and supervises the review of the design and construction of new dams and the inspection program for existing dams in Pennsylvania. He received a B.S. degree in civil engineering from the University of Notre Dame and holds a masters degree in government administration. He was a member of the previous National Research Council committee on dam safety, which produced the 1977 report, A Review of the U.S. Bureau of Reclamation Program on the Safety of Existing Dams.

JAMES M. MURPHY is a professional engineer in Massachusetts and a member of the American Institute of Architects Construction Hazards Committee. He is familiar with the insurance aspects of dams. He has been with Fred S. James and Company, Inc., as vice president and director of technical services since 1975. Early in his career, he was a safety engineer and loss control specialist for various insurance companies. Mr. Murphy received a B.S. degree in industrial management from Northeastern University and has approximately 30 years of experience in risk management and loss prevention.

ROBERT D. SOKOLOVE is a lawyer with the firm of Ford, Farquhar, Kornblut, and O'Neill in Washington, D.C. He has served as trial attorney for both the U.S. Department of Housing and Urban Development and the Federal Emergency Management Agency. He received his law degree from Franklin Pierce Law Center in Concord, New Hampshire, and has received advanced training in hydrology and hydraulics in flood determination at the University of California at Davis. His litigation experience has primarily involved insurance and negligence, as well as land use, environmental law, administrative law, and contracts.

BRUCE A. TSCHANTZ is a professor of civil engineering at the University of Tennessee. In 1980, on leave for

one year from the university, he was chief of federal dam safety for FEMA. He holds a Sc.D. degree in civil engineering from New Mexico State University. From 1977 to 1979, Dr. Tschantz coordinated the executive office review of federal agency dam safety procedures, which in 1979 resulted in new federal guidelines for dam safety. His principal expertise is in dam safety, flood plain management, and the hydrologic impacts of strip mining.

ERIK H. VANMARCKE is professor of civil engineering at MIT. He holds a Ph.D. degree in civil engineering from MIT and organized MIT programs on "Risk and Decisions in Geotechnical Engineering" (1976) "New Perspectives on Dam Safety" (1979). His principal expertise is in risk analysis of dams and other structures. Dr. Vanmarcke was a committee member on the 1977 National Research Council study of dam safety.

HOMER B. WILLIS is a consulting engineer in private practice. He holds a B.S. degree in civil engineering. He had much experience in the field of dam safety while working for the Corps of Engineers, including the development of a training program for state employees in safety inspections of dams and the writing of reports on results of the national program for inspection of nonfederal dams.

Technical Consultant

CHARLES F. CORNS is a consulting engineer specializing in dam safety and the structural engineering of all types of water resources projects. He holds a B.S. degree in civil engineering from Akron University. In January 1977, he retired from the U.S. Army Corps of Engineers, where he had been the chief structural engineer for the National Water Resources Development Program (civil works). Mr. Corns also served as the technical consultant for a previous National Research Council study of dam safety.