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ENGINEERING AND DESIGN

SAFETY OF DAMS - POLICY AND PROCEDURE

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CHAPTER 1

Introduction

1-1 Purpose.

The safety of dams is a major concern of the Corps of Engineers, just as it has been since the Corps began building dams in the 1840's. The purpose and intent of this regulation[1] is to ensure that responsible officials at all levels within the decentralized organization of the Corps of Engineers implement and maintain a strong dam safety program in compliance with "Federal Guidelines for Dam Safety". The program ensures that all water control structures, including dams, levees, pump stations, and navigation structures, are designed, constructed, and operated safely and effectively under all conditions, based on the following definitions of dam safety and dam safety program purposes, as adopted by ICODS.

a. Dam Safety: Dam safety is the art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe functioning is not explicitly determined by its original design and construction. It also includes all actions taken to identify or predict deficiencies and consequences related to failure, and to document, publicize, and reduce, eliminate, or remediate, to the extent reasonably possible, any unacceptable risks.

b. Dam Safety Program Purposes: The purposes of a dam safety program are to protect life, property, and the environment by ensuring that all dams are designed, constructed, operated, and maintained as safely and effectively as is reasonably possible. Accomplishing these purposes requires commitments to continually inspect, evaluate, and document the design, construction, operation, maintenance, rehabilitation, and emergency preparedness of each dam and the associated public. It also requires the archiving of documents on the inspections and history of dams and the training of personnel who inspect, evaluate, operate, and maintain them. Programs must instill an awareness of dams and the hazard potential that they may present in the owners, the users, the public, and the local and national decision-makers. On both local and national scales, program purposes also include periodic reporting on the degree of program implementation. Key to accomplishing these purposes is to attract, train, and retain a staff proficient in the art and science of dam design.

1-2 Applicability.

[1] This regulation supersedes EP 1110-2-13 dated 28 June 1996, ER 1110-2-50 dated 22 August 1975, ER 1110-2-100 dated 1 December 1998, ER 1110-2-101 dated 31 January 1993, ER 1110-2-110 dated 8 July 1985, ER 1110-2-1155 dated 12 September 1997, ER 1110-2-1156 dated 31 July 1992, and ER 1110-2-1451 dated 10 August 1978.

This regulation applies to HQUSACE elements, major subordinate commands (MSC), districts, and field operating activities (FOA) having responsibility for planning, site selection, design, construction, operation, maintenance, inspection, evaluation, and rehabilitation of water control structures such as dams and appurtenant structures, levees, flood walls, pump stations, and navigation structures.

1-3 References.

Required and related references are listed in Appendix A.

1-4 Glossary.

Abbreviations and terms, which may not be familiar to the reader, are defined in Appendix B.

1-5 Scope.

This regulation prescribes the policy, organization, responsibilities, and procedures for implementation of dam safety program activities within the Corps of Engineers to assure continued safety, structural integrity, and operational adequacy of Civil Works water control facilities. The regulation combines a number of previous regulations to provide a single document for the overall dam safety program. The dam safety program involves many organizations within Headquarters U. S. Army Corps of Engineers (HQUSACE), the Major Subordinate Commands (MSC's), and districts, including engineering, operation and maintenance, and program and project management, throughout the life cycle of applicable projects. Commanders and managers at all levels are responsible to ensure that sufficient highly qualified personnel are available to meet project purposes and that programs related to dam safety are established and funded to achieve compliance with the requirements herein.

CHAPTER 2

General Considerations

2-1. History of Dam Safety. A history of dam safety within the Corps of Engineers and how it relates to dam safety in the nation is provided in Appendix C.

2-2 Federal Guidelines for Dam Safety.

a. In 1977, President Carter issued a memorandum directing three actions:

(1) That all Federal agencies having responsibility for dams conduct a thorough review of their practices which could affect the safety of these structures and report their findings to the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET).

(2) That FCCSET prepare the "Federal Guidelines for Dam Safety" for use by all Federal agencies.

(3) That an Interagency Committee on Dam Safety (ICODS) be established to promote and monitor Federal and state dam safety programs.

b. In 1979, the "Federal Guidelines for Dam Safety" was published, and ICODS was given oversight responsibility for dam safety. The key management practices outlined in the guidelines are as follows (Federal Emergency Management Agency 1979, reference 33):

(1) Establish a Dam Safety Officer and appropriate staff.

(2) Maintain an updated inventory of dams.

(3) Document design criteria and construction activities.

(4) Prepare initial reservoir filling plans and reservoir regulation criteria.

(5) Prepare operation and maintenance instructions and document activities.

(6) Maintain a training and awareness program.

(7) Prepare and maintain Emergency Action Plans (EAP's) for each dam.

(8) Establish a program of periodic inspections and evaluation of dams.

(9) Monitor and evaluate the performance of each dam and appurtenant structure and provide remedial construction as necessary.

c. The "Federal Guidelines for Dam Safety" requires each agency responsible for the design, construction, operation, or regulation of a dam project to be structured with a single identifiable, technically qualified head responsible for assuring that all management and technical safety aspects of dam engineering are adequately considered throughout the development and operation of the project. That position must have continuity of guidance and direction, and authority and resources to ensure these responsibilities can be carried out. To comply with these guidelines the Dam Safety Officer shall be a Registered Professional Engineer in charge of the program with a technical staff tasked to implement the program.

2-3 Levels of Responsibility for Dams.

a. The Corps of Engineers involvement in dams can be categorized as follows:

(1) Dams the Corps of Engineers has designed, constructed, operates, and maintains, and has ownership. This includes appurtenant structures such as navigation locks, powerhouses and Corps' owned levees that retain permanent pools, whose failure could potentially yield loss of life, or environmental or economic damage.

(2) Dams the Corps has designed and constructed, but are operated and maintained by others. Ownership remains with the Corps of Engineers.

(3) Dams the Corps has designed and constructed, but are operated and maintained by others. Ownership is transferred to the sponsor.

(4) Dams designed, constructed, operated, maintained, and owned by others where flood control storage is provided at Federal expense under the authority of the 1944 Flood Control Act.

(5) Dams designed, constructed, operated, maintained, and owned by others and later modified by the Corps for the owner.

(6) Dams where the Corps has issued permits under its regulatory authority.

(7) Dams inspected and evaluated by the Corps under the authority of the National Program for the Inspection of Non-Federal Dams, PL 92-367.

b. In categories 1 and 2, the Corps of Engineers is responsible for dam safety. For dams in category 3, the primary dam safety responsibility is with the agency or sponsor who accepted project ownership. The Corps' responsibility is to fulfill the requirements of the Project Cooperation Agreement (PCA) including periodically inspecting the project to evaluate its performance and maintenance. In category 4 the Corps maintains pertinent data on the project and participates in inspections to ensure that the Federal flood control interest is properly maintained. In category 5 the Corps has a legal liability based on the work accomplished by the Corps to modify the dam. For categories 6 and 7, the Corps has no legal liability or financial responsibility for dam safety.

CHAPTER 3

Administration of Dam Safety Within the Corps of Engineers

3-1 General.

The Corps of Engineers maintains a three-level decentralized organization, HQUSACE, MSC, and district or FOA. Each level shall be staffed with qualified personnel in areas of design, construction, inspection and operations of dams and appurtenant structures, commensurate with the level of risk to the public from a dam failure. Dam Safety Officers, Dam Safety Program Managers, and various other positions providing final approval of engineering products and services to ensure the protection of life, property and the environment, are required by ER 690-1-1212, *Professional Registration as a Selective Placement Factor*, dated 30 November 2001, reference 14, to be registered professionally. Registration of all USACE engineers, architects, landscape architects, surveyors, geologists, and related professions at GS-12 and above is strongly encouraged. Each organizational level shall have a Dam Safety Officer with supporting organization as outlined in this chapter.

3-2 HQUSACE.

a. Organization. The USACE Dam Safety Officer is the Chief, Engineering and Construction Division, Directorate of Civil Works. He is supported by the HQUSACE Dam Safety Committee and the Corps of Engineers Dam Safety Program Management Team (CEDSPMT). The standing HQUSACE Dam Safety Committee includes the USACE Dam Safety Officer, the Special Assistant for Dam Safety, HQUSACE Dam Safety Program Manager, National Inventory of Dams Program Manager, and members with extensive knowledge and expertise in the following areas:

(1) Project Operations and Maintenance
(2) Geotechnical Engineering/Engineering Geology
(3) Hydraulics and Hydrology
(4) Mechanical and Electrical Equipment
(5) Dam Construction
(6) Structural Engineering
(7) General Engineering Policy
(8) Risk Assessment/Research
(9) Planning and Policy
(10) Programs and Project Management
(11) Security
(12) Dams on Military Installations

Other disciplines and areas of expertise shall be represented as required. A representative from the Public Affairs Office should be invited to the committee meetings.

b. Responsibilities.

(1) USACE Dam Safety Officer. The USACE Dam Safety Officer shall be a registered professional engineer, and is responsible directly to the Chief of Engineers for dam safety activities. The USACE Dam Safety Officer coordinates dam safety activities with the various elements of the Directorate of Civil Works and informs the Director concerning the condition of Corps dams. The USACE Dam Safety Officer is responsible for ensuring the Corps of Engineers maintains a proactive dam safety program, implementing all practices and procedures outlined in the "Federal Guidelines for Dam Safety". He[2] is responsible for establishing technical criteria and prioritizing work. He or his designated representative(s) will represent the Department of Defense on the National Dam Safety Review Board and ICODS. He ensures that programs to implement dam safety needs and to monitor the activities at the various levels of the Corps are established. The USACE Dam Safety Officer serves as chair of the HQUSACE Dam Safety Committee. He will assess USACE dam safety activities utilizing the best available techniques and programs, and periodically report to the Director of Civil Works and Chief of Engineers.

(2) Special Assistant for Dam Safety. The Special Assistant acts for the USACE Dam Safety Officer in the execution of daily program activities and serves as Chairman of the Corps of Engineers Dam Safety Program Management Team (CEDSPMT). The Special Assistant shall be a registered professional engineer with management abilities and knowledge and experience in the design and construction of dams. The Special Assistant works for and reports directly to the USACE Dam Safety Officer. He serves as the Department of Defense and/or Corps of Engineers representative on various national teams as directed by the USACE Dam Safety Officer.

(3) HQUSACE Dam Safety Program Manager. The Dam Safety Program Manager shall be a registered professional engineer with management abilities and knowledge and experience in the design and construction of dams. The Dam Safety Program Manager conducts the daily activities for the overall dam safety program and serves as the Recording Secretary of CEDSPMT. He coordinates the HQUSACE review of dam safety reports and prepares Corps-wide dam safety budget submissions. The Dam Safety Program Manager works in close coordination with the Special Assistant for Dam Safety. He serves as the Department of Defense and/or Corps of Engineers representative on various national teams as directed by the USACE Dam Safety Officer. He will issue, at least annually, an updated membership list for the HQUSACE Dam Safety Committee and the Corps of Engineers Dam Safety Program Management Team.

(4) HQUSACE Dam Safety Committee. The Committee serves as technical advisors to the Dam Safety Officer and will meet at least semiannually or as directed. The Committee will make period inspections and field visits as necessary, and will perform the following functions:

(a) Review each reservoir regulation, operation, emergency response plan and dam safety preparedness. Ensure data for each dam is current in the inventory of dams.

(b) Review the research and development program to ensure the latest technologies related to dam safety receive consideration and evaluation.

[2] It is recognized that the Dam Safety Officer may be either a man or a woman. Where "he" is used in this regulation it is understood to be "he/she".

(c) Review reports and make recommendations on dam safety modifications to the Assistant Secretary of the Army for Civil Works through the USACE Dam Safety Officer.

(d) Prepare committee meeting minutes and post the minutes to USACE Dam Safety web site.

(5) Corps of Engineers Dam Safety Program Management Team. The CEDSPMT shall be organized and function in accordance with Appendix D of this regulation and EC 15-2-1, dated 8 November 2002. The team will meet as required to review and recommend changes to USACE Dam Safety policy. This team periodically reviews and evaluates policy, technical criteria and practices, administrative procedures, and regulatory functions for adequacy to support the agency's dam safety program. Functions include oversight of design, construction, operation, maintenance, inspection, evaluation, and rehabilitation programs to improve internal practices related to dam safety. An annual review of the status of Emergency Action Plans and dam safety training will be accomplished. This team will also perform the following functions:

(a) Review and evaluate USACE dam safety practices, procedures, policies, directives, regulations, technical criteria, administrative procedures, and regulatory functions for consistency and adequacy to support the Corps' dam safety program.

(b) Review and recommend that dam safety organizational staffing of highly qualified personnel is sufficient at all levels and that the MSC dam safety program is sufficiently funded to achieve program requirements.

(c) Make recommendations for future research and development in areas related to dam safety.

(d) Prepare team meetings minutes and post to the USACE Dam Safety web site.

3-3 Major Subordinate Commands (MSC).

a. Organization.

(1) Dam Safety Officer. The MSC Dam Safety Officer shall be a registered professional engineer reporting directly to the Commander. The MSC Dam Safety Officer will be the SES responsible for the engineering elements of the organization except that the Chief of Engineering may be designated the Dam Safety Officer when the SES is not a Professional Engineer. The Dam Safety Officer will serve as the Chairman of the MSC Dam Safety Committee.

(2) Dam Safety Committee. The standing committee will include the Dam Safety Officer and Dam Safety Program Manager plus additional members as required. Recommended disciplines are:

(a) Project Operations and Maintenance
(b) Geotechnical Engineering/Engineering Geology
(c) Hydraulics and Hydrology
(d) Mechanical and Electrical Equipment
(e) Dam Construction

(f) Structural Engineering
(g) Program Management
(h) Security
(i) Emergency Management

Other disciplines and areas of expertise may be represented, as required by the Dam Safety Officer or Commander.

(3) Dam Safety Program Managers. Dam Safety Program Managers shall be registered professional engineers with knowledge and experience in the design and construction of dams. The MSC Dam Safety Program Manager shall report directly to the Dam Safety Officer.

b. Responsibilities. The MSC Dam Safety Officer is responsible for quality assurance, coordination, and implementation of the MSC dam safety program. In this capacity he must establish procedures to ensure that he is fully advised on all Dam safety issues. Quality assurance responsibilities include:

(1) Ensuring that the organization is staffed with qualified personnel for program implementation and to meet program requirements.

(2) Establishing dam safety related work priorities and ensuring that these priorities are addressed during budget development.

(3) Ensuring that an independent technical review is conducted for all features of dam projects. In technically complex cases, the analytical methods and processes used by the district are reviewed for adequacy and approval.

(4) Ensuring that adequate exploration and testing is accomplished in all stages of design and construction of water control projects.

(5) Ensuring that adequate performance monitoring and evaluations of all dams is conducted and documented.

(6) Ensuring that Emergency Action Plans are maintained and regularly updated.

(7) Establishing and monitoring a public awareness program and coordinating with state agencies as required.

(8) Ensuring that adequate dam safety training and dam safety exercises are being conducted.

(9) Ensuring that accurate data is submitted for the inventory of Corps dams.

(10) Monitoring and participating in dam safety exercises.

(11) Conducting quality assurance activities for all features of civil works dam projects, including review of district dam safety quality management plans.

(12) Participating in periodic inspections and field visits to ensure that the district programs are conducted in accordance with the district quality control plans and requirements of this regulation. The MSC should also verify that the district inspection team composition is appropriate for the project features, that members of the team are trained, and that the project has a current Emergency Action Plan.

(13) Reviewing and approving periodic inspection reports in accordance with this regulation.

(14) Monitoring the performance of District Dam Safety Programs including DSPMT, upward reporting, submitting data to HQ for NID and biennial report to Congress.

c. Coordination with District Commands. District Dam Safety Officers and Dam Safety Program Managers should be invited to MSC Dam Safety Committee meetings for interaction on regional dam safety issues. The MSC Dam Safety Committee should periodically meet at a district location.

3-4 District Commands.

a. Organization. The district Dam Safety Officer shall be a registered professional engineer and will generally be the chief of the engineering organization. The district Dam Safety Officer shall Chair the district Dam Safety Committee. The Dam Safety Program Manager shall also be a registered professional engineer with dam design and construction experience. The Dam Safety Program Manager shall report directly to the Dam Safety Officer. The dam safety committee includes the Dam Safety Officer, the Dam Safety Program Manager, and other district staff with extensive knowledge or expertise in the following areas:

(1) Project Operations and Maintenance
(2) Geotechnical Engineering/Engineering Geology
(3) Hydraulics and Hydrology
(4) Mechanical and Electrical Equipment
(5) Dam Construction
(6) Structural Engineering
(7) Program Management
(8) Security
(9) Emergency Management

Other disciplines or areas of expertise may be represented, as required.

b. Responsibilities. The district Dam Safety Officer is responsible for ensuring that the dam safety program is fully implemented. The Dam Safety Committee, advisory to the Dam Safety Officer, should meet at least twice annually and forward meeting minutes to the MSC. District responsibilities include, but are not limited to:

(1) Ensuring organizational staff of qualified technical and field personnel is sufficient for program implementation.

(2) Monitoring and evaluating the performance of all dams and appurtenant structures and recommending remedial measures when necessary. Data collection for the NID and biennial report to Congress. It is mandatory that the Dam Safety Program Management Tools (DSPMT) database be used for monitoring and reporting dam safety items. A description of the DSPMT database is given in Appendix E.

(3) Establishing priorities for dam safety related work. The Dam Safety Officer, as a member of the district Corporate Board, shall defend the list of dam safety work priority items. Dam safety work items are any work items impacting the safety and operation of the project.

(4) Ensuring that dam safety training of technical staff and project operation and maintenance personnel is conducted.

(5) Ensuring each dam has an adequate surveillance plan.

(6) Ensuring adequate independent technical reviews for dams and appurtenant structures are accomplished. The Dam Safety Officer shall certify that all design documents and periodic inspection reports have been subjected to an independent technical review and that the documents and reports are technically adequate.

(7) Ensuring that adequate exploration and testing are accomplished during design and construction of civil works water control projects.

(8) Performing periodic inspections, other inspections, and field visits. Periodically evaluating spillways, embankments and appurtenant structures of district water control projects using current criteria.

(9) Coordinating and participating with local and State dam safety officials in the inspection and evaluation of non-Federal dams, upon request.

(10) Ensuring that dam safety products are developed in accordance with documented district Project Management Business Processes. Quality Assurance/Quality Control shall be performed and certified.

(11) Monitoring the dam safety aspects of the district's Water Control Management Program.

(12) Monitoring and reporting any evidence of operational restrictions or distress, including earthquake effects, of dams and appurtenant structures.

(13) Ensuring each dam owned by the district has an up-to-date Emergency Action Plan in accordance with Chapter 11 of this ER. The district shall ensure that annual coordination and review is accomplished, including review of Emergency Notification Procedures. Emergency Action Plans should be distributed to and coordinated with all affected local agencies to use as a basis for preparing their Evacuation Plans. The district shall identify and contact appropriate State or local officials to suggest that evacuation plans be developed in accordance with Chapter 11 of this regulation and ER 1130-2-530, *Flood Control Operations and Maintenance Policies*, reference 30.

(14) Establishing dam safety public awareness programs and coordinating them with local interests. The district shall maintain emergency notification procedures for utilization in a dam safety emergency situation and for use during dam safety exercises. Public awareness programs should also be established for all types of levees and water control facilities.

(15) Overseeing all security related activities, issues, and initiatives at dams and related structures to ensure that projects are secure from outside interference.

(16) Monitoring ongoing planning, design, and construction of project modifications for dam safety for adequate funding, and ensuring that they are executed in accordance with this ER or other applicable regulations.

(17) Coordinating with City, County, and State dam safety officials concerning their review requirements for projects initiating the design phase. Ensuring completed projects are properly turned over to the local project sponsor with a complete set of project documentation.

(18) Reviewing proposed design changes to district water control projects under construction and providing dam safety input at design change meetings.

(19) Ensuring that all completed water control projects have a complete set of project documentation including: Water Control Manual; Operations, Maintenance, Repair, Rehabilitation and Replacement Manual; Embankment Performance and Criteria Report; Foundation Report; Concrete Materials Report; Emergency Action Plan; As-Built Drawings; and Initial Reservoir Filling Plan. On new projects the Project Geotechnical and Concrete Materials Completion Report replaces the Embankment Criteria and Performance Report, the Foundation Report, and the Concrete Materials Report.

(20) Ensuring that the district has an up-to-date Dam Safety Quality Management Plan, that each dam safety related report or design has a Quality Control Plan and that the final product is certified with a Quality Control Certificate upon completion.

3-5 Professional Registration. It is intended and desirable that the Dam Safety Program Manager at every level be a registered professional engineer. However, the Dam Safety Officer may approve the selection of a highly qualified registered professional geologist as the Dam Safety Program Manager when filling the position. Persons holding Dam Safety Program Manager positions at the time this regulation takes effect may continue in the position until they move to another position or retire.

CHAPTER 4

Planning and Design Process

4-1 General.

The civil works planning and design process for a new dam or for modification of an existing facility is continuous, although the level of technical detail varies with the progression through the different phases of project development and implementation. The phases of the process are reconnaissance, feasibility, pre-construction engineering and design (PED), construction, and finally operation, maintenance, repair, replacement and rehabilitation (OMRR&R). Detailed guidance on each phase is given in ER 1110-2-1150, *Engineering and Design of Civil Works Projects*, reference 23. This regulation only concerns issues and activities related to dam safety.

4-2 Dam Safety During the Planning Phase.

During the reconnaissance phase all Design Documentation Reports (DDR's), manuals and reports, including the EAP, Reservoir Control Report, and post-construction documentation of foundation, materials, and construction should be identified, scheduled, and resourced in coordination between the planning staff and the Dam Safety Officer or his representatives. During the feasibility phase the project OMRR&R and dam safety requirements must be discussed with the sponsor and State. The local sponsor shall be informed that they will be expected to comply with all State and Federal dam safety requirements. A turnover plan for non-Federally operated dams must be prepared to establish definite turnover criteria or date to the sponsor and to identify funding for the first Periodic Inspection. This information shall be documented in the Project Management Plan (PMP) and in the Feasibility Report (Appendix D). Guidance on policy and procedures for the turnover of completed dam projects to local sponsors is given in Policy Guidance Letter No. 39, *Responsibilities of the Corps of Engineers and Local Sponsor to Ensure Safe Operation, Maintenance, Repair, Replacement and Rehabilitation for Flood Control and Multipurpose Dams Constructed Under the Provisions of PL 99-662*, reference 50. When the Project Cooperation Agreement is developed during the feasibility phase, the Dam Safety Officer or his representative shall ensure that dam safety requirements are included in the agreement.

4-3 Dam Safety During the Design Phase.

During the design phase the Dam Safety Officer, or his representative, shall ensure that the design criteria includes the most current dam safety requirements and that the design is properly documented for the project records. Based on experience with existing dams, specific areas of dam safety concerns during the design phase include the following items.

a. A policy of public safety awareness shall be adhered to in all phases of design and operation of dam and lake projects to assure adequate security for the general public in downstream areas.

b. A real estate interest is required in downstream areas where a spillway discharge would create or significantly increase a potentially hazardous condition. Specific guidance on

this issue is found in Chapter 14 - Acquisition of Lands Downstream From Spillways for Hydrologic Safety Purposes.

c. In 1975 a policy was established that all future lakes impounded by Civil Works projects would be provided with low-level discharge facilities capable of lowering the reservoir pool to a safe level within a reasonable time. This feature provides capability for safely responding to unanticipated needs such as repair or major rehabilitation for dam safety purposes. Specific guidance on this issue is found in Chapter 13 - Low Level Discharge Facilities for Drawdown of Impoundments.

d. An adequate instrumentation and monitoring system is required by the "Federal Guidelines for Dam Safety" as well as by good engineering practice. The purposes of the instrumentation are fourfold, to (1) provide data to validate design assumptions, (2) provide information on the continuing behavior of the water control structure, (3) observe the performance of critical known features, and (4) advance the state-of-the-art of dam engineering. The rationale for the instrumentation shall be thoroughly documented. Although the monitoring system is expected to evolve commensurate with the observed performance of the dam, and develop with the history and experience of the project, an initial system shall be designed and constructed to provide a background of data during initial reservoir filling, sufficient to identify problems and to verify design assumptions. Flexibility shall be provided in the program to allow for changes from anticipated foundation conditions that are encountered during construction and/or operations. Specific guidance on design of instrumentation and monitoring systems is given in Chapter 7 - Instrumentation for Safety Evaluations of Civil Works Projects.

e. The Initial Filling Plan shall be prepared and documented in a Design Documentation Report.

f. During the construction phase the operation and maintenance manuals shall be developed, including the Water Control Plan and the Emergency Action Plan (EAP). Specific guidance for preparation of the EAP is given in ER 1130-2-530, *Flood Control Operations and Maintenance Policies*, reference 30, and in Chapter 11 of this ER.

CHAPTER 5

Construction, Operation, and Maintenance Activities

5-1 General.

Because significant design changes may occur during construction, it is imperative that the project construction phase be properly documented and that the key designers remain a significant part of the Project Delivery Team until construction is completed. The transition from construction to operation may consist of overlapping activities. Therefore, it is very important that problems encountered during construction be adequately accommodated prior to the operational phase. Rigorous and continuous vigilance, checking, and inspection, for as long as the dam is operational, are necessary for dam safety as problems may occur following many years of trouble-free operation. This is particularly true for untested flood control dams where a significant percentage of the maximum head has not occurred. (James 1990, reference 43; International Commission on Large Dams 1987, reference 42; Morrison-Knudsen Engineers 1986, reference 47; Schurer 1988, reference 53). Operations and maintenance policies for flood control operations are covered in ER 1130-2-530, *Flood Control Operations and Maintenance Policies,* reference 30.

5-2 Operation and Maintenance Manual.

The Operation and Maintenance (O&M) manual provides guidance and instructions to project personnel for proper operation and maintenance of the facility. The O&M manual contains a narrative summary of the critical dam features including design features with safety limits, equipment operating and testing procedures, instrumentation requirements, probable failure modes, a history of problems, and how those problems could adversely affect the structure under stress. The O&M manual shall be prepared during the construction phase and shall be updated as features are added to the project or when equipment is replaced.

5-3 Project Geotechnical and Concrete Materials Completion Report for Major USACE Projects.

ER 1110-1-1901, *Project Geotechnical and Concrete Materials Completion Report for Major USACE Projects,* reference 18, requires, as part of the permanent project record, documentation of the as-constructed geotechnical and concrete materials aspects of all major, complex and unique engineered projects constructed by USACE, including all subsequent modifications. This report, replacing the Foundation Report, the Embankment Criteria and Performance Report, and the Concrete Materials Report, will be a part of the Project Management Plan (PMP). The information and data in this document shall be presented and discussed with the sponsor/owner. The report provides, in a single document, the significant information needed by the sponsor, USACE technical staff and other team members to become familiar with the project. The report will facilitate accurate, timely inspections and performance evaluations, and serve as the basis for developing and implementing appropriate, effective modifications, “flood fighting” efforts,

and emergency and/or remedial actions to prevent flood damage or required as a result of unsatisfactory performance (ER 1110-1-1901).

5-4 Instrumentation and Monitoring.

All USACE dams and other water control facilities are required to have a level of instrumentation that enables proper monitoring and evaluation of the structure during the construction period and under all operating conditions. Instrumentation systems are also expected to furnish data on structural behavior for application to future designs. Each structure must have instrumentation to measure hydrostatic pressure, embankment seepage, foundation underseepage, and displacement of major elements of the structure. Strong motion accelerometers are to be installed in structures located in designated seismic regions. After a project is operational for several years, scheduled maintenance, repair, and replacement of instrumentation shall be part of the normal plan of operation. Instrumentation shall be properly maintained or replaced, as necessary, in order to obtain accurate readings. Readings shall be made at scheduled frequency and shall be properly recorded and analyzed. Detailed information on instrumentation for earth and rockfill dams is given in EM 1110-2-2300, reference 9, and EM 1110-2-1908, reference 6. Information on instrumentation for concrete dams is given in EM 1110-2-2200, reference 8, and EM 1110-2-4300, reference 10. Full reliance shall not be placed on instrumentation alone to forecast performance since it is impossible to install sufficient instrumentation to monitor every possible problem area. An extremely important part of the monitoring program is visual observation to determine evidence of distress and unsatisfactory performance (Duscha 1982, reference 2). Project personnel must receive training in basic engineering considerations pertaining to major structures, with procedures for surveillance, monitoring, and reporting of potential problems, and with procedures for emergency operations.

5-5 Initial Reservoir Filling.

a. General. Reservoir filling is defined as a deliberate impoundment to meet project purposes and is a continuing process as successively higher pools are attained for flood control projects. The initial reservoir filling is the first test of the dam to perform its design function. To monitor this performance, the filling rate should be controlled to the extent feasible, to allow time needed for a predetermined surveillance program, including the observation and analysis of instrumentation data (Duscha and Jansen 1988, reference 3). A plan for initial reservoir filling has been required for all new Corps of Engineers reservoir projects since 1979. 2, *Initial Reservoir Filling*, reference 33, provides guidance for use in preparing the plan.

b. Design Documentation Report (DDR). As a minimum, the documentation on initial reservoir filling will include:

(1) The preferred filling rate and the available options to control the rate of reservoir rise.

(2) The surveillance necessary to detect most likely occurring problems.

(3) A plan for reading the instruments and evaluating the data.

(4) A plan for inspecting the dam and downstream areas.

(5) Instructions for observers on conditions or instrumentation readings requiring immediate attention of personnel authorized to make emergency decisions.

(6) An emergency plan listing responsibilities, name and/or positions, telephone numbers, and radio frequencies to be used (as appropriate).

c. Existing Corps Reservoir Projects. Existing operational projects, where the maximum pool (top of flood control pool) has not been experienced, shall be reviewed for compliance with requirements as outlined in paragraph 5-5b. For those conditions where contingency plans have not been documented and potential danger exists due to filling and/or impounded storage, a report is required outlining those plans. The document may be titled "Surveillance Plan" providing that additional initial filling requirements are deemed not to have significant potential impacts on the safety of the structure.

5-6 Reporting Distress.

a. General. Evidence of distress shall be immediately reported to the district Dam Safety Officer. If an engineering evaluation of the evidence of distress indicates the need for immediate remedial action, the Dam Safety Officer shall immediately report such conditions through command channels to the USACE Dam Safety Officer. The USACE Dam Safety Officer shall notify the Director of Civil Works and the Commander, USACE if necessary.

b. Procedures. When evidence of distress is reported to the district Dam Safety Officer, he will confirm the situation and determine if an engineering evaluation of the condition is needed or remedial measures are required. Initial notification shall be made by telephone to the MSC Dam Safety Officer and at HQUSACE. A written summary and appropriate photographs shall follow the initial notification. An after action report shall be made and may be sent by email. A post distress inspection shall be performed to evaluate damages or changes caused by any event listed in the following subparagraph. If the distress is significant enough to require operational restrictions, the implementation of restrictions shall be reported as well. If the USACE Dam Safety Officer cannot be contacted, the reporting office shall follow the notification sequence shown in HQUSACE Notification Plan.

c. Evidence of Distress. Typical evidence of distress to report are:

(1) Sloughs, settlement, or slides in embankments such as earth or rockfill dams, urban levees, and bridge abutments or slopes, spillway slopes or channels, and lock and dam abutments.

(2) Evidence of piping or muddy water boils in the area of a structure such as embankments, abutments, dam monoliths, lock walls, or cofferdams.

(3) Abnormal increases or decreases of flow from foundation drains, structural joints, or face drains of concrete dams.

(4) Any significant increases in seepage quantities through or under embankments or abutments.

(5) Any significant change in pore-water pressure in either embankments or their foundations or abutments.

(6) Any significant change in uplift pressures under concrete structures.

(7) Unusual vertical or horizontal movement or cracking of embankments or abutments.

(8) Significant cracking of mass concrete structures, either during construction or after completion.

(9) Sinkholes or localized subsidence in the foundation of, or adjacent to, embankments or other pertinent structures critical to the safe operation of the project.

(10) Excessive deflection, displacement, or vibration of concrete structures (e.g., tilting or sliding of intake towers, bridge piers, lock walls, or floodwalls).

(11) Erratic movement, binding, excessive deflection, or vibration of outlet and spillway gates and large flow control devices.

(12) Significant damage to any structure (e.g., barge damage to bridge piers or lock walls or ice flow damage to intake towers and access bridge piers).

(13) Significant damage to, or changes in, structures, foundations, reservoir levels, groundwater conditions, and adjacent terrain as a result of seismic events. Special inspections for damages shall be made immediately following the event as described in ER 1110-2-1802, *Reporting Earthquake Effects*, reference 25.

(14) Excessive vibration, binding, unusual noises, movements, or deflections of gate hoist operating equipment.

(15) Actual hydraulic equipment operating pressure in excess of 125 percent of the normal operating pressure. Electric motor operating equipment overheating or stalling.

(16) Erratic movement or unusual sounds, such as bumping, jumping, or popping of lock miter gates.

(17) Wire lifting cables or lifting chains having broken strands or deformed, worn, or severely corroded links.

(18) Frequent power interruptions.

(19) Excess movement of penstock flexible couplings.

(20) Penstocks or turbine spiral cases that show signs of distress such as deformation or cracking.

(21) Failure of major mechanical or electrical equipment at local flood protection projects or locks and dams.

(22) Any other indications of distress or potential failure that could inhibit the operation of a project or endanger life and property.

d. HQUSACE Notification Plan. The notification plan is published electronically with copies to all Dam Safety Officers and Dam Safety Program Managers. It will be updated each January, or as needed, to ensure that names and telephone numbers are current and accurate. If the notification plan is not available, the HQUSACE Operations Center should be notified at (202) 761-1001.

5-7 Dam Safety Training.

The "Federal Guidelines for Dam Safety" requires that field office employees be trained in problem detection, evaluation, and appropriate remedial (emergency and non-emergency) measures. The district Dam Safety Officer must ensure that a sufficient number of personnel are trained to assure adequate coverage at all times. ER 1130-2-530, reference 30, provides specific guidance on dam safety training requirements for operations and maintenance personnel and contractors at high hazard potential dams. All new field employees and field contractor personnel shall have a minimum of 6 hours training shortly after starting duty and at least 6 hours refresher training every four years. All formal training shall be documented. Chapter 12 of this ER provides additional detail on the various types of dam safety training available.

5-8 Modifications to Completed Projects.

In general, modifications to completed projects may be made under existing authority for changes in: project operation, real estate interest, physical alteration of a project feature, the addition of project features, or changes in the purposes of a project. However, if the modification serves new purposes or increases the scope of services beyond that intended at the time of authorization, or to extend services to new beneficiaries, the modification requires reauthorization by Congress. Specific guidance on modification to completed projects is found in Chapter 10- Modifications to Existing Projects. All modifications (including those for environmental or other purposes) must be evaluated to ensure there are no adverse impacts to project performance, and must be approved by the Dam Safety Officer. Modifications to projects shall be incorporated into the Project Geotechnical and Concrete Materials Completion Report in accordance with the provisions of ER 1110-1-1901, reference 18.

5-9 Rehabilitation of Dams for Dam Safety.

Rehabilitation or modification of Corps of Engineers dams for qualifying dam safety purposes is accomplished through the Major Rehabilitation Program and the Dam Safety Assurance

Program. Repairs and modifications not applicable to these programs shall be accomplished under the Operations and Maintenance program.

a. Dam Safety Assurance Program. The Dam Safety Assurance Program provides special cost sharing in accordance with Section 1203 of Water Resources Development Act of 1986 for modification of completed Corps of Engineer dams to eliminate certain safety concerns related to hydrologic and seismic deficiencies. Chapter 8 of this ER provides guidance on the Dam Safety Assurance Program.

b. Major Rehabilitation Program. The Major Rehabilitation Program is designed to accomplish significant, costly, one-time structural rehabilitation or major replacement work (other repairs related to dam safety are accomplished under the normal Operation and Maintenance program or the Dam Safety Assurance Program). The Major Rehabilitation Program restores the project to its original condition to serve as originally intended. Modifications to improve project operation efficiency can also be accomplished under this program. Non-emergency repairs of stability and seepage are applicable under this program. Specific requirements for this program are found in Chapter 9 - Major Rehabilitation Program.

c. Operations and Maintenance Program. Normal repair and rehabilitation work that does not qualify for funding under either the Dam Safety Assurance Program or the Major Rehabilitation Program will be funded under the regular O&M Program. Work recommended in the Periodic Inspection Report shall be prioritized and funded through this program unless qualifying under another program.

CHAPTER 6

Periodic Inspection and Continuing Evaluation

6-1 Policy.

a. Civil Works structures whose failure or partial failure could result in loss of life or major damage to permanent structures, utilities, or transportation facilities shall be periodically inspected and evaluated to ensure structural stability, safety, and operational adequacy. This policy is to be accomplished as follows:

(1) Inspections and evaluations shall be supported by appropriate instrumentation programs that provide timeliness and level of accuracy needed for evaluations under all operating conditions. During periods when a reservoir is or is expected to be above the maximum pool of record or above a threshold level established from past performance, an appropriate team shall be dispatched to monitor and evaluate performance and verify the adequacy of flood and outlet control gates and other equipment, which facilitates downstream releases. A report of performance outlining the findings and evaluation shall be prepared and documented in a memorandum for record (MFR) with copy furnished to the MSC for information within 30 days after the event. Special inspections shall be performed during and immediately after any unusual loading events. Evaluation reports shall provide a basis for initiating timely remedial or rehabilitation measures.

(2) The operating entity is responsible for periodic inspections and evaluations (after the first periodic inspection) of facilities constructed by the Corps and turned over to others for operation and maintenance. The Corps may conduct subsequent inspections and write a report on behalf of the Project Sponsor, provided appropriate procedural and financial reimbursement arrangements are made. Inspections will be conducted in accordance with appropriate guidance contained in the operation and maintenance manual for the facility and in accordance with applicable portions of this document. In addition, any inspection responsibilities established by the Project Cooperation Agreement (PCA) will be related to the operating entity at the time of their acceptance of the structure. Dams built by the Corps and turned over to others for Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) shall include in the Operation and Maintenance (O&M) manual a requirement for the Corps to conduct the first and second inspections and/or first filling inspection in accordance with this regulation. These inspections are to ensure design/construction quality. See ETL 1110-2-231, reference 32, for the initial reservoir filling and surveillance plan. The Corps is responsible for the first periodic inspection. See Policy Guidance Letter No. 39, dated 13 November 1992, 51, for Corps and sponsor responsibilities.

(3) Under the authority of ER 1130-2-530, reference 30, the Corps, at Federal expense, will participate in inspections of a sponsor operated and maintained structure (e.g., local flood protection project) to assure that the structure is conforming to the requirements of the PCA, the agreed upon inspection program, and the operation and maintenance program.

(4) In cases where ownership of major elements of a project are divided between the Corps and other organizations, private sector (e.g. power plants), government or municipal, the Corps will inspect those features of non-Corps elements that could adversely affect the stability, safety, or operational adequacy of the Corps-owned portion of the project, and includes features not constructed by the Corps.

(5) Non-Federal dams located upstream of a Corps project may potentially affect the safety of the Corps project. When inspecting a Corps structure or project it may be appropriate to evaluate the safety of the upstream non-Federal dam(s) and to ascertain operational procedures or emergency situations that could make excessive demands on a Corps project. When failure of an upstream non-Federal structure would cause overtopping or other major damage to the Corps project, the Corps shall obtain and review the current comprehensive inspection report, such as a Federal Energy Regulatory Commission (FERC) or State Dam Safety Agency report for the respective structure. If the non-Federal project has not been inspected in the last five years, the Corps shall coordinate with the owner and the regulatory authority to have the dam inspected. Every effort should be made to encourage owners of such projects to comply with the inspection requirements in the Model State Dam Safety Program (FEMA Publication XXX).

(6) Federally owned dams (non-Corps) on a military installation may have a substantial bearing on the safety of life and endanger downstream property. The Corps, on request of the installation, may inspect these dams on a cost reimbursable basis. This policy extends to non-Federally owned dams on a military installation where the safety of life and Federal property are in jeopardy from a failure. These inspections shall be performed and documented in the same manner as the inspections of Corps dams, except that the reports should be forwarded to the Installation Support Agency.

b. It is essential that the Corps maintain institutional knowledge and technical expertise in the disciplines related to dam design and safety. An important component of this knowledge is gained by conducting periodic inspections and evaluations by district and MSC engineering, construction, and operations personnel. Lessons learned by multi-disciplinary inspection teams over a long period of observations and analyses could be applied to the design, construction, operation, and maintenance of existing and future projects. Districts are responsible for all decisions made as a result of the inspection program; therefore the periodic inspections of significant and high hazard potential structures shall not be contracted. Where manpower constraints exist, inspections may be augmented, in order of preference, by use of Corps of Engineers personnel from other districts, or other MSC's, on a fully reimbursable basis; or by contracting for qualified personnel as inspection participants and/or for specialized functions, such as underwater diving or camera work, or other tasks requiring special skills or equipment not available in the district. Care must be taken to maintain in-house capability for the on-site conduct of the program and continue to keep the involved disciplines (design, construction, and operations personnel) fully integrated in project inspections. This does not imply the necessity for maintaining all technical disciplines in all districts.

6-2 Program Implementation.

A Periodic (comprehensive) Inspection schedule will be established based on the project size,

importance, or its hazard potential. Other inspections, including intermediate, informal, and annual inspections, should be conducted between Periodic Inspections. MSC commanders are responsible for program management and oversight. District commanders are responsible to implement the inspections.

a. Frequency of Inspections. Inspections of all water control facilities shall be conducted as outlined below:

(1) Dams and Appurtenant Structures. The guidance for developing the interval for inspections of dams, navigation structures, and appurtenant structures set forth in the following subparagraphs does not preclude other inspection intervals as the situation or structural integrity warrants. Nor does this guidance preclude the surveillance plan for the initial filling of Corps reservoirs as prescribed by ER 1110-2-1150 and ETL 1110-2-231.

(a) Initial Periodic Inspection. The first periodic inspection and evaluation of a new earth or rock-fill dam shall be carried out immediately after topping out the embankment and prior to impoundment of the pool. The initial inspection of concrete dams shall be accomplished immediately prior to impoundment of reservoir water. However, if involuntary impoundment occurs before the first inspection of either an embankment dam or a concrete dam is accomplished, the inspection shall be performed at that time.

(b) Second Periodic Inspection. The second inspection for new earth or rock-fill dams shall be made at a reasonable stage of the normal operating pool. For concrete dams an inspection shall be performed at the normal operating pool, or no later than one year after impoundment is initiated.

(c) Subsequent Periodic Inspections. Subsequent inspections for concrete structures, and earth or rock-fill dams and embankments will be performed at one-year intervals for the next two years. The next two inspections will occur at two-year intervals and then be extended to a maximum interval of five-years. Inspection intervals more frequent than indicated above shall be scheduled, if conditions warrant, as approved by the District Dam Safety Officer.

(d) Intermediate Inspections. For projects on a five-year inspection cycle, an intermediate inspection of all or some of the features may be scheduled, if warranted. Selection shall be based on consequences of failure, age, degree of routine observation, a natural event such as an earthquake, performance record and history of remedial measures. Intermediate inspections shall also be made of any portion of a project exposed during dewatering that could not be accomplished during the scheduled periodic inspection and shall include special inspections as described in paragraph 6-2 a (1) above. A summary of the findings from intermediate inspections is to be included in the next periodic inspection report.

(e) Informal Inspections. Appropriate employees at the project shall make frequent observations of the dam and appurtenant structures. The purpose is to identify and report abnormal conditions and evidence of distress in accordance with training instructions and guidance. Any unusual conditions that seem critical or dangerous shall be reported immediately

using proper procedures and channels, as required by Chapter 5, paragraph 5-6, of this regulation.

(2) Navigation Structures. The guidance for developing inspection intervals for dams with locks, set forth in the following subparagraphs differs from flood control dams because of the levels of risk involved. Normally the risk of a navigation dam failure is an economic consequence from loss of the navigation pool, and not the risks to human life in downstream communities. This guidance does not preclude other intervals of inspection as the situation or structural integrity warrants.

(a) Initial Periodic Inspection. The initial periodic inspection of navigation projects shall be made immediately prior to flooding of cofferdams, culverts or chambers.

(b) Second Periodic Inspection. A second inspection of new or major-rehabilitated navigation projects shall be made no later than one year after the new operating pool has been attained.

(c) Subsequent Periodic Inspections. Subsequent inspections are not to exceed five years, without obtaining prior approval of the USACE Dam Safety Officer.

(d) Intermediate Inspections. Intermediate inspections shall be performed for any portion of a project exposed during dewatering that could not be accomplished during the scheduled periodic inspection. The intermediate inspection reports shall be included in the next periodic inspection report.

(3) Other Structures. The district is responsible for establishing periodic inspection intervals, not to exceed five years, for other Corps-Owned and Operated Structures, including, but not limited to, major levees, floodwalls, channels, pumping stations, and conduits. Inspection intervals must be defined in the project Operation and Maintenance (O&M) manual. Projects designed and constructed by the Corps, but operated and maintained by the sponsor, will also have inspection intervals defined in the O&M manual.

(4) Hydraulic Steel Structures (HSS). ER 1110-2-8157, *Responsibility for Hydraulic Steel Structures*, reference 28, requires fracture critical members to be inspected every five years and that all HSS be inspected every 25 years, even if dewatering is required. Hydraulic Steel Structures include lock gates, dam spillway gates, tainter valves, flood protection gates, stoplogs, bulkheads, and lifting beams used for installing other Hydraulic Steel Structures.

(5) Stilling basins. When feasible, stilling basins should be dewatered for inspection for each five-year Periodic Inspection if there have been significant releases through the stilling basin and potential damage or wear is suspected. If no significant releases through the stilling basin have occurred, and there is no suspicion of damage or wear, the dewatering may be deferred until the next five-year Periodic Inspection. The district Dam safety Officer may require a diver inspection or hydro-acoustic survey to verify that there is no significant debris in the basin or damage to the structure. When stilling basins cannot feasibly be dewatered, except for emergency repairs, diver inspections or hydro-acoustic surveys shall be performed at five-

year intervals and soundings taken each year. Significant releases are those sustained for more than two weeks resulting from pools filling more than 25 percent of the flood storage.

b. Report. A formal technical report of inspection, entitled (project name) Project, Periodic Inspection Report (number of report), shall be prepared for permanent record and for reference for needed remedial work for all periodic inspections. This report shall be based on a detailed, systematic technical inspection and evaluation of each structure and its individual components regarding its safety, stability, structural integrity and operational adequacy. Intermediate inspection reports shall be included in an appendix. See Appendix F for report content and format.

(1) Inspections or routine observations indicating that the safety of a structure is in jeopardy shall be reported in accordance with Chapter 5, paragraph 5-6, of this regulation.

(2) Inspections indicating necessity for project modifications, major repairs, rehabilitation, replacement or need for further study beyond the scope of normal maintenance shall be reported to the MSC Dam Safety Officer in the memorandum transmitting the report. Inspection reports of conditions requiring major modification shall contain a statement as to whether studies will be pursued under authority of the Major Rehabilitation Program, or the Dam Safety Assurance Program.

(3) A draft of the Executive Summary shall be sent to USACE Dam Safety Officer and the MSC Dam Safety Officer by e-mail within 90 days of completion of the formal inspection. See Appendix F of this regulation for information on preparing and submitting the Executive Summary. The final version of the Executive Summary shall be entered into the Dam Safety Program Management Tools (DSPMT) database.

c. Report Completion and Submittal Schedule. At least two copies of the certified periodic inspection report, including independent technical review, are to be submitted by the district to the MSC Dam Safety Officer within 150 days after the inspection. The district shall establish completion and tracking standards for the review of periodic inspection and evaluation reports. The submission shall include a summary of the satisfactory resolution to all review comments. The District Dam Safety Officer shall certify the independent technical review and the inspection report prior to submittal to the MSC Dam Safety Officer. Reports Control Symbol (RCS) is exempt based on AR 335-15, paragraph 5-2e(8).

d. Report Approval. The MSC Dam Safety Officer is responsible for approval of the inspection report.

e. Annual MSC Program Report. Each MSC must submit annually (1 Nov) a report to the USACE Dam Safety Officer summarizing all periodic inspections accomplished in the fiscal year just ended to report major recommended repairs, including estimated cost and schedule. The report should also describe all periodic inspections that were not accomplished as required by this regulation with the reason why the inspection was not accomplished. Since the MSC is responsible for quality assurance of all periodic inspections, each MSC shall require the districts to establish appropriate quality control inspection procedures that shall be approved by the MSC.

The MSC should provide technical representation on all periodic inspections of high and significant hazard potential water control structures. The MSC Dam Safety Officer or Dam Safety Program Manager should personally accompany the inspection team on at least one inspection per district annually to evaluate the districts implementation of their quality control procedures.

f. Obligation to Others. In cases where ownership of major elements is divided between the Corps and others, information pertinent to the condition of project elements owned by others, as observed by the Corps inspection team, shall be furnished to the co-owner. The district Dam Safety Officer will furnish this information to the FERC, when hydro-electric power projects are under the purview of the Federal Power Act (41 Stat. 1063, U.S.C. 791-823) 10 June 1920, as amended (FPA). Owners of such FERC licensed facilities shall be advised that the information made available by the Corps will not be presented as representing results of inspections performed for the licensee by the Corps and is not a substitute for the FERC inspection under the FPA.

6-3 Instrumentation.

Instrumentation, essential in evaluating project performance, will be incorporated in the project structures as appropriate to measure and monitor forces, pressures, loads, stresses, displacement, alignment, plumb and other conditions related to monitoring the structural safety and stability (see Chapter 7 for more information).

6-4 Responsibilities.

a. The district Dam Safety Officer shall be responsible for:

(1) Formulating the inspection plans, conducting the inspections, processing and analyzing the results of the instrument observations, evaluating the condition of the structures, recommending the schedule of the next inspection, and preparing and submitting the periodic inspection and evaluation reports.

(2) Preparing an annual report, which summarizes the periodic inspection and evaluation program for the 12-month period ending 30 September. The report shall include the number, type and list of structures inspected and district cost of inspections including reports, average cost of inspections, status of reports being prepared, and a brief narrative on the major findings of both full periodic inspections and evaluations and interim inspections. This report shall also include the five-year inspection plan. Contract costs shall be included in the report for inspections augmented by contracted services. The report shall be submitted to the MSC Dam Safety Officer by 31 October.

(3) Coordinating with the district Operations and Programs & Project Management (PPM) Divisions to ensure sufficient funding for inspections and remedial measures is budgeted in the Operations and Maintenance, General budget**,** prioritizing recommended remedial measures as necessary.

(4) Notifying Operations Division personnel of scheduled inspections and requesting their assistance and participation. For projects or structures being inspected for the first time, personnel from the Construction Division shall be invited to participate. The appropriate State Dam Safety official(s) shall be invited to attend the inspection. If hydropower is a feature of the project and the project is licensed by FERC, FERC and the licensee shall be invited. The district Operations Division Chief should ensure that the project staff is prepared during the periodic inspection to operate those project components whose failure to operate properly could impair the operational capability and/or usability of the structure. Where the operation of these components is vital to the safe operation of the project under emergency conditions, the components shall be operated using emergency power to assure the inspection team that all critical project features will function under emergency conditions or in the absence of the normal source of power. Testing of the emergency power source shall require, if possible, the maximum power demand expected under emergency conditions. Additional details and requirements are described in Appendix F.

(5) Forwarding the approved periodic inspection and evaluation report to the district Operations Division for implementation of recommendations. The Dam Safety Officer shall coordinate with Programs and Project Management (PPMD) and Operations Divisions to develop schedule and funding prioritization.

(6) Ensuring the inspection team is comprised of expertise necessary to execute a thorough and technically sound inspection. Lacking district expertise the Dam Safety Officer should obtain assistance from HQUSACE, MSC, other FOA's, or by contract. HQUSACE personnel will not normally participate in inspections unless requested or when project conditions dictate. See Appendix F for further details.

(7) Maintaining assurances that sponsors with OMRR&R responsibilities are performing as required under the PCA agreements.

(8) Ensuring all recommendations made in the inspection report are resolved.

b. The District Operations Division shall be responsible for:

(1) Accompanying the inspection team on the inspection and providing the support required for the inspection.

(2) Performing required preliminary inspections, such as Gate Operability and Capability Inspections, and furnishing completed reports to the inspection team.

(3) Acting on inspection recommendations in a timely manner in accordance with the deficiency classification table timeline in Appendix F.

(4) Completing an annual inspection of all water control projects.

c. The Programs and Project Management Division shall be responsible for supporting the program with proper funding and coordinate and cooperate with the project sponsor as needed.

d. The MSC Dam Safety Officer shall provide quality assurance, oversight and management for this program. As a minimum, the MSC Dam Safety Officer shall:

(1) Provide representation at the first and second periodic inspections, the inspection of high hazard potential structures, and the inspection of structures whose condition or performance has warranted more frequent attention.

(2) Provide oversight for the monitoring of data collection, processing, evaluation, and inspection activity.

(3) Retain approval authority for the frequency and scope of future inspections, and maintain the inspection schedule. Inspection intervals in excess of 5 years require written request and approval by USACE Dam Safety Officer

(4) Establish and maintain an MSC regional database using DSPMT to include periodic inspection schedules and history of project remedial measures, unless this information is otherwise recorded in an official database. The history of remedial measures implemented by hired labor or contract shall include such items as project deficiencies, status of deficiencies, completion status and dates, estimates and actual expenditures, funding sources, priority levels, responsible elements, and report number.

6-5 Program Review.

At the end of each fiscal year, the district Dam Safety Officer shall review and set priorities for the recommended remedial actions for the next budget submission. The Dam Safety Officer shall present the prioritized list to the district Corporate Board for implementation.

6-6 Reporting Distress.

Refer to Chapter 5, paragraph 5-6, of this regulation for procedures when reporting evidence of distress.

6-7 Funding.

Periodic inspection reports shall be funded from the district's fiscal year allocation for project operation and maintenance. Costs incurred by Headquarters and MSC’s will be funded from the General Expense appropriation.

a. Funding for the inspection and evaluation program during the period of construction shall be under Cost Code 51, Appropriation 96X3122, Construction, General. The term "period of construction" is defined as the period from the issuance of the solicitation for the first construction contract to the date the District Engineer notifies the sponsor in writing of the

government's determination that construction is complete; or, to the date the Government takes beneficial occupancy (for solely Corps-retained projects).

b. Funding for the inspection and evaluation program after the project components are placed in operation shall be under Appropriation 96X3123, Operation and Maintenance, General.

CHAPTER 7

Instrumentation for Safety Evaluations of Civil Works Structures

7-1 Policy.

All Civil Works water control projects shall have an adequate level of instrumentation to enable design engineers to monitor and evaluate the safe performance of the structures during the construction period and under all operating conditions. The term "project" includes all dams, appurtenant structures, facilities, levees and any other structure whose failure or malfunction would cause loss of life or severe property damage. The district Dam Safety Officer in coordination with the MSC Dam Safety Officer shall ensure that an appropriate level of instrumentation exists at each project, that adequate maintenance is programmed, that sufficient effort and funding is devoted to the program, that timely reduction, interpretation and evaluation of the data occurs and that the technical level of performance evaluation is adequate.

7-2 General.

The planning, design and layout of an instrumentation program is an integral part of the project design. Instrumentation data is an extremely valuable asset that supplies an insight into the actual behavior of the structure relative to design intent for all operating conditions, establishes performance that is uniquely characteristic to the structure, and provides a basis for predicting future behavior. As structures age and new design criteria are developed, the historical data provides much of the information necessary to evaluate the safety of the structure with respect to current standards and criteria. Older structures may require additional instrumentation to gain a satisfactory level of confidence in assessing safe performance. Instrumentation data can be of benefit only if the instruments consistently function reliably and the data values are compared to the documented design limits and historical behavior. Automation of dam safety instrumentation is a proven, reliable approach to obtaining instrumentation data and other related condition information. Automation offers a feasible alternative to obtaining routine data that may not otherwise be obtained due to resource constraints. Automation can also be helpful with investigating and analyzing performance conditions that require frequent, timely and accurate information that cannot be accomplished manually. Assistance is available through ER 1110-1-8158, *Corps-Wide Centers of Expertise Program,* reference 19.

7-3 Planning.

a. The design and construction of new projects as well as the rehabilitation, dam safety modifications and normal maintenance of older projects present opportunities to prepare for the future engineering analyses of structural performance. Careful attention and detail shall be incorporated into the planning of instrumentation systems and programs to ensure that the required information is obtained. Once the parameters that are critical to satisfactory performance are determined by the design, appropriate instrument devices are selected to provide the engineering measurements to the magnitude and precision, and response time necessary to evaluate the parameters. Generally, the types of measurements are:

1. Horizontal and vertical movement.
2. Alignment and plumb.
3. Stresses and strains in soil and rock-fill.
4. Pore pressure.
5. Uplift pressure.
6. Phreatic surfaces.
7. Seismic effects.
8. Seepage clarity and quantity.

ER 1110-2-103, *Strong Motion Instrument for Recording Earthquake Motions in Dams,* reference 20 , gives guidance on instrumentation for seismic effects. EM 1110-2-1004, *Deformation Monitoring & Control Surveying,* reference 4, gives guidance on monitoring horizontal and vertical movements. EM 1110-2-1913, *Design and Construction of Levees,* reference 6, provides guidance on levee design and construction. EM 1110-2-2300, *Earth and Rock-Fill Dams: General Design and Construction,* reference 7, provides information on design and construction of earth and rock-fill embankments. EM 1110-2-4300, *Instrumentation for Concrete Structures,* reference 8, provides information on instrumentation requirements for concrete structures.

b. In all circumstances, background information that may affect the validity of the data or the analysis of the performance is documented and baseline instrument data for each type of measurement is obtained for future comparison. Other considerations include the potential damage during construction, effects of a severe environment on the instruments, maintenance and personnel requirements for data collection and evaluation. Automated systems have additional requirements as follows:

(1) Each instrument must maintain the ability to be read manually.

(2) Each instrument shall have the capability to be read electronically prior to entering the automated net.

(3) The system shall use a microcomputer to act as the network monitor station to collect, process, display and produce a hard copy of the data at the project office or other designated point. This network monitor station must also be capable of performing a quality control check of instrument readings, respond to a preset threshold level, interface with existing project hardware and software applications and have the ability to be queried from the district or other remote location.

(4) A backup communication link to the district shall be provided for the data transmission.

(5) The automated system does not relieve or replace the normal visual inspection schedule of the project features to include the instrumentation.

c. In addition to these primary automation requirements, consideration shall also be given to backup power supply, lightning protection, maintenance, vandalism, system diagnosis and software versatility. It is not recommended that automation be accomplished for all instrument requirements, but only to achieve those monitoring objectives that require the characteristics of automation, such as the need for remote data acquisition, the need for frequent observation, etc.

7-4 Performance Prediction.

During the initial project design, or reevaluation in the case of existing structures, the physical properties of the construction materials, design data, loading conditions and the appropriate factors of safety shall be utilized to determine the desired threshold limits for each performance parameter. Quantitative values shall be established for these limits that can be accurately translated into measurements that are easily and readily obtained in the field, which will enable the designers and operators to evaluate the behavior and performance of the structure. A detailed discussion of the design assumptions shall be presented in the design documentation report (DDR). The threshold limits along with the predicted performance levels shall be addressed in the project instrumentation DDR and in detailed instructions to project personnel and any other personnel involved with the instrumentation.

7-5 Installation and Maintenance.

Instrumentation for a project shall be included in the design phase, during construction and throughout the life of the project as conditions warrant. After a project has been operational for several years, appropriate maintenance, repair and replacement of instrumentation must be accomplished during the normal operation to assure continuous data acquisition and analyses of critical performance parameters. Note that specialized expertise may be required to install and maintain automated instrumentation.

7-6 Data Collection, Interpretation and Evaluation.

The frequency with which instrumentation data is obtained must be tailored to the instrument purpose, period of construction, investigation or other interest, and project operating conditions. In all cases, sufficient calibration and background data must be obtained to ensure that a reliable database is available to facilitate subsequent comparisons. The subsequent reading of instruments during construction and operating conditions shall be based on an anticipated rate of loading or changes in reservoir levels. The timely reduction and interpretation of instrumentation data are essential for a responsive safety evaluation of the project. For all Corps projects, this reduction and interpretation shall occur as soon as conditions warrant from the time that the data were obtained. The evaluation of the data shall follow immediately. As a minimum, all data shall be plotted as instrument response with respect to time, as well as to reservoir level or other range of loading. The WinIDP software, reference 64, is a state-of-the-art tool that has been developed specifically for dam safety instrumentation and is available to all districts through CEMVS-ED-G. More detailed guidance for data acquisition, interpretation and presentation is given in EM 1110-2-1908, reference 5.

7-7 Reporting.

After the project is complete, the instrumentation data along with the written evaluation shall be consolidated and submitted to the MSC in accordance with ER 1110-1-1901, *Project Geotechnical and Concrete Materials Completion Report for Major USACE Projects*, reference 18, and Chapter 6 of this regulation.

7-8 Funding. The appropriate funding (General Investigation, Construction General and/or Operation and Maintenance General appropriations) shall be utilized to accomplish the level of instrumentation outlined in this regulation within the time indicated.

CHAPTER 8

Dam Safety Assurance Program

8-1 Dam Safety Assurance Program.

a. The Dam Safety Assurance Program provides for special cost-sharing in accordance with Section 1203 of the Water Resources Development Act of 1986 (reference 65) for modification of completed Corps of Engineers dam projects that are potential safety hazards in light of current engineering standards and criteria. The problems that meet the approval criteria generally fall into two categories: hydrologic and seismic. A third category, changes in the state-of-the-art, could be available if approved by the Assistant Secretary of the Army. The program is intended to facilitate upgrading of those project features that have hydrologic and/or seismic deficiencies related to dam safety in order to permit the project to function safely and effectively. The Dam Safety Assurance Program may also be used to modify dams built by the Corps of Engineers and turned over to local interests to operate, maintain, repair, rehabilitate, and replace.

b. In order to qualify, the modifications must be within the Chief of Engineers' discretionary authority to rectify, plus meet the eligibility requirements described below. Projects approved under the Dam Safety Assurance Program will require a Dam Safety Assurance Program Evaluation Report, budget justification, and other supporting data in accordance with the annual budget Engineer Circular as described in ER 5-7-1(FR) (reference 11). Generally, existing project authorities are considered sufficient to permit improvements to the project for safety purposes, if such improvements do not alter the scope or function of the project or substantially change any of its specifically authorized purposes.

c. Project modifications that will require additional authorization may be studied under the authority of Section 216 of the Rivers and Harbors Act of 1970 (reference 54), following the guidance in Chapter 2 of ER 1105-2-100, *Planning Guidance Notebook*, (reference 16). Modifications to project features, which do not qualify under this regulation, will continue to be accomplished under the programs funded by the Operations and Maintenance, General, or Flood Control, Mississippi River and Tributaries (FC,MR&T) appropriations, respectively.

8-2 Eligibility.

a. Examples of project features eligible for modification under this program are as follows:

(1) Modifying existing or constructing new facilities to provide stable and adequate discharge capability to safely pass the Inflow Design Flood (IDF), as defined in ER 1110-8-2(FR), *Inflow Design Floods for Dams and Reservoirs,* (reference 29).

(2) Raising the dam height to prevent overtopping during occurrence of the IDF.

(3) Increasing structural stability of the dam, foundation, abutments, and equipment support or other structures to withstand current hydrologic, hydraulic, and/or seismic loading.

b. Dams designed and/or constructed by the Corps of Engineers and turned over to others for operations and maintenance may be modified under this program.

c. Modifications to projects may be proposed for inclusion in the Dam Safety Assurance Program by submitting a letter report requesting that the project be placed on the HQUSACE high priority list if all of the below conditions exist. The request shall include a brief write-up describing the dam safety problem and a summary of the proposed remedial measures and a pertinent data sheet.

(1) The work is required for continued safe operation of the project for its authorized purposes.

(2) The work does not include additions or betterments, which constitute a change in project, scope, function, or authorized purposes.

(3) The work meets applicable criteria, as specified for dam safety assurance projects in the budget EC for the budget year in which it is to be initiated.

d. The total average annual benefits of the existing project shall be greater than the annual costs of the modification plus additional operation, maintenance, repair, replacement and rehabilitation (OMRR&R), if any. In the event that the benefits do not exceed the costs, consideration will be given to breaching the dam and the rationale for not selecting the breaching option will be provided if improvement is recommended. Include an economic analysis if the estimated cost of the recommended work is greater than $10 million, or is greater than 25% of the replacement cost of the total project. The economic analysis is to be conducted on a sunk cost basis, i.e., all annual costs associated with the modification would be compared with the total project annual benefits. The results of this analysis will provide some perspective on the economics of providing the proposed work; however, where there is a significant question of safety, a benefit-to-cost ratio will not be calculated.

8-3 Policy on Hydrologic Criteria.

The following policy is used as a basis to make decisions on the merits of dam safety modifications to meet current hydrologic criteria:

a. General. Dam safety modifications related to hydrologic deficiencies shall be recommended to meet or exceed the Base Safety Condition (BSC). The BSC is met when a dam failure related to hydrologic capacity will result in no increase in downstream hazard potential over the hazard that would have existed if the dam had not failed. Recommendations for any modifications that would accommodate floods larger than the flood identified as the BSC must be supported by an analysis that presents the incremental costs and benefits of the enhanced design in a manner that demonstrates the merits of the recommendation.

b. Discussion.

(1) Planning for dam safety assurance program modifications will consider combinations of structural design modifications as well as nonstructural measures, including downstream actions and changes in water control plans or other influential operating factors. The recommended plan, except when circumstances noted in paragraph 8-3c(3) below apply, shall be for the dam safety modification which meets or exceeds the BSC. Recommendations for modifications that would accommodate floods larger than the flood identified as the BSC will require additional analysis as described in paragraph 8-3b(3)(b) and 8-3c(2) below.

(2) Determination of the flood that identifies the BSC will require definition of the relationship between flood flows and adverse impacts with and without dam failure for a range of floods that fully utilize the existing structure up to the Probable Maximum Flood (PMF). Selection of a BSC predicated on the potential hazard to life from dam failure requires supporting information to demonstrate that the safety of the population would actually be threatened. The evaluation shall distinguish between total population downstream of a dam and the population that would likely be in a life threatening situation given the extent of pre-failure flooding, warning time available, evacuation opportunities, and other factors that might affect the occupancy of the incrementally inundated area at the time the failure occurs. Appropriate freeboard necessary to accommodate potential wind and wave conditions will be included for all flood evaluations.

(3) The evaluation consists of two phases.

(a) Phase I is a comparative hazard analysis in which the Threshold Flood (TF) and the BSC are established. The TF is the flood that fully utilizes the existing dam, i.e., the flood that just exceeds the design maximum water surface elevation at the dam (top of the dam minus freeboard). The BSC is determined by comparing the loss of life for various floods, expressed as percentages of the PMF, with and without dam failure. PMF is determined in accordance with standard hydrometeorological procedures. The flood, expressed as a percentage of PMF, for which loss of life is not different for with-and-without dam failure conditions, is the BSC, but shall never be more than 100% of the PMF.

(b) Phase II is the risk-cost analysis required if modifications for a flood greater than the BSC are recommended. This is the more traditional risk analysis where the costs of making the improvements are balanced against the economic losses expected from collapse of the structure. Those losses include the cost of additional downstream damage, the cost of repairing the dam, and the cost associated with the loss of project services.

c. Policy Implementation.

(1) A detailed description of the Phase I analysis, including examples, is given in reference 41. The organization and display of the data is a vital component of this "comparative hazard analysis" phase, enabling a comprehensive overview of the key considerations and decision variables.

(2) The Phase II risk analysis is like a multi-objective decision problem. The justification for increasing the level of dam safety beyond the BSC as a design criterion will be based on a

more subjective weighing and trading off of a number of intangibles and engineering reliability and social factors. These may include, but are not limited to, unique location and population concentration factors, and unique national interest of the specific area that would be affected. The justification for increments of additional safety beyond the BSC requires that the additional risk reduction be explicitly balanced against increased costs. It is imperative that the display of data and weighing rationale is clear so that others in the decision chain can reach an independent conclusion.

(3) Selection of a recommended level of modification shall also reflect traditional concerns for economy. Modification costs in the vicinity of the scale of improvement identified as the BSC shall be examined for sudden increases in the cost/scale of improvement relationship. This type of change could occur, for instance, when costly highway relocation is encountered near the scale of improvement identified as the BSC. An adjustment in the level of fix recommended may be warranted under these conditions. On the other hand, the large increase in costs may be justified if a significant reduction in the hazard potential with dam failure versus without dam failure is achieved.

(4) Conduct of the analysis will require careful application of professional judgment for determining those parameters where data and modeling capability are limited. Therefore, the importance of documenting the logic of the assumptions that are critical to the conclusions and recommendations drawn from the analysis cannot be overemphasized. Also, the evaluation will produce a significant amount of information that can be used throughout the decision-making process, particularly in those cases where it is appropriate to precede beyond the BSC. The information shall be displayed in a format that assists the decision maker when evaluating the important trade-offs involved.

8-4 Policy on Seismic Criteria.

The following policy will be used to make decisions on the merits of dam safety modifications related to current earthquake design criteria:

a. General. Projects that retain or have the potential to retain a pool, failure of which would result in loss of life, substantial property damage, or indirect loss such as the loss of essential emergency services provided by the dam, are required to survive and remain safe during and following the maximum credible earthquake (MCE) event. Such projects must also be capable of remaining operational with only minor repair during and after an operating basis earthquake (OBE). Minor repair is that which can be accomplished within operation and maintenance limitations. In those instances where a combination of events is required before failure would occur (e.g., both an earthquake and a flood), a combined risk analysis shall be prepared.

b. Discussion.

(1) Technical requirements for selecting seismic design values and performing design analyses are periodically updated in Engineering Circulars. These criteria, along with current state-of-the-art techniques, are intended to be used in such studies and analyses. Criteria levels,

safety factors, and design methods are the same as that for new projects unless specifically noted as being different in technical guidance documents or by written direction from HQUSACE.

(2) Since judgment of ground motion parameters for design is based on geologic and seismic history, future strong seismic events may raise the design values against which stability is analyzed. Should such a situation occur, the district, if convinced that the ground motion parameters have changed significantly enough to affect safety of the project, shall prepare an evaluation report as provided for in paragraph 8-7 and in Part I or II of Appendix G of this regulation.

(3) Strong motion accelerometers placed on or around Corps of Engineers dams are intended to record ground motion at the site and verify the seismic design of the structure. If these instruments record ground motion parameters that (after analysis) are found to be below the values used in design, but yet the structure received damage, the occurrence and recommendations for action need to be documented. If no action is recommended, a letter report will be prepared and submitted through the MSC to HQUSACE, ATTN: CECW-E. If action is anticipated, an evaluation report will be prepared and submitted in accordance with the guidance herein.

(4) Seismic stability of auxiliary structures and devices, such as regulating outlets, regulating outlet towers, spillway gates, retaining walls, hydraulic equipment, and electric supply, both permanent and standby, shall be analyzed and modified in accordance with ER 1110-2-1806 (reference 26), where necessary to provide for the dam safety policy of subparagraph 8-4a above, including requirements for dams to remain operational following the OBE. Auxiliary structures that do not affect dam or operational safety, shall be judged for modification on economic or other grounds.

(5) Seismic stability assessment for dam safety may also involve reservoir rim slides, critical retaining walls, foundation or abutment changes, or any other feature that might contribute to dam failure.

8-5 Policy on Changes in State-of-the-Art Design or Construction Criteria.

Modifications required on a project due to State-of-the-Art changes, but not related to hydrologic or seismic deficiencies as discussed in paragraphs 8-3 and 8-4 above will be decided on a case-by-case basis. Correction of seepage through an embankment, or an inadequate structural feature will be submitted under the Major Rehabilitation Program or the Operation and Maintenance Program.

8-6 Policy on Cost Sharing.

a. Legislation. Section 1203 of WRDA 1986 (reference 64) requires that costs incurred in modifications for dam safety assurance shall be recovered in accordance with provisions of the statute. Repayment of costs, except for irrigation, may be made, with interest, over a period not to exceed 30 years in accordance with provisions of subsection (a)(2) of the legislation. Costs assigned to irrigation will be recovered by the Secretary of Interior in accordance with Public

Law 98- 404 (reference 51). Where costs to the sponsor are less than $25,000 the requirement for cost sharing has been waived in WRDA 2000.

b. Sponsor Identification.

(1) Requirements for cost sharing sponsorship, and the identification of non-Federal sponsors must occur early in the study process, to insure that the non-Federal interests are willing cost sharing partners. Uncertainty about sponsorship and lack of meaningful sponsor involvement in the scope and extent of dam safety repairs will delay dam safety assurance work. Before initiating discussions with project sponsors on cost sharing, an interpretation on the need for sponsorship and the application of the generic guidance contained in this regulation must be forwarded to HQUSACE, ATTN: CECW-A, for approval.

(2) Dam safety assurance evaluation reports will include documentation of substantive involvement and coordination with non-Federal sponsors, and expressions of their willingness to cost share in the dam safety assurance work.

c. Fifteen percent of the cost of the dam safety modification will be allocated among purposes and shared with the appropriate project sponsors. General procedures for determining the amount of sponsor cost are outlined in the following subparagraphs:

(1) Projects with a Formal Cost Allocation. In this case, 15% of the cost of the modification for dam safety assurance will be allocated among project purposes in the same percent as the construction expenditures in joint-use facilities are allocated in the cost allocation currently in effect. The cost allocated to each project purpose will then be shared in the same percentage as when the project was constructed, or when the purpose was added, whichever is appropriate. For large reservoir projects, it is likely that the cost assigned to flood control is 100% Federal. The cost assigned to power generation is most likely 100% non-Federal (to be reimbursed by the sale of the power). Costs may have been allocated to water supply or to conservation. Costs allocated directly to water supply are 100% non-Federal costs. Where costs have been allocated to conservation, water supply users may have contracted for a portion or all of the conservation storage. In such cases, the contract will need to be modified if it does not include provisions of payment for the proposed work. For illustrative purposes, assume a dam safety modification cost of $15 million, and a formal cost allocation that assigns 60% of the construction costs to hydropower, (with 45% as the hydropower joint-use construction costs); and 40% of the construction costs to flood control. Under this example, hydropower interests would have to repay $1,012,500 [($15,000,000 x 0.15) x 0.45]. If there was no sharing of the initial construction costs allocated to flood control, all of the modification costs assigned to flood control would be Federal. If a sponsor shared in the initial construction costs allocated to flood control, the dam safety costs assigned to flood control would be shared on the same percentage basis. In cases where storage is reallocated from flood control to another purpose, the sponsor for the added purpose is responsible for repaying a share of the dam safety modification costs. For example, if a contract were executed for water supply that assigned 1.5% of the joint-use cost of major replacements to a water supply sponsor, this sponsor would be required to repay $33,750 of the dam safety costs [($15,000,000 x 0.15) x 0.015].

(2) Projects without a Formal Cost Allocation, but with a Signed Project or Local Cooperation Agreement. A cooperation agreement for the initial project construction may contain an allocation or assignment of costs among project purposes. For projects with this type of agreement, 15% of the cost of the dam safety modification will be assigned to project purposes in the same manner as costs were allocated for the project or local cooperation agreement, and shared in the same percentage according to the terms of the agreement. The percent joint-use facilities cost shall be used if available; otherwise, the assignment is based on percent of total cost. As before, assume a dam safety modification of $15,000,000; a local cooperation agreement requiring a sponsor to provide a one-time payment of $3,000,000 (5%) toward the construction of a project with an actual initial construction cost of $60,000,000. The sponsor in this example would be required to repay $112,500 [($15,000,000 x 0.15) x 0.05].

8-7 Reporting Requirements.

In order to identify and process work under the Dam Safety Assurance Program, a report must be prepared that documents the analysis and evaluation processes that were made for those work items meeting the policy requirements of this regulation. The content of the report is set forth in the following subparagraphs:

a. Report. The report will be called Dam Safety Assurance Program Evaluation Report. It will be prepared following the format shown in Part III of Appendix G. This report is the decision document that must be approved by HQUSACE before initiation of detailed design leading to the preparation of the plans and specifications. The procedure and contents of the geotechnical investigation for embankment dams will be conducted in accordance with Part I, Appendix G. The structural section will be prepared in accordance with Part II. Both will be appended to the report. Detailed field investigations and office studies will be limited to those necessary to evaluate the need to modify a dam and related facilities, and to recommend further action. The report should be designed to develop a basis for decision on: (1) the need for and justification of the proposed modification for dam safety; (2) the appropriateness of funding under the Dam Safety Assurance Program; (3) whether the work requires additional authorization; (4) whether the work is subject to cost-sharing, and identification of the cost sharing partner, and the potential sponsor's willingness to cost share; (5) the scope and cost of design requirements; and (6) the estimated cost for construction. In those instances where there is need for a special engineering investigation required by detailed design effort, i.e., hydraulic modeling, structural modeling and testing, they shall be identified in the report. A plan of study and cost estimate for these special efforts shall be included. See paragraph 8-11a for funding guidance on the evaluation investigation and report preparation.

b. Engineering Investigations. Engineering investigations required to support the proposed modification for dam safety are set forth in the following subparagraphs:

(1) Hydrologic/Hydraulic Investigations. Hydrologic/hydraulic investigations are accomplished to determine the design that will meet the dam safety requirements. Investigations generally include hydrologic modeling, hydrograph routings, determination of the probable maximum flood and base safety condition, freeboard design requirements and other site-specific

hydrologic/hydraulic investigations. Documentation of these investigations will be included in the Hydrologic and Hydraulic Section of the report.

(2) Geotechnical/Structural Investigations. In order to provide a rational, cost-effective approach to the requirements of ER 1110-2-1806, a study is performed in three parts consistent with the regulation. Phases I and II will be included as subsequent appendices to the Dam Safety Assurance Evaluation Report and performed with Operations and Maintenance funds. Phase III study activities are normally performed with Operations and Maintenance funds after approval of the Report, as part of detailed engineering and design activities leading to the preparation of the plans and specifications. The Phase I report develops information needed to assess the potential for seismic instability and to provide a basis for requesting approval to continue with a detailed study of seismic stability (Phase II) using state-of-the-art dynamic methods. Phase III consists of preparing design documents, plans and specifications for remedial measures, if warranted.

8-8 Transmittal and Review of the Dam Safety Assurance Program Evaluation Report.

a. Three copies of the report shall be transmitted by the district, after a rigorous independent technical review, to the MSC Dam Safety Officer and ten copies shall be transmitted to HQUSACE (CECW-E) for concurrent review. The MSC shall provide a Memorandum to CECW-E concerning its recommendation for approval.

(1) Once the report is transmitted, further work on the project may be accomplished only upon approval from HQUSACE.

(2) In the event that the report is approved by HQUSACE subject to specific comments by either the HQUSACE or the MSC, the district shall provide the MSC and the HQUSACE acceptable documentation during the design phase to show compliance with the comments.

b. The HQUSACE Dam Safety Officer has approval authority on these reports. The Dam Safety Officer will notify OASA(CW) of report approvals and provide one copy of the approved reports to OASA(CW).

c. When the estimated Federal share of the project cost is $15,000,000 or less, the MSC Dam Safety Officer has approval authority for the report. In these cases the following procedures will be followed:

(1) The District shall transmit ten copies of the report to the MSC Dam Safety Officer and one copy of the report to HQUSACE (CECW-E), in lieu of the number of copies shown in paragraph 8-8a. above.

(2) Once the report is transmitted, further work on the project may be accomplished only upon approval from HQUSACE.

(3) After the MSC Dam Safety Officer has approved the report, the MSC shall transmit two copies of the approved report with comments to HQUSACE (CECW-E).

(4) The USACE Dam Safety Officer will notify OASA(CW) of the report approval and provide one copy of the approved report to OASA(CW).

(5) In the event that the report is approved by the MSC subject to specific comments, the district shall provide the MSC acceptable documentation during the design phase to show compliance with the comments.

d. Following report approval, the district may request Construction, General, funds from the Dam Safety Assurance and Seepage/Stability Program to proceed with engineering and design activities. The district may also budget for construction new start funds under the Construction, General appropriation. Refer to paragraph 8-11 for additional funding guidance, including information on the Mississippi River and Tributaries account.

8-9 Design Documentation Report.

Design documentation shall follow the guidance in ER 1110-2-1150 and Appendix G of this regulation.

8-10 Plans and Specifications.

Plans and specifications will be prepared in accordance with the requirements of ER 1110-2-1150, reference 23.

8-11 Funding.

a. Evaluation Reports. Charges for preparation of the evaluation report may be made in two ways; against the Dam Safety Assurance Studies feature in the O&M, General account or the maintenance portion of the Flood Control, Mississippi River and Tributaries (FC,MR&T) account: (1) under the specific project name for projects maintained by the Corps of Engineers; and (2) under the category of Inspection of Completed Works for projects designed and/or constructed by the Corps of Engineers but turned over to others for operation and maintenance.

b. Engineering Investigations. All Phase I and II investigations will be funded in the same manner described above.

c. Design and Plans and Specifications. Following approval of the project, and based on the schedule of recommended work in the evaluation report, funds from the Construction, General, or the maintenance portion of the FC, MR&T account may be used to continue design, and complete plans and specifications (Phase III for structural/ seismic investigations).

d. Construction. A district will request funding for the new construction start of an approved dam safety project through the normal budgetary process. Construction or land acquisition may not commence until construction funds have been specifically allocated for the required work, and a project cooperation agreement or amendment has been executed, if required. Dam Safety Assurance Program construction projects will be funded under the Construction, General appropriation title or the construction portion of the FC, MR&T account.

8-12 Hazard Potential Classification.

Appendix G of this regulation shows the hydrologic hazard potential (low, significant, high) losses posed by dams to life, property, lifeline, and the environment.

CHAPTER 9

Major Rehabilitation Program

9-1 Purpose.

To permit construction of infrequent, costly structural rehabilitation or major replacement works that are intended to extend the useful life of a project or a principal feature thereof at projects operated and maintained by the Corps of Engineers.

9-2 Policy.

a. Major Rehabilitation shall consist of either one or both of two mutually exclusive categories - Reliability or Efficiency Improvement. Rehabilitation is major project feature restoration consisting of structural work on a Corps' operated and maintained facility such as a lock, dam, hydropower plant, etc., intended to improve reliability of an existing structure, the result of which will be a deferral of capital expenditures to replace the structure. Rehabilitation will be considered as an alternative when it can significantly extend the physical life of the feature and can be economically justified by benefit-cost analysis. The work will extend over at least two full construction seasons and will exceed the threshold amount shown in the annual budget guidance circular. Efficiency Improvement category will enhance operational efficiency of major project components. Operational efficiency will increase outputs beyond the original project design. Major Rehabilitation for the purpose of this regulation will be defined as activities that are partially or completely funded by US Army Corps of Engineers Federal Appropriations.

b. Projects approved for Major Rehabilitation will require budget justification and other supporting data similar to the budget information prepared for construction projects. The Major Rehabilitation Program is limited to the major repair or restoration of main structures such as dams, locks, powerhouses, and breakwaters, exclusive of electrical, mechanical, and other equipment, except that such equipment may be included where it is essential to and integral with the feature of the project being rehabilitated. As a further exception, the Major Rehabilitation Program may include the periodic replacement of large individual items of major equipment such as turbines and generators when they are part of a major replacement program. Major repairs to or replacement of boats, trucks, mobile cranes**,** and similar mobile equipment are excluded from this program. In case of emergency rehabilitation, where delays would jeopardize the safety of the project, reprogramming of existing Operation and Maintenance, General funds will be considered. This procedure will reduce administrative burdens and delays otherwise involved in the development of adequate information and data in support of fund requests, and in adhering to the regular budget justification and appropriation process for funding of Major Rehabilitation projects under Construction, General. The Major Rehabilitation Program is not applicable to local protection projects, dams, or other works turned over to local interests for operation, maintenance and major replacement.

c. Dam Safety Assurance and Seepage/Stability Correction Program. A subset of the Major Rehabilitation Program is the Seepage/Stability Correction Program. The purpose of the

Seepage/Stability Correction Program is to address seepage and static stability of dams and other water control structures owned and operated by the Corps of Engineers. In addition to the normal economic analysis, projects under the Seepage/Stability Correction Program consider loss of life and other losses that would occur in the event of a dam failure.

9-3 Funding.

The cost of preparation of the Evaluation Report for a Major Rehabilitation Project shall be funded by the project Operations and Maintenance work allowance. Once the report is approved, further work on the modifications shall be funded from the Operations and Maintenance account until the work is budgeted and funded by the Construction, General, appropriations. The Seepage/Stability Correction Program is an exception to funding future work with Operations and Maintenance funds. Under the Seepage/Stability Correction Program, the Major Rehabilitation project is funded the same as a Dam Safety Assurance Program project. The approving official at HQUSACE notifies OASA(CW) of the approval, and further engineering and design work is funded from the Construction, General, appropriation, under the Dam Safety and Seepage/Stability Correction Program.

9-4 Program Requirements.

Major rehabilitation may be included in the Major Rehabilitation Program if all of the following conditions exist:

a. The structural work does not include additions or betterments, which constitute a change in project purpose, size, capacity or location. Modernization of operating equipment (except for mobile equipment) to meet current design standards may be incidentally included.

b. The estimated cost of the work complies with requirements in paragraph 9-2 a, above. For multi-project systems that are operated as a single project, the dollar amount applies separately to each component project.

c. The structural work is required for continued operation of the project for its authorized purposes.

d. The work meets applicable criteria, as specified for Major Rehabilitation New Starts in the annual Budget EC, for the budget year in which it is to be initiated.

e. The accomplishment of the work satisfies program requirements as demonstrated by an evaluation report.

9-5 Procedural Requirements.

In order to identify and process work for inclusion in the Major Rehabilitation Program, the following reporting and design procedures will be followed:

a. Evaluation Report. The reporting officer is to conduct a reconnaissance and prepare a report for preliminary evaluation of those work items meeting the definitions of paragraph 9-4. The report will be prepared on the basis of pertinent information and data readily available. Detailed field investigations and office studies will be kept to a minimum. The report shall be designed to develop a basis for decision on: (a) the need for and justification of the rehabilitation, (b) the appropriateness of funding under the Major Rehabilitation Program, (c) whether the work requires additional authorization, (d) whether the work is subject to cost sharing, (e) scope and cost of subsequent investigation and design requirements, and (f) level of design review required. The report is to be prepared in accordance with Appendix G of this regulation. If the estimated cost of the recommended work is greater than $10 million, or is greater than 25 percent of the estimated replacement cost of the total project, the Evaluation Report is to be expanded to include a detailed economic analysis of the recommended work and other feasible alternatives.

b. Submittal and Review of the Evaluation Report.

(1) Ten copies of the report will be transmitted with recommendations of the Division Engineer to HQUSACE (CECW-OM). If the work is under the Seepage/Stability Correction Program two additional copies of the evaluation report will be forwarded to the USACE Dam Safety Officer.

(2) Once the Evaluation Report is transmitted, further work may be accomplished only upon approval from HQUSACE (CECW-OM) or (CECW-E in the case of Seepage/Stability Correction Program work).

(3) Upon review of the Evaluation Report, either the Chief, Operations Division, or the Chief, Engineering and Construction Division, will approve or disapprove the recommended work under the Major Rehabilitation Program.

c. Design Documentation Report. A single design documentation report will be prepared on any project feature(s) to be rehabilitated, based on the plan approved in the Evaluation Report. The design documentation report shall be prepared in accordance with Appendix G of this regulation. Unless there are extremely unusual conditions or changes from the Evaluation Report, the approval level for the design documentation report will be in accordance with ER 1110-2-1150.

d. Other Design Documentation Report Transmittal or Distribution Requirements. The requirements of ER 1110-2-1150 are applicable to the Major Rehabilitation design documentation report transmittal, review and approval process.

9-6 Plans and Specifications.

Plans and specification will be prepared, reviewed, approved and distributed in accordance with the following requirements:

a. Design and Plans and Specifications. The reporting officer may, upon receipt of approval of an evaluation report, conduct design studies and prepare a design documentation

report and plans and specifications using funds from the Operation and Maintenance, General, appropriation, or funds from the Construction, General, appropriation, as outlined in paragraph 9-3.

b. Construction Funds. Following receipt of HQUSACE approval of the Evaluation Report, the reporting officer may budget for construction funds under the Major Rehabilitation Program category of Construction, General, following the format of continuing construction as required by ER 11-2-240. Construction or land acquisitions may not be started until funds have been specifically appropriated and allotted for the required work. All work on a project with approved Evaluation Reports for Seepage/Stability Correction Program work may be funded with funds from the Dam Safety and Seepage/Stability Correction Program line item of the Construction, General appropriation.

CHAPTER 10

Other Modifications to Completed Projects

10-1 Purpose.

To provide guidance on the use of available authorities, as compared to the need for new project authorizations, for study and accomplishment of modifications to completed projects. Completed projects may include structures other than dams, i.e. levees, floodwalls, floodways, channels, pumping plants, navigation structures, etc.

10-2 Definitions.

a. Original project development. Planning, land acquisition, design and construction, which fulfilled the initial project authorization requirements (plus, if applicable, similar accomplishments for any subsequently completed project modifications).

b. Completed project. A project, or separately funded portion of a project, is considered complete when any one of the following conditions is met:

(1) When contracts, or hired labor activities, for all work included in the plan of improvement contemplated when final appropriations were made by Congress have been physically completed.

(2) Same as (1) above, except that a determination was made that some element of work was not required.

(3) More than two years have elapsed since the year completion funds were appropriated and only minor work items remain to be completed.

c. Project modifications. Changes in project operation, change in real estate interest, physical change of a project feature, the addition of project features, or changes in the purposes of a project.

10-3 General.

Significant modifications to completed projects (modifications which involve new Federal construction or real estate acquisition in order to serve new purposes, to increase the scope of services to authorized purposes beyond that intended at the time of project construction, or to extend services to new beneficiaries (areas)) require authorization by Congress. Ordinarily, such authorization is achieved through the General Investigations program as a consequence of a feasibility (survey) report submitted to Congress in response to a specific directive from the Congress, usually in recognition of local interests' perceptions of needs. It is, however, a general policy of the Chief of Engineers that completed Corps projects be observed and monitored by the Corps to ascertain whether they continue to function in a satisfactory manner and whether potential exists for better serving the public interest. Such monitoring may be accomplished

coincidentally in carrying out existing project inspection programs, as a by-product of contacts with local interests and other Federal agencies, and through the day-to-day observations of on-site Corps personnel charged with project operations. Whenever reporting officers find that changes in a completed project may be desirable, investigations shall be undertaken to document the need for and feasibility of project modification. To the extent possible, modifications to completed projects shall be accomplished under existing authorities. Pertinent existing authorities are discussed in paragraphs 10-4 through 10-8. If a needed modification cannot be accomplished using these authorities, additional authorization must be sought as discussed in paragraphs 10-9 and 10-10.

10-4 Modification Under Existing Authority, General.

a. Project authority. Project authorizations may provide authority for the Chief of Engineers to modify project operation or facilities to account for conditions expected at a future date. Because of the range of authority, which may be available in project authorizations, it is not possible to detail the modifications, which may be undertaken in this manner. Prior to proposing modifications using other authorities, reporting officers should thoroughly review the legislative history and related project documents for the individual project of concern to determine if sufficient authority already exists within the specific project authorities.

b. Project deficiencies. Occasionally, a project may deserve modification because its original development was inherently deficient. Given certain conditions and qualifications, measures to correct such deficiencies may be undertaken. This subject is covered in detail in paragraph 10-5 in connection with completed projects that are operated and maintained by local interests. The criteria set forth for modifications to correct deficiencies in such projects are also generally applicable to projects operated and maintained by the Corps.

10-5 Modifications Requiring Congressional Authorization.

If a desirable modification cannot suitably be pursued under any of the authorities or programs discussed in the preceding paragraphs, implementation will require additional Congressional authorization. The necessary studies and report preparation required to obtain such authorization shall be undertaken using existing Congressional study authorities which request a review of the specific project or basin, if available. If such specific study authorities are not available, Section 216 of the Flood Control Act of 1970 (Public Law 91-611) (reference 54) may be used. Section 216 states:

> “The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest.”

Studies undertaken using the authority provided by Section 216 will be accomplished using the "Review of Completed Projects Program." Requests for guidance regarding funding, reporting and processing of reports to obtain additional authorization using this program shall be addressed to CDR USACE (CECW-P) WASH DC 20314-1000.

CHAPTER 11

Emergency Response

11-1 Emergency Planning.

An emergency situation is a condition that develops unexpectedly, endangers the structural integrity of the dam and/or downstream property and human life, and requires immediate action. Such a situation cannot be properly responded to unless plans and preparations have been made well in advance. Preparation for dealing with an emergency situation is the heart of emergency planning, and it includes preparation of an Emergency Action Plan and proper training of the field and office forces in proper implementation of the plan. An Emergency Action Plan is a plan of action to reduce the potential for property damage and loss of life in an area affected or about to be affected by a dam failure or large flood. It includes both the portion of a dam safety plan prepared by the Corps of Engineers and the complementary evacuation plan prepared by non-Federal interests. It is important that Corps field personnel interface with downstream officials and local responders on an annual basis to discuss the Emergency Action Plan and the local evacuation plan.

11-2 Background.

Corps of Engineers major subordinate commands were instructed in March 1978 to begin preparation of flood Emergency Action Plans for dams under their jurisdiction. Initially the effort was directed to delineating the areas downstream from the dams that would be flooded in the event of dam failure or large release of floodwater without dam failure. In June 1980 the Corps of Engineers issued detailed instructions for the preparation of flood Emergency Action Plans (U.S. Army Corps of Engineers, Hydrologic Engineering Center 1980, 1982) (references 56, 57). Subsequently, in August 1983, the Corps of Engineers distributed case studies of an Emergency Action Plan and evacuation plan to field offices (U.S. Army Corps of Engineers, Hydrologic Engineering Center 1983a, 1983b) (references 58, 59). Guidance (U.S. Army Corps of Engineers, Hydrologic Engineering Center 1980) has been provided for preparation of Emergency Action Plans to deal with potential emergencies caused by:

a. Spillway discharges sufficiently large to cause flooding in downstream areas.

b. Flooding upstream of dams due to backwater effects or high pool levels.

c. Dam failure.

11-3 Emergency Action Plans and Emergency Exercises.

Procedures for preparation of Emergency Action Plans and Emergency Exercises are included in Appendix I.

CHAPTER 12

Dam Safety Training

12-1 Overview.

The Corps of Engineers has an extensive program for training personnel in all matters related to its mission in water resources development. Much of the training is directly or indirectly related to dam safety. A comprehensive training program is conducted for dam operation and maintenance personnel. This program is designed to acquaint project personnel with basic engineering considerations pertaining to the major structures, with procedures for surveillance, monitoring and reporting of potential problems, and with emergency operations. In addition, the technical staff at the District office requires training to build expertise and ability to respond to emergencies. The Corps of Engineers has a training course on "Dam Safety in the Corps of Engineers" and has supported the development of the Training Aids for Dam Safety (TADS) Program (Walz 1990b) (reference 63). In 1991, the Federal Energy Regulatory Commission initiated a training course on "Emergency Action Plan" (Gotzmer 1991) (reference 40). A listing of Government sponsored training courses relating to dam safety was prepared by the Interagency Committee on Dam Safety (ICODS) Subcommittee on Training (Federal Emergency Management Agency 1986b) (reference 35). ASDSO web site.

12-2 National Dam Safety Conferences.

12-3 Exchange Training – District to District.

12-4 Training Program for Operations and Maintenance Personnel.

a. Dam Safety. Recognizing the important role that onsite operations and maintenance personnel have in dam safety, major subordinate command commanders were directed in 1978 to develop a training program which addresses the following items (ER 1130-2-530, United States Committee on Large Dams 1982) (references 30, 55):

(1) Discussion of basic typical design considerations for various types of construction, including hydraulic considerations and foundation factors.

(2) Procedures for monitoring potential problem areas.

(3) Dam safety features in design and construction.

(4) Normal operation, surveillance, monitoring, and reporting procedures.

(5) Emergency operations, surveillance, monitoring, and reporting procedures.

(6) Project specific features and history of problems and potential problems.

b. Exercises. Upon completion of the initial safety training at a new project, EAP exercises are developed based on the most probable emergency situations that might occur on each major dam feature. Operations and Maintenance personnel shall be retrained every 4 years.

12-5 Sample Dam Safety Training Course Outline for Project Personnel.

a. Purpose of Training Program

(1) Basic Objectives

(2) History of Dam Failures. (Reference: Lessons from Dam Incidents, International Commission on Large Dams, 1973; Inspection, Maintenance and Rehabilitation of Old Dams, ASCE, 1974; Safety of Small Dams, ASCE, 1975; The Evaluation of Dam Safety, ASCE, 1977).

(3) Films or Slides Depicting Dam Safety Problems or Failures. (Reference: Existing Southwestern Division Films).

b. Dam Safety Features in Design and Construction.

(1) Design Philosophy for Dams. (Reference EM 1110-2-2200, *Gravity Dam Design,* EM 1110-2-2300, *Earth and Rockfill Dams - General Design and Construction Considerations,* Chapter 6 of this ER).

(2) Design Assumptions, Construction History, Salient Features and Regulating Philosophy for the Project. (Reference: ER 1110-2-1801, ER 1110-1-1901, *Project Geotechnical and Concrete Materials Completion Report for Major USACE Projects*).

(3) Past Monitoring, Experiences and Performance for Projects. (Reference Chapter 6 of this ER).

c. Normal Operation, Surveillance, Monitoring and Reporting Procedures.

(1) The Value and Use of Instrumentation.

(2) Effect of Pool Rises on Monitoring Requirements.

(3) Reservoir Regulation Manuals.

(4) Day-to-Day Surveillance.

(5) Documentation of Plans, Records, Reports, etc.

(6) Generalizations on What is and What is Not Critical to Safety of the Structure.

(7) Public Relations with Local Communities.

(8) Coordination and Notification to Downstream Water Users and Recreationists on Controlled Releases and Flushing Operations.

d. Emergency Operation, Surveillance, Monitoring and Reporting Procedures.

(1) Observations of Evidence of Distress.

(2) Methods of Treating Obvious Safety Problems.

(3) Knowledge of Potential Flood Area Downstream.

(4) Alerting Corp of Engineer Offices to Emergency Conditions.

(5) Alerting Police and Local Civil Defense Groups to Emergency Conditions.

12-6 Corps of Engineers Training Course on Dam Safety.

The Corps of Engineers Proponent Sponsored Engineer Corps Training (PROSPECT) program offers a course titled “Dam Safety in the Corps of Engineers”. Through lectures, case histories, and structured student discussions, the course covers all aspects of a dam safety program. The course outlines technical considerations (hydrologic, seismic, geotechnical, electrical/mechanical and structural) as well as the operational requirements (operation, maintenance, surveillance, preparedness, training, and notification). The scope and implementation details of the Dam Safety Assurance Program are covered in detail. Presentations, video modules, case histories, and a walk-through inspection are used to effectively present a multidiscipline approach to the successful monitoring and evaluation of Corps of Engineers dams.

12-7 Training Aids for Dam Safety.

a. Background. In 1986, the Corps of Engineers, along with 13 other Federal Agencies, all members of the Interagency Committee on Dam Safety, joined forces to develop a professionally prepared TADS Program. The TADS materials, as shown in Table 13-1, are arranged in three components that cover dam safety inspections, dam safety awareness and program development, and evaluations and remedial actions (Federal Emergency Management Agency 1992b, Veesaert 1990) (references 38, 61).

b. Structure. The entire package consists of 21 self-paced individual instruction modules that focus on performance of job tasks. Each module features a workbook text. The material is presented in a straightforward, easy-to-manage manner. Each workbook contains a glossary of terms and a list of references from which to obtain additional information. Nine of the modules are supplemented with videotapes that illustrate certain concepts. Because the modules are self-contained, individuals may tailor a learning program to meet specific work requirements or personal needs (Federal Emergency Management Agency 1992b, Veesaert 1990).

c. Utilization of the program. The TADS Program offers a standardized approach to dam safety training. The Corps of Engineers, as one of the primary sponsors of the TADS Program, distributes the TADS materials to each Corps of Engineers field office through the Engineering and Construction Division, Directorate of Civil Works, HQUSACE. All MSC’s and districts shall maintain a complete set of modules including the videotape supplements.

Table 12-1
Training Aids for Dam Safety Modules

Safety Inspection of Dams (for engineers with little or no inspection experience and technicians with some familiarity with dams)

- Preparing to Conduct a Dam Safety Inspection
- Documenting and Reporting Findings From a Dam Safety Inspection
- Inspection of Embankment Dams *
- Inspection of Concrete and Masonry Dams*
- Inspection of the Foundation, Abutments, and Reservoir Rim
- Inspection of Spillways and Outlet Works *
- Inspection and Testing of Gates, Valves, and Other Mechanical Systems
- Instrumentation for Embankment and Concrete Dams *
- Identification of Material Deficiencies
- Evaluation of Facility Emergency Preparedness

Dam Safety Awareness, Organization, and Implementation (for dam owners and operators, with some applicability for inexperienced engineers, technicians, administrators, and the general public)

- Dam Safety Awareness*
- How to Organize a Dam Safety Program
- How to Organize an Operation and Maintenance Program
- How to Develop and Implement an Emergency Action Plan *
- Identification of Visual Dam Safety Deficiencies

Data Review, Investigation and Analysis, and Remedial Action for Dam Safety (for engineers with some applicability for dam owners and operators)

- The Dam Safety Process
- Evaluation of Hydrologic Adequacy
- Evaluation of Hydraulic Adequacy
- Evaluation of Concrete Dams Stability
- Evaluation of Embankment Dams Stability and Deformation
- Evaluation of Seepage Conditions

* Modules have videotape supplements.

CHAPTER 13

Low Level Discharge Facilities for Drawdown of Impoundments

13-1 Purpose.

Provides policy, objectives, and procedures in regard to facilities for drawdown of lakes to be impounded by Civil Works projects.

13-2 Policy.

It is the policy of the Chief of Engineers that all lakes impounded by Civil Works projects have low level discharge facilities to meet the criteria for drawdown set forth herein. Low-level discharge facilities, capable of essentially emptying the lake, provide flexibility in future project operation for unanticipated needs such as major structure repair, environmental controls or changes in reservoir regulation. The criteria set forth herein governs the majority of impoundment projects. However, if impracticable to provide drawdown capability because of size (unusually small or large) or because of a unique function, projects may be exempt from the criteria upon presentation of information in accordance with paragraph 13-4, below.

13-3 Design Criteria.

As a minimum, low-level discharge facilities will be sized to reduce pool level within four months to the higher of the following pool levels:

(a) a pool level that is within 20 feet of the pre-project “full channel” elevation, or

(b) a pool level resulting in storage in the reservoir equal to 10 percent of the beginning pool level. The beginning pool level for drawdown is at spillway crest for uncontrolled spillways and at top of spillway gates for controlled spillways. Inflow into the lake during the drawdown period will be computed average flow for each month of the year. The drawdown period inflow will be the equivalent to the average flow of the highest consecutive four-month period.

13-4 Design Study and Reporting Requirements.

Feasibility (survey) reports and subsequent pertinent Design Documentation Reports (DDR’s) shall include the results of studies made to determine facilities required for drawdown of impoundments. The discharge capacity required to satisfy project purposes and diversion requirements during construction may be sufficient to meet the drawdown criteria set forth in paragraph 13-3, above. Where additional capacity is required an analysis of the most practical and economical means of increasing the capacity to meet the drawdown criteria will be performed. A synopsis of the alternatives considered and details of the recommended plan shall be included in the DDR. The report shall include the effects of the required discharge capacity on project costs, on existing downstream projects, and on the potential for downstream damage.

When, due to specific project conditions, a drawdown capacity is recommended which does not meet the criteria set forth in paragraph 13-3, above, the following information shall be presented:

a. The drawdown period using the maximum drawdown capability of the proposed project facilities, under the situation described in paragraph 13-3, above. Information shall be included on the pool elevation and corresponding storage volume at end of the period.

b. Information on facilities that would be required to meet the design criteria for drawdown, including the estimated first cost and annual cost of these facilities. If the estimated cost for such facilities is significantly greater than for the proposed project facilities, similar information on intermediate facilities shall be provided.

Reporting subsequent to the DDR shall include related discharge rating curves; hydrographs with inflow, outflow and pool stage plots; lake regulation plans needed for project purposes and needed to satisfy the drawdown criteria; and other data essential in evaluating the study.

CHAPTER 14

Acquisition of Lands Downstream from Spillways for Hydrologic Safety Purposes

14-1 Purpose.

To provide guidance on the acquisition of lands downstream from spillways for the purpose of protecting the public from potential hazards imposed by spillway discharges.

14-2 Discussion.

A policy of public safety awareness will be adhered to in all phases of design and operation of dam and lake projects to assure adequate security for the general public in areas downstream from spillways. A real estate interest will be required in those areas downstream of a spillway where spillway discharge could create or significantly increase a potentially hazardous condition. The real estate interest will extend downstream to where the spillway discharge would not significantly increase potential hazards. A real estate interest is not required in areas where flood conditions would clearly be non-hazardous.

14-3 Hydrologic Criteria.

The construction and operation of a dam and spillway may create or aggravate a potential hazard in the spillway discharge area. Therefore, an appropriate solution shall be developed in a systematic manner. All pertinent facts need to be considered to assure that the risk to non-Federal interests does not exceed conditions that would prevail without the project. General hydrologic engineering considerations are as follows:

a. Probability of spillway use. Pool elevation versus probability of filling relationships can change materially after initial construction. Spillway use may be more frequent than anticipated. The infrequent use of a spillway is not a basis for the lack of adequate downstream real estate interest.

b. Changes in project functions. Water resource needs within river basins change and pool levels may be adjusted to provide more conservation storage, particularly when high-level limited-service spillways are provided. Such changes normally increase spillway use and are to be considered.

c. Volume and velocity of spillway flow. The amount of flow and destructive force of the flow from a spillway during floods up to the spillway design flood can vary from insignificant to extremely hazardous magnitudes. The severity and area of hazard potential associated with spillway discharge will vary depending on specific project site conditions. Therefore, the hazard potential is to be analyzed on a project-by-project basis.

d. Development within floodway. If development within the floodway downstream from a spillway is not present at the time of project construction, the existence of the reservoir may encourage development. Adverse terrain conditions do not preclude development. Sparse present development is not a basis for lack of real estate acquisition.

e. Debris movement within floodway. The availability of erodible material in a spillway flow area intensifies the hazard potentials of spillway flow. In fact, debris may be transported to downstream areas that otherwise would not be adversely affected. Extreme erosion may result from high velocities and turbulence. Both debris and erosion must be evaluated and considered.

f. Flood warning and response potential. Small projects generally have short time periods available to warn downstream inhabitants and may be unattended prior to spillway use. The ability to convince individuals to leave most of their worldly possessions to the ravages of spillway flow may be severely limited. In some cases flood warning systems may be necessary; however, this subject is beyond the scope of this portion of this regulation. Warning systems are not an adequate substitute for a real estate interest in lands downstream of spillways.

g. Location of spillways. Spillways shall be located to minimize the potential hazards associated with their discharge and the total project cost (cost of spillway structure and downstream lands). Spillways, outlet works, stilling basins and outlet channels shall be designed to minimize hazards to downstream interest insofar as is physically and economically reasonable.

14-4 Real estate.

The real estate interest required downstream of spillways will be adequate to assure carrying out project purposes and to protect non-Federal interest from potential hazards created by spillway flows. The interest may be either fee or permanent easement. A permanent easement must exclude all overnight and/or permanent habitation structures subject to damage by spillway flows and activities that would increase the potential hazards. No real estate interest is required for:

a. Areas where the imposed or aggravated flood condition is non-hazardous. Affected interest shall be informed of the nature of the imposed non-hazardous flood condition.

b. Areas where the construction and operation of a dam and spillway does not increase or create a potentially hazardous condition.

14-5 Alternative Land Uses.

In some cases lands acquired in fee downstream from spillways can be effectively used for purposes other than hydrologic safety. Therefore, the entire cost of the fee may not be an additional project cost. For example, the fee lands downstream of a spillway may be used for wildlife management essential to project purposes in lieu of other lands suitable for similar purposes at another location.

14-6 Procedural Guidance.

Procedures regarding the application of the principles outlined in the above paragraphs are as follows:

a. For flood magnitudes up to the probable maximum flood determine the “with” and “without project” flood conditions downstream of a dam spillway for the following:

(1) Flooded area
(2) Flood depth
(3) Flood duration
(4) Velocities
(5) Debris and erosion

b. Determine the combinations of flood magnitudes and the above flood conditions that could be the most hazardous and/or result in the greatest increase in hazard potential from “without” to “with project” flood conditions. Designate these combinations of flood magnitude and flood conditions as the critical conditions.

c. For the critical conditions selected above, outline the areas where the project could increase and/or create (impose) one or more of the critical conditions. Areas where spillway flows do not create or increase flood conditions are excluded from further analysis.

d. Determine where the imposed critical conditions as outlined above would be potentially hazardous and non-hazardous. Non-hazardous areas are defined as those areas where:

(1) Flood depths are a maximum of 2 feet in urban and rural areas.
(2) Flood depths are essentially non-damaging to urban property.
(3) Flood durations are a maximum of 3 hours in urban areas and 24 hours in agricultural areas.
(4) Velocities do not exceed 4 feet/per second.
(5) Debris and erosion potentials are minimal.
(6) Imposed flood conditions would be infrequent. That is, the exceedence frequency shall be less than 1%.

Potentially hazardous areas are those where any of the above criteria are exceeded.

e. Based upon the information developed above and the principles outlined in paragraphs 14-2 through 14-4, decide on the extent of area and estate required for hydrologic safety purposes.

14-7 Reporting.

Lands to be acquired downstream from spillways and intended purposes will be identified and the cost included in evaluation reports and real estate design documents. Additional specific information in support of land acquisition shall be provided in the Design Documentation Report and on dam modernization reports. This information shall include topographic maps, area flooded maps, velocities, erosion and debris areas “with” and “without” the project. Real estate

boundaries and discussions of items in paragraph 14-4 are also essential in the Design Documentation Reports and dam modernization reports.

CHAPTER 15

Risk Assessment

15-1 Purpose.

To provide guidance on the evaluation framework to be used in Corps of Engineers flood control and flood damage reduction studies. For further guidance, please refer to ER 1105-2-101, *Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical stability, and Economics in Flood Damage Reduction Studies* (reference 17), which is jointly promulgated by Planning and Engineering and applies to Hydrology/Hydraulic, Geotechnical, Structural, and Economic evaluations, and to EM 1110-2-1619, *Risk-Based Analysis for Flood Damage Reduction Studies,* (52). ER 1105-2-100, *Planning Guidance Notebook,* (reference 16), and Policy Guidance Letter No. 26, *Benefit Determination Involving Existing Levees,* 23 December 1991, (reference 49) also provide guidance for risk assessment studies.

15-2 Background.

a. Risk and uncertainty are intrinsic in water resources planning and design. They arise from measurement errors and the inherent variability of complex physical, social, and economic situations. All measured or estimated values in project planning and design are to various degrees inaccurate. Invariably the “true” values are different from any single, point values presently used in project formulation, evaluation, and design.

b. The Corps develops best estimates of key variables, factors, parameters, and data components in the planning and design of flood damage reduction projects. These estimates are considered the “most likely” values. They are frequently based on short periods of record, small sample sizes, measurements subject to error, and innate residual variability in estimating methods. Sensitivity analysis has been the primary tool for considering uncertainty in project planning and design. Sensitivity analysis, however, frequently presumes that the appropriate range of values is identified and that all values in that range are equally likely. In addition, the results of this analyses are typically reported as a single, most likely value that is treated by some as if it were perfectly accurate.

c. Risk-based analyses can be advantageously applied to a variety of water resources planning and design problems. The approach captures and quantifies the extent of the risk and uncertainty in the various planning and design components of an investment project. The total effect of risk and uncertainty on the project’s design and economic viability can be examined and conscious decisions made reflecting an explicit tradeoff between risks and costs. Risk-based analysis can be used to compare plans in terms of the likelihood and variability of their physical performance, economic success, and residual risks.

d. Budget constraints, increased customer cost sharing and public concern for project performance and reliability are issues that must be addressed in the assessment of Federal water resources investments. Explicit consideration of risk and uncertainty can help address these issues and improve investment decisions.

15-3 Definitions.

Risk-Based Analysis, for the purposes of this chapter of this regulation, is defined as an approach to evaluation and decision making that explicitly, and to the extent practical, analytically, incorporates considerations of risk and uncertainty. It is recognized that the “true” values of planning and design variables and parameters are frequently not known with certainty and can take on a range of values. One can describe, however, the likelihood of a parameter taking on a particular value by a probability distribution. The probability distribution may be described by its own parameters, such as mean and variance for a normal distribution, or minimum, maximum, and most likely for a triangular distribution. The approach combines the underlying risk and uncertainty information so that the engineering and economic performance of a project can be expressed in terms of probability distributions.

15-4 Variables in a Risk-Based Analysis.

A variety of planning and design variables may be incorporated into risk-based analysis in a flood damage reduction study. Economic variables in an urban situation may include, but are not necessarily limited to, depth-damage curves, structure values, content values, structure first-floor elevations, structure types, flood warning times, and flood evacuation effectiveness. Other variables may be important for other types of projects. For example, in agricultural areas seasonality of flooding and cropping practices may be important. The uncertainty of these variables may be due to sampling, measurement, estimation, forecasting, and modeling errors. For hydrologic and hydraulic analysis, the principle variables are discharge and stage. Uncertainty in discharge exists because record lengths are often short or do not exist where needed, precipitation-runoff computation methods are inaccurate, and the effectiveness of flood flow regulation measures is not precisely known. Uncertainty factors that affect stage might include conveyance roughness, cross-section geometry, debris accumulation, ice effects, sediment transport, flow regime, bed form, and others. For geotechnical and structural analysis of levees, the principle source of uncertainty is the structural performance of an existing levee. Uncertainty in structural performance occurs due to a levee’s physical characteristics and construction quality. These, in turn, influence the Probable Non-failure Point (PNP) and Probable Failure Point (PFP) required in the reliability assessment of existing levees.

15-5 Policy and Required Procedures.

a. All flood damage reduction studies will adopt risk-based analysis as described herein. The risk-based analysis approach and results shall be documented in the principal decision document used for recommending authorization and/or construction. This involves feasibility reports, DDR’s, and general reevaluation reports. For reconnaissance studies, the proposed feasibility study risk-based analysis will be developed to the task level and included in the Project Study Plan (PSP). The PSP will describe the methods to be used to quantify the uncertainties of the key variables, parameters, and components and the approach to combining these uncertainties into higher-level measures of overall economic and engineering performance and reliability. Some proposed projects may reach the Preconstruction Engineering and Design (PED) phase without employing risk-based analysis. In those cases where a reevaluation effort is

proposed and standard freeboard assumptions or other engineering standards were used which are critical to sizing and/or performance of project features, a reformulation of the project using risk-based analysis, as described herein, shall be undertaken to determine the appropriate project for construction recommendation.

b. The ultimate goal is a comprehensive approach in which the values of all-key variables, parameters, and components of flood damage reduction studies are subject to probabilistic analysis. Not all variables are critical to project justification in every instance. In progressing toward the ultimate goal, the risk-based analysis and study effort shall concentrate on the uncertainties of the variables having the largest impact on study conclusions. At a minimum, the following variables must be explicitly incorporated in the risk-based analysis: the stage-damage function for economic studies (with special emphasis on structure first floor elevation, depth-per cent damage relationships, and content and structure values for urban studies); for studies in agriculture areas, other variables (e.g., time of year, crop type and costs of production) will be key and shall be used in the economic analysis; discharge associated with exceedance frequency for hydrologic studies; conveyance roughness and cross-section geometry for hydraulic studies; and reliability of existing structures.

c. The National Economic Development (NED) plan will be the scale of the flood damage reduction alternative that reasonably maximizes expected net benefits, (expected benefits less expected costs). It will be calculated explicitly including uncertainties in the key variables. Consideration of increments in project scale beyond the NED plan is permissible to improve project performance and to manage residual risks to people and property. Existing policy governing project increments beyond the NED plan must, however, be followed.

d. The estimate of NED benefits and costs will be reported both as a single expected value and on a probabilistic basis (value of the benefit and its associated probability) for each planning alternative. The confidence, in probabilistic terms, that net benefits are positive and that the benefit to cost ratio is at or above 1.0 and other selected values will be presented for each planning alternative.

e. The flood protection performance will be presented. The risk-based analysis will quantify the performance of all scales of all alternatives considered for final recommendation. This requires explicitly considering the joint effects of the uncertainties associated with key hydrologic, hydraulic, and geotechnical variables. This performance will be reported in the following three ways:

(1) the expected annual probability of the alternative being exceeded,

(2) the equivalent long-term risk of exceedance over 10-, 20-, and 50-years using the binomial formula, and

(3) the conditional probability of non-exceedance of specified events.

Additionally, this performance shall be described in terms of the percent chance of containing a specific historic flood should it occur.

f. The distribution of residual flood damage and other relevant aspects of residual risks shall also be displayed. The residual risk shall be reported as the expected annual probability of each alternative being exceeded. For comparison purposes, the without-project risk in terms of the annual probability of flood damages occurring and the annual probability of other property hazards (fire, wind, etc.) will be displayed. Residual human health and safety risks will be displayed. To aid this display and to improve the understanding of the residual risk, inundation maps showing flood depths, should the project be exceeded, shall be provided. In addition, a narrative scenario for events that exceed the project design shall be provided. Both the inundation map and the narrative scenario shall be provided for each alternative considered for final selection.

g. All project increments comprise different risk management alternatives represented by the tradeoffs among engineering performance, economic performance, and project costs. These increments contain differences in flood damage reduced, residual risk, and local and Federal project cost. It is vital that the local sponsor and residents understand these tradeoffs in order to fully participate in an informed decision-making process.

h. Special Guidance.

(1) The term and concept of freeboard to account for hydraulic uncertainty will no longer be used in levee and floodwall projects. The term or concept of level of protection is no longer useful and will not be used in describing project performance.

(2) Analysis to assure safe, reliable, and predictable performance of the project will be included. Such analysis will formulate features to manage overtopping at the least damaging or other planned location, which provides superiority at pumping stations and other critical locations. The analysis of these features will consider their contribution to the project’s performance, reliability, and cost.

CHAPTER 16

Security for Civil Works Structures

16-1. Policy. Security is another aspect of dam safety. A dam cannot be fully safe unless there is an adequate security plan. All dams within the USACE shall maintain an adequate security posture in order for the project to be operated in a safe and secure manner. The safety of employees, project visitors, and area residents should be considered. All project employees shall be familiar with the applicable security regulations, standard operating procedures and regulatory guidance and be capable of discharging their duties on the project site relative to security matters. The District Engineer is ultimately responsible for the security of the project site and personnel within in his/her area of responsibility (AOR) and shall rely upon the District Dam Safety committee for guidance.

16-2. General. All USACE dams shall maintain an adequate security posture so as to be operated in a safe and secure manner. It must be realized that the baseline security posture for day-to-day operations will vary from project to project. The baseline security posture for USACE dams will be based on the completion of project specific Vulnerability and Risk Assessments which take into account project criticality, threat (criminal or terrorist), current physical security posture and law enforcement response capabilities. Once established, the baseline security posture will become the norm.

16-3. Crime Prevention. Crime Prevention is a command responsibility. A successful program requires continuing command emphasis; criminal activity should not be allowed to detract from mission accomplishment.

16-4. Physical Security Plan. All dams will have a project specific Physical Security Plan. The format for this plan should follow the format as detailed within Appendix F, FM 3-19-30 (Physical Security) as referenced by Chapter 2-9, AR 190-13 (The Army Physical Security Program). As required by regulatory guidance, the Physical Security Plan and all annexes shall be exercised once every two years to evaluate its effectiveness.

16-5. Physical Security Inspections**.** Inspections are conducted when no prior physical security inspection exists, at regularly scheduled intervals, and when directed by competent authority. Whenever possible security should be included in annual, periodic, and special inspections of projects. The inclusion of a security element in these inspections is intended to make the inspections more comprehensive.

16-6. Security Systems. The purpose of security systems installed at dams is to “Deter, Delay, Detect, and Assess”. This is accomplished through the deployment of a layered and an integrated system. Components of the system consist of but are not limited to Perimeter Fencing, Security Lighting, Access Control, Vehicle Barriers, Intrusion Detection Systems (IDS), Closed Circuit Television (CCTV), etc. The security system for a project should be inspected during regular dam safety inspections.

16-7. Antiterrorism: The basis for the USACE Antiterrorism Program is AR 515-13 (Antiterrorism). All dams will have a viable, project specific Antiterrorism and Force Protection Plan in place that allows for the elevation and decrease of Force Protection Condition Measures as detailed in Chapter B, AR 525-13. Each project (dam) shall have the capability to immediately attain and maintain the FPCON measures associated with Force Protection Condition "Alpha" through "Charlie" as defined in AR 525-13. Dams are only expected to be able to attain and maintain the measures required for the implementation of FPCON Delta for periods of short duration. District Engineers may increase the FPCON posture at specific project sites based upon the receipt of credible threat information. Should this be required, the applicable District shall notify HQUSACE of this requirement through the initiation of a CAT III Serious Incident Report (SIR), via Englink, with a copy to the Corps Dam Safety Officer. IAW the provisions of DA MSG, 111308ZMAR 02, Force Protection Condition (FPCON) Implementation, updated AR 525-13, Antiterrorism (4 Jan 02), District Engineers may initiate a process to waiver certain FPCON measures that are deemed inappropriate for current operations or for proper threat mitigation. Basically if it is determined that certain FPCON measures are inappropriate for current operations, or for proper threat mitigation, the MSC Commander can waive a particular measure, at a particular project site (dam) but not the whole FPCON Level. However, if a higher HQ (USACE or MSC) dictates the implementation of a particular measure, the district shall have to implement it. Blanket waivers are not authorized and are considered on a case-by-case basis. MSC's will establish the waiver process within their command.

16-8. Risk Assessment Methodology – Dams (Ram-D). RAM-D is a methodology developed by the Interagency Forum on Infrastructure Protection (IFIP), of which USACE was a Charter Member, to assess the vulnerability of dams regardless of the nature of its operation (production of hydro-electric power; navigation; flood control, etc.) All dams will undergo an initial assessment by a qualified team utilizing the RAM-D process. The risk assessment shall be reviewed as part of periodic inspections and a re-validation shall be scheduled if needed. Additionally, in cases where there has been significant change at the project site (new gates, new construction, change of mission, etc.) the risk assessment shall be reviewed as part of the implementation of the new operating plan.

16-9. Contingency and Crisis Management Plans. All dams will require a Contingency and Crisis Management Plan. For significant and high hazard potential dams, this plan should be an annex to the Emergency Action Plan. These plans should document the steps how the respective dams will respond to increased security requirements and/or react to various disasters (man-made or otherwise). One element that should not be overlooked in these plans is the "Communications" segment detailing internal and external communications schemes.

16-10. Resource Plan. The District Dam Safety Committee shall review the project resource plans for security related items as part of it overall review of the project's annual budget submission for dam safety related items.

16-11. Reporting Requirements. All criminal activity (theft, vandalism, assault, trespassing, etc.) occurring on dam project sites will be reported immediately to the respective District Security Officers and documented and/or reported IAW ER 190-1-50 and/or AR 190-40 and USACE Supplement to AR 190-40. Additionally, all suspicious incidents (i.e.; suspected

surveillance of facilities, out of the ordinary visitors, etc.) shall also be reported to the District Security Officer who in-turn will initiate a TSI Report via Englink. Activity directly effecting the safety of a dam shall also be report to the Dam Safety Officer.

APPENDIX A

References

1. Basinger 1990
Basinger, D.L. 1990 (Feb). "Have You Reviewed Your Emergency Action Plan Lately?", *Hydro Review*, Vol 9, No. 1, pp 22-28.

2. Duscha 1982
Duscha, L.A. 1982 (Apr). "U.S. Army Corps of Engineers Programs for Safety of Dams in the United States," United States Committee on Large Dams, *Dam Safety Practices and Concerns in the United States*, Denver, CO pp 25-54.

3. Duscha and Jansen 1988
Duscha, L.A. and Jansen, R.B. 1988. "Surveillance," Jansen, R.B., ed., *Advanced Dam Engineering for Design, Construction, and Rehabilitation*, Van Nostrand Reinhold, New York, pp 777-797.

4. EM 1110-1-1004 *Geodetic and Control Surveying*

5. EM 1110-2-1619, *Risk-Based Analysis for Flood Damage Reduction Studies.*

6. EM 1110-2-1908, *Instrumentation of Embankment Dams and Levees.*

7. EM 1110-2-1913 *Design and Construction of Levees*

8. EM 1110-2-2200, *Gravity Dam Design.*

9. EM 1110-2-2300 *Earth and Rock-Fill Dams: General Design and Construction*

10. EM 1110-2-4300 *Instrumentation for Concrete Structures*

11. ER 5-7-1(FR), *Project Management*.

12. ER 200-2-2, *Procedures for Implementing NEPA.*

13. ER 405-1-12, *Real Estate Handbook.*

14. ER 690-1-1212, *Professional Registration as a Selective Placement Factor.*

15. ER 1105-2-20 (Chapter 7)

16. ER 1105-2-100, *Planning Guidance Notebook.*

17. ER 1105-2-101, *Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies*

18. ER 1110-1-1901, *Project Geotechnical and Concrete Materials Completion Report for Major USACE Projects.*

19. ER 1110-1-8158 *Corps-wide Centers of Expertise*

20. ER 1110-2-103, *Strong Motion Instrument for Recording Earthquake Motions in Dams,*

21. ER 1110-2-111, *Periodic Safety Inspection and Continuing Evaluation of USACE Bridges.*

22. ER 1110-2-240 *Water control Management*

23. ER 1110-2-1150, *Engineering and Design of Civil Works Projects*.

24. ER 1110-2-1302, *Civil Works Cost Estimating.*

25. ER 1110-2-1802, *Reporting Earthquake Effects*.

26. ER 1110-2-1806, *Earthquake Design and Evaluation for Civil Works Projects.*

27. ER 1110-2-1942, *Inspection, Monitoring and Maintenance of Relief Wells.*

28. ER 1110-2-8157, *Responsibility for Hydraulic Steel Structures.*

29. ER 1110-8-2 (FR), *Inflow Design Floods for Dams and Reservoirs*.

30. ER 1130-2-530, *Flood Control Operations and Maintenance Policies*.

31. ER 1165-2-132, *Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects.*

32. ETL 1110-2-231, *Initial Reservoir Filling*.

33. Federal Emergency Management Agency 1979
Federal Emergency Management Agency, 1979 (Jul). "Federal Guidelines for Dam Safety," FEMA 93, (Prepared by the Ad Hoc Interagency Committee on Dam Safety of the Federal Coordinating Council for Science, Engineering, and Technology), Washington, DC.

34. Federal Emergency Management Agency 1985a
Federal Emergency Management Agency. 1985 (Feb). "Emergency Action Planning Guidelines for Dams," FEMA 64, Washington, DC.

35. Federal Emergency Management Agency 1986b
Federal Emergency Management Agency. 1986, (Jan). "Training Courses Related to Dam Safety," FEMA 92, Washington, DC.

36. Federal Emergency Management Agency 1989a

Federal Emergency Management Agency. 1989 (Jan). "Exercise Design Course - Guide to Emergency Management Exercises," SM 170.2, Washington, DC.

37. Federal Emergency Management Agency 1989b
Federal Emergency Management Agency. 1989 (Jan). "Exercise Design Course - Student Workbook," SM 170.1, Washington, DC.

38. Federal Emergency Management Agency 1992b
Federal Emergency Management Agency. 1992 (Sep). "National Dam Safety Program, 1990 &1991 A Progress Report," FEMA 236, Vol 2, Washington, DC.

39. Federal Energy Regulatory Commission 1991
Federal Energy Regulatory Commission. 1991 (Apr). "Engineering Guidelines for the Evaluation of Hydropower Projects," FERC 0119-2, Washington, DC.

40. Gotzmer 1991
Gotzmer, J.W. 1991 (Sep). "Emergency Action Plans: The Comprehensive Exercise," *Proceedings of the Eighth Conference of the Association of State Dam Safety Officials,* pp 216-224.

41. "*Guidelines for Evaluating Modifications of Existing Dams Related to Hydrologic Deficiencies,*" IWR Report 86-R-7, October 1986.

42. International Commission on Large Dams 1987
International Commission on Large Dams. 1987. "Dam Safety Guidelines," Bulletin 59, Paris, France.

43. James 1990
James, R. 1990 (May). "Safety of Dams as Related to Design and Construction," *Design and Safety Surveillance of Embankment Dams,* U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

44. Jansen 1983
Jansen, R.B. 1983. *Dams and Public Safety,* U.S. Department of the Interior, Bureau of Reclamation, Denver, CO.

45. Jansen 1988b
Jansen, R.B. 1988 (Jun). "Dam Safety in America," *Hydro Review,* Vol 7, No 3, pp 10-20.

46. Mahoney 1990
Mahoney, D.J. 1990 (Jun). "FERC's Dam Safety Program: A New Focus on Monitoring," *Hydro Review,* Vol 9, No. 3, pp 38-45.

47. Morrison-Knudsen Engineers, Inc. 1986
Morrison-Knudsen Engineers, Inc. 1986 (Sep). "Inspection and Performance Evaluation of Dams," EPRI AP-4714, Electric Power Research Institute, Palo Alto, CA.

48. National Research Council 1985
National Research Council, 1985. *Safety of Dams, Flood and Earthquake Criteria,* National Academy Press, Washington, DC.

49. Policy Guidance Letter No. 26, Benefit Determination Involving Existing Levees, 23 December 1991.[3]

50. Policy Guidance Letter No. 39, "Responsibilities of the Corps of Engineers and Local Sponsor to Ensure Safe Operation, Maintenance, Repair, Replacement and Rehabilitation for Flood Control and Multipurpose Dams Constructed Under the Provisions of PL 99-662," dated 13 November 1992.

51. Reclamation Safety of Dams Act Amendments of 1984, P.L. 98-404.

52. Reed 1987
Reed, J.A. 1987 (Nov). "Suggested Procedures for Safety Inspection of Dams," Ohio Department of Natural Resources, Columbus, OH.

53. Schurer et al 1988
Schurer, J., Wilkerson, E., Norfleet, J.,Sciver, J.V., Huntington, C., Lee, C., and Rogers, A. 1988 (Jan). "Dam Safety Manual," Denver, CO.

54. Section 216, River and Harbor and Flood Control Act of 1970 (P.L. 91-611).

55. United States Committee on Large Dams 1982
United States Committee on Large Dams. 1982 (Apr). "Dam Safety Practices and Concerns in the United States," Denver, CO.

56. U.S. Army Corps of Engineers, Hydrologic Engineering Center 1980
U.S. Army Corps of Engineers, Hydrologic Engineering Center. 1980 (Jun). "Flood Emergency Plans Guidelines for Corps Dams," Research Document No. 13, Davis, CA.

57. U.S. Army Corps of Engineers, Hydrologic Engineering Center 1982
U.S. Army Corps of Engineers, Hydrologic Engineering Center. 1982 (Jan). "Emergency Planning for Dams, Bibliography and Abstracts of Selected Publications," Davis, CA.

58. U.S. Army Corps of Engineers, Hydrologic Engineering Center 1983a
U.S. Army Corps of Engineers, Hydrologic Engineering Center 1983a (Aug). "Example Emergency Plan for Blue Marsh Dam and Lake," Research Document No. 19, Davis, CA.

59. U.S. Army Corps of Engineers, Hydrologic Engineering Center 1983b

[3] The Planning Guidance Letters can be found at http://www.usace.army.mil/inet/functions/cw/cecwp/branches/guidance_dev/pgls/pglindex.htm

U.S. Army Corps of Engineers, Hydrologic Engineering Center 1983b (Aug). "Example Plan for Evacuation of Reading, Pennsylvania, in the Event of Emergencies at Blue Marsh Dam and Lake," Research Document No. 20, Davis, CA.

60. U.S. Army Engineer District, Omaha 1987
U.S. Army Engineer District, Omaha. 1987 (Aug). "Garrison Dam Safety Training Exercise, Lake Sakakawea, Missouri River, North Dakota," Omaha, NE.

61. Veesaert 1990
Veesaert, C.J. 1990 (Jun). "Standardizing the Approach to Dam Safety Training," *Hydro Review,* Vol 9, No 3, pp 46-50.

62. Walz, 1990a
Walz, A.H. 1990 (May). "History of Dam Safety." *Design and Safety Surveillance of Embankment Dams,* U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

63. Walz 1990b
Walz, A.H. 1990 (May). "History of Dam Safety," *Design and Safety Surveillance of Embankment Dams,* U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

64. Water Resources Development Act of 1986, P.L. 99-662, Title XII.

65. WinIDP; *Corps of Engineer Data Management Software*.

APPENDIX B

Glossary

B-1 Abbreviations.

ADAS.....Automated Data Acquisition System

ASDSO.....Association of State Dam Safety Officials

BSC.....Base Safety Condition

CEDSPMT…Corps of Engineers Dam Safety Program Management Team

COE.....Corps of Engineers

CQC.....Contractor Quality Control

DA.....Department of the Army

DDR.....Design Documentation Report

DHS Department of Homeland Security

DSAP.....Dam Safety Assurance Program

DSPMT….Dam Safety Program Management Tools

EAP.....Emergency Action Plan

ERDC Engineer Research and Development Center

EIS.....Environmental Impact Statement

EPRI.....Electric Power Research Institute

FCCSET.....Federal Coordinating Council for Science, Engineering, and Technology

FC, MR&T...Flood Control, Mississippi River and Tributaries

FCSA.....Feasibility Cost Sharing Agreement

FEMA.....Federal Emergency Management Agency

HQUSACE...Headquarters, U.S. Army Corps of Engineers

HSS.....Hydraulic Steel Structures

HTRW.....Hazardous, Toxic and Radioactive Waste

ICODS.....Interagency Committee on Dam Safety

ICOLD.....International Commission on Dam Safety

IDF.....Inflow Design Flood

IPMP.....Initial Project Management Plan

IRC.....Issue Resolution Conference

ITR Independent Technical Review

LCA.....Local Cooperation Agreement

MCACES...Micro Computer Aided Cost Engineering System

MCE.....Maximum Credible Earthquake

MDE.....Maximum Design Earthquake

MSC.....Major Subordinate Commands

NDSRB....National Dam Safety Review Board

O&M.....Operation and Maintenance

OBE.....Operating Basis Earthquake

OMRR&R...Operation, Maintenance, Repair, Replacement and Rehabilitation

P&S.....Plans and Specifications

PCA.....Project Cooperation Agreement

PCCR.....Policy Compliance & Criteria Review

PDT Project Delivery Team

PED.....Preconstruction Engineering and Design

PGM.....Project Guidance Memo

PMF.....Probable Maximum Flood

PMP.....Probable Maximum Precipitation

PMP.....Project Management Plan

PPMD.....Programs and Project Management Division

PROSPECT...Proponent-Sponsored Engineer Corps Training

QA.....Quality Assurance

RAM-D Risk Assessment Methodology for Dams

REMR.....Repair, Evaluation, Maintenance, and Rehabilitation

SDF.....Spillway Design Flood

SEE.....Safety Evaluation Earthquake

SEF.....Safety Evaluation Flood

SSR.....Seismic Safety Review

TADS.....Training Aids for Dam Safety

TF.....Threshold Flood

TRC.....Technical Review Conference

USACE.....United States Army Corps of Engineers

USCOLD...U.S. Committee on Large Dams (renamed United States Society on Dams, USSD)

USSD United States Society of Dams

VE.....Value Engineering

WES.....U.S. Army Engineer Waterways Experiment Station

WRDA.....Water Resources Development Act

B-2 Terms.

Abutment
That part of the valley side against which the dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section to take the thrust of an arch dam where there is no suitable natural abutment. The left and right abutments of dams are defined with the observer viewing the dam looking in the downstream direction, unless otherwise indicated.

Acre-foot
A unit of volumetric measure that would cover 1 acre to a depth of 1 foot. It is equal to *43,560* cubic feet.

Adit
A nearly horizontal underground excavation in an abutment having an opening in only one end. An opening in the face of a dam for access to galleries or operating chambers.

Appurtenant structure
Ancillary features of a dam such as inlet and outlet works, spillways, tunnels, or powerplants.

Axis of dam
The vertical plane or curved surface, chosen by a designer, appearing as a line, in plan, or in cross-section, to which the horizontal dimensions of the dam are referenced.

Baffle block
A block, usually of concrete, constructed in a channel or stilling basin to dissipate the energy of water flowing at high velocity.

Base thickness
Also referred to as base width. The maximum thickness or width of the dam measured horizontally between upstream and downstream faces and normal to the axis of the dam, but excluding projections for outlets, or other appurtenant structures.

Batter
Angle of inclination from the vertical.

Bedrock
The consolidated body of natural solid mineral matter which underlies the overburden soils.

Berm
A nearly horizontal step in the sloping profile of an embankment dam. Also a step in a rock or earth cut.

Borrow area
The area from which material for an embankment is excavated.

Breach
An eroded opening through a dam, which drains the reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional opening, which allows uncontrolled discharge from the reservoir.

Catastrophe
A sudden and great disaster causing misfortune, destruction, or irreplaceable loss extensive enough to cripple activities in an area.

Channel
A general term for any natural or artificial facility for conveying water.

Cofferdam
A temporary structure enclosing all or part of the construction area so that construction can proceed in the dry. A diversion cofferdam diverts a river into a pipe, channel, or tunnel.

Compaction
Mechanical action, which increases the density by reducing the voids in a material.

Conduit
A closed channel to convey water through, around, or under a dam.

Construction joint
The interface between two successive placings or pours of concrete where bond, and not permanent separation, is intended.

Contact grouting
Filling, with cement grout, any voids existing at the
contact of two zones of different materials, e.g.,
between a concrete tunnel lining and the surrounding
rock.

Contractor Quality Control (CQC)
The construction contractor's system to manage, control, and document his own, his supplier's, and his subcontractor's activities to comply with contract requirements.

Core
A zone of low permeability material in an embankment dam. The core is sometimes referred to as central core, inclined core, puddle clay core, rolled
clay core, or impervious zone.

Core wall
A wall built of relatively impervious material, usually
of concrete or asphaltic concrete, in the body of an
embankment dam to prevent seepage.

Crest of dam
See top of dam.

Cross section
An elevation view of a dam formed by passing a plane through the dam perpendicular to the axis.

Cutoff trench
A foundation excavation later to be filled with impervious material so as to limit seepage beneath a dam.

Cutoff wall
A wall of impervious material usually of concrete, asphaltic concrete, or steel sheet piling constructed in the foundation and abutments to reduce seepage beneath and adjacent to the dam.

Dam
A barrier constructed across a watercourse for the purpose of storage, control, or diversion of water.

a. Afterbay dam. See regulating dam.

b. Ambursen dam. A buttress dam in which the upstream part is a relatively thin flat slab usually
made of reinforced concrete.

*c. Arch dam. A c*oncrete or masonry dam, which is curved upstream so as to transmit the major part of the water load to the abutments.

d. Buttress dam. A dam consisting of a watertight part supported at intervals on the downstream side by a series of buttresses. A buttress dam can take many forms, such as a flat slab or a massive head buttress.

e. Cofferdam. A temporary structure enclosing all or part of the construction area so that construction can proceed in the dry. A diversion cofferdam diverts a stream into a pipe, channel, tunnel, or other watercourse.

f. Crib dam. A gravity dam built up of boxes, crossed timbers, or gabions filled with earth or rock.

g. Diversion dam. A dam built to divert water from a waterway or stream into a different watercourse.

h. Double curvature arch dam. An arch dam, which is curved vertically as well as horizontally.

i. Earth dam. An embankment dam in which more than 50 percent of the total volume is formed of compacted earth material generally smaller than 3-inch size.

j. Embankment dam. Any dam constructed of excavated natural materials or of industrial waste materials.

k. Gravity dam. A dam constructed of concrete and/or masonry, which relies on its weight and internal strength for stability.

1. Hollow gravity dam. A dam constructed of concrete and/or masonry on the outside but having a hollow interior and

relying on its weight for stability.

m. Hydraulic fill dam. An earth dam constructed of materials, often dredged, which are conveyed and placed by suspension in flowing water.

n. Industrial waste dam. An embankment dam, usually built in stages, to create storage for the~ disposal of waste products from an industrial process. The waste products are conveyed as fine material suspended in water to the reservoir impounded by the embankment. The embankment may be built of conventional materials but sometimes incorporates suitable waste products.

o. *Masonry dam.* Any dam constructed mainly of stone, brick, or concrete blocks jointed with mortar. A dam having only a masonry facing should not be referred to as a masonry dam.

p. *Mine tailings dam.* An industrial waste dam in which the waste materials come from mining operations or mineral processing.

q. Multiple arch dam. A buttress dam composed of a series of arches for the upstream face.

r. Overflow dam. A dam designed to be overtopped.

s. Regulating dam. A dam impounding a reservoir from which water is released to regulate the flow downstream.

t. Rockfill dam. An embankment dam in which more than 50 percent of the total volume is composed of compacted or dumped cobbles, boulders, rock fragments, or quarried rock generally larger than 3-inch size.

u. Roller-compacted concrete dam. A concrete gravity dam constructed by the use of a dry mix concrete transported by conventional construction equipment and compacted by rolling, usually with vibratory rollers

v. Rubble dam. A stone masonry dam in which the stones are unshaped or uncoursed.

w. Saddle dam (or dike). A subsidiary dam of any type constructed across a saddle or low point on the perimeter of a reservoir.

x. Tailings dam. See mine tailings dam.

Dam failure
The uncontrolled release of impounded water. It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters, which adversely affect a dam's primary function of impounding water, is properly considered a failure. They are, however, normally amenable to corrective action.

Dam Safety:
Dam safety is the art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe functioning is not explicitly determined by its original design and construction. It also includes all actions taken to identify or predict deficiencies and consequences related to failure, and to document, publicize, and reduce, eliminate, or remediate to the extent reasonably possible any unacceptable risks.

Dam Safety Program
The purposes of a dam safety program are to protect life, property, and the environment by ensuring that all dams are designed, constructed, operated, and maintained as safely and effectively as is reasonably possible. Accomplishing these purposes require commitments to continually inspect, evaluate, and document the design, construction, operations, maintenance, rehabilitation, and emergency preparedness

of each dam and the associated public. It also requires the archiving of documents on the inspections and history of dams and the training of personnel who inspect, evaluate, operate, and maintain them. Programs must instill an awareness of dams and the potential hazard that they may present in the owners, the users, the public, and the local and national decision-makers. On both local and national scales, program purposes also include periodic reporting on the degree of program implementation. Key to accomplishing these purposes is to attract, train, and retain a staff proficient in the art and science of dam design.

Dam safety preparedness
The quality or state of being prepared to deal with emergency conditions which endanger the structural integrity of the dam and/or downstream property and human life.

Design water level
The maximum water elevation including the flood surcharge that a dam is designed to withstand.

Design wind
The most severe wind that is reasonably possible at a particular reservoir for generating wind setup and runup. The determination will generally include the results of meteorological studies, which combine wind velocity, duration, direction, and seasonal distribution characteristics in a realistic manner.

Diaphragm wall (membrane)
A sheet, thin zone, or facing made of an impervious
material such as concrete, steel, wood, or plastic.
Also see core wall.

Dike
See saddle dam.

Diversion channel, canal, or tunnel
A waterway used to divert water from its natural course. The term is generally applied to a temporary arrangement, e.g., to by-pass water around a dam site during construction. "Channel" is normally used instead of "canal" when the waterway is short.

Drain, blanket
A layer of pervious material placed to facilitate drainage of the foundation and/or embankment**.**

Drain, chimney
A vertical or inclined layer of pervious material in an embankment to facilitate and control drainage of the embankment fill.

Drain, toe
A system of pipe and/or pervious material along the downstream toe of a dam used to collect seepage from the foundation and embankment and convey it to a free outlet.

Drainage area
The area, which drains to a particular point on a river or stream.

Drainage curtain
Also called drainage wells or relief wells. A line of vertical wells or boreholes to facilitate drainage of the foundation and abutments and to reduce water pressure.

Drawdown
The difference between a water level and a lower
water level in a reservoir within a particular time.
Used as a verb, it is the lowering of the water surface.

Earthquake
A sudden motion or trembling in the earth caused by the abrupt release of accumulated stress along a fault.

Earthquake, Maximum Credible (MCE)
The most severe earthquake that can be expected to occur at a given site on the basis of geologic and seismological evidence.

Earthquake, Maximum Design (MDE)
A postulated seismic event, specified in terms of specific bedrock motion parameters at a given site, which is used to evaluate the seismic resistance of man-made structures or other features at the site.

Earthquake, Operating Basis (OBE)
The earthquake(s) for which the structure is designed to resist and remain operational. It reflects the level of earthquake protection desired for operational or economic reasons and may be determined on a probabilistic basis considering the regional and local geology and seismology.

Earthquake, Safety Evaluation (SEE)
The earthquake, expressed in terms of magnitude and closest distance from the dam site or in terms of the characteristics of the time history of free-field ground motions, for which the safety of the dam and critical structures associated with the dam are to be evaluated. In many cases, this earthquake will be the maximum~ credible earthquake to which the dam will be exposed. However, in other cases where the possible sources of ground motion are not easily apparent, it may be a motion with prescribed characteristics selected on the basis of a probabilistic assessment of the ground motions that may occur in the vicinity of the dam. To be considered safe, it should be demonstrated that the dam can withstand this level of earthquake shaking without release of water from the reservoir.

Earthquake, synthetic
Earthquake time history records developed from mathematical models that use white noise, filtered white noise, and stationary and nonstationary filtered white noise, or theoretical seismic source models of failure in the fault zone. (White noise is random energy containing all frequency components in equal proportions. Stationary white noise is random energy with statistical characteristics that do not vary with time).

Embankment
A raised structure to hold back water or to carry a roadway.

Emergency
An emergency, in terms of dam operation, is a condition, which develops unexpectedly, endangers the structural integrity of the dam and/or downstream property and human life, and requires immediate action.

Emergency Action Plan (EAP)
A plan of action to be taken to reduce the potential for property damage and loss of life in an area affected by a dam failure or large flood.

Energy dissipater
A device constructed in a waterway to reduce the kinetic energy of fast flowing water.

Epicenter
The point on the earth's surface located vertically above the point of origin of an earthquake.

Fault
A fracture or fracture zone in the earth crust along which there has been displacement of the two sides relative to one another.

Fault, active
A fault which, because of its present tectonic setting, can undergo movement from time to time in the immediate geologic future.

Fault, capable
An active fault that is judged capable of producing macro earthquakes and exhibits one or more of the following characteristics:

a. Movement at or near the ground surface at least once within the past *35,000* years.

b. Macroseismicity (3.5 magnitude Richter or greater) instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault.

c. A structural relationship to a capable fault such that movement on one fault could be reasonably expected to cause movement on the other.

d. Established patterns of microseismicity, which define a fault, with historic macroseismicity that can reasonably, be associated with the fault.

Fetch
The straight-line distance across a body of water subject to wind forces. The fetch is one of the factors used in calculating wave heights in a reservoir.

Filter (filter zone)
One or more layers of granular material graded (either naturally or by selection) so as to allow seepage through or within the layers while preventing the migration of material from adjacent zones.

Flashboards
Structural members of timber, concrete, or steel placed in channels or on the crest of a spillway to raise the reservoir water level but that may be quickly removed in the event of a flood.

Flip bucket
An energy dissipater located at the downstream end of a spillway and shaped so that water flowing at a high velocity is deflected upwards in a trajectory away from the foundation of the spillway.

Flood
A temporary rise in water levels resulting in inundation of areas not normally covered by water. May be expressed in terms of probability, of exceedance per year such as one percent chance flood or expressed as a fraction of the probable maximum flood or other reference flood.

Flood routing
A process of determining progressively over time the amplitude of a floodwave as it moves past a dam or downstream to successive points along a river or stream.

Flood, antecedent
A flood or series of floods assumed to occur prior to the occurrence of an inflow design flood.

Flood, base safety standard (BSS)
The inflow design flood where there is no significant increase in adverse consequences from dam failure compared to non-failure adverse consequences.

Flood, Safety Evaluation (SEF)
The largest flood for which the safety of a dam and appurtenant structure is to be evaluated.

Flood, Inflow Design (IDF)
The flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Flood, Probable Maximum (PMF)
The most severe flood that is considered reasonably possible at a site as a result of meteorological and hydrologic conditions.

Floodplain
An area adjoining a body of water or natural stream that has been or may be covered by floodwater.

Freeboard
Vertical distance between the design water level and the top of dam.

Full pool
The reservoir level that would be attained when the reservoir is fully utilized for all project purposes, including flood control.

Gallery
A passageway in the body of a dam used for inspection, foundation grouting, and/or drainage.

Gantry crane
A fixed or traveling bent-supported crane for handling heavy equipment.

Gate
A movable, watertight barrier for the control of water in a waterway.

a. *Bascule gate.* See flap gate.

b. Bulkhead gate. A gate used either for temporary closure of a channel or conduit before dewatering it for inspection or maintenance or for closure against flowing water when the head difference is small, e.g., for diversion tunnel closure.

c. Crest gate (spillway gate). A gate on the crest of a spillway to control the discharge or reservoir water level.

d. Drum gate. A type of spillway gate consisting of a long hollow drum. The drum may be held in its raised position by the

water pressure in a flotation chamber beneath the dam.

e. Emergency gate. A standby or auxiliary gate used when the normal means of water control is not available. Sometimes referred to as guard gate.

f. Fixed wheel gate (fixed roller gate or fixed axle gate). A gate having wheels or rollers mounted on the end posts of the gate. The wheels bear against rails fixed in side grooves or gate guides.

g. Flap gate. A gate hinged along one edge, usually either the top or bottom edge. Examples of bottom-hinged flap gates are tilting gates and fish belly gates so called from their shape in cross section.

h. Flood gate. A gate to control flood release from a reservoir.

i. Outlet gate. A gate controlling the flow of water through a reservoir outlet.

j. Radial gate (tainter gate). A gate with a curved upstream plate and radial arms hinged to piers or other supporting structure.

k. Regulating gate (regulating valve). A gate or valve that operates under full pressure flow conditions to regulate the rate of discharge.

l. Roller drum gate. See drum gate.

m Roller gate (stoney gate). A gate for large openings that bears on a train of rollers in each gate guide.

n. Skimmer gate. A gate at the spillway crest whose prime purpose is to control the release of debris and logs with a limited amount of water. It is usually a bottom hinged flap or Bascule gate.

o. Slide gate (sluice gate). A gate that can be opened or closed by sliding in supporting guides.

Gate chamber
Also called valve chamber. A room from which a gate or valve can be operated, or sometimes in which the gate is located.

Geotextiles
Any fabric or textile (natural or synthetic) when used as an engineering material in conjunction with soil, foundations, or rock. Geotextiles have the following uses: drainage, filtration, separation of materials, reinforcement, moisture barriers, and erosion protection.

Groin
The area along the contact (or intersection) of the face of a dam with the abutments.

Grout
A fluidized material that is injected into soil, rock, concrete, or other construction material to seal openings and to lower the permeability and/or provide additional structural strength. There are four major types of grouting materials: chemical, cement, clay, and bitumen.

Grout curtain
One or more zones, usually thin, in the foundation into which grout is injected to reduce seepage under or around a dam.

Grout blanket
An area of the foundation systematically grouted to a uniform shallow depth.

Grout cap
A concrete pad constructed to facilitate subsequent pressure grouting of the grout curtain.

Hazard classification
The rating for a dam based on the potential consequences of failure. The rating is based on potential for loss of life and damage to property that failure of that dam could cause. Such classification is related to the amount of development downstream of a dam.

Head, static
The vertical distance between two points in a fluid.

Head, velocity
The vertical distance that would statically result from the velocity of a moving fluid.

Headrace
A free-flow tunnel or open channel that

conveys water to the upper end of a penstock; hence, the terms “headrace tunnel” and ‘headrace Canal.”

Heel
The junction of the upstream face of a gravity or arch dam with the ground surface. For an embankment dam the junction is referred to as the upstream toe of the dam.

Height, above ground
The maximum height from natural ground surface to the top of a dam.

Height, hydraulic
The vertical difference between the maximum design water level and the lowest point in the original streambed.

Height, structural
The vertical distance between the lowest point of the excavated foundation to the top of the dam.

Heel
The junction of the upstream face of a gravity or arch dam with the ground surface. For an embankment dam the junction is referred to as the upstream toe of the dam.

Height, above ground
The maximum height from natural ground surface to the top of a dam.

Height, hydraulic
The vertical difference between the maximum design water level and the lowest point in the original streambed.

Height, structural
The vertical distance between the lowest point of the excavated foundation to the top of the dam.

Inclinometer
An instrument, usually consisting of a metal or plastic tube inserted in a drill hole and a sensitized monitor either lowered into the tube or fixed within the tube. This measures at different points the tube’s inclination to the vertical. By integration, the lateral position at different Levels of the tube may be found relative to a point, usually the top or bottom of the tube, assumed to be fixed. The system may be used to measure settlement during embankment construction (Bartholomew, Murray, and Goins 1987). A reference benchmark is used to establish the top of the inclinometer casing. The instrument probe is lowered to each slip joint in the casing, and the depth to each joint is read directly off the tape. Settlement measurements are made as each section of casing is added during embankment construction.

Initial reservoir filling
A deliberate impoundment to meet project purposes
(a continuing process as successively higher pools are
attained for flood control projects).

Instrumentation
An arrangement of devices installed into or near dams (i.e., piezometers, inclinometers, strain gages, measurement points, etc.), which provide for measurements that can be used to evaluate the structural behavior and performance parameters of the structure.

Intake
Any structure in a reservoir, dam, or river through which water can be discharged.

Inundation map
A map delineating the area that would be flooded by a particular flood event.

Length of dam
The length along the top of the dam. This also includes the spillway, powerplant, navigation lock, fish pass, etc., where these form part of the length of the dam. If detached from the dam these structures should not be included.

Liquefaction
A condition whereby soil undergoes continued deformation at a constant low residual stress or with low residual resistance, due to the buildup and maintenance of high pore water pressures, which reduces the effective confining pressure to a very low value. Pore pressure buildup Leading to liquefaction may be due either to static or cyclic stress applications and the possibility of its occurrence will depend on the void ratio or relative density of a cohesionless or slightly cohesive soil and the confining pressure.

Logboom
A chain of logs, drums, or pontoons secured end-to-end and floating on the surface of a reservoir so as to divert floating debris, trash, and logs.

Maximum flood control level
The highest elevation of the flood control storage.

Maximum pool
The highest pool elevation resulting from the inflow design flood.

Maximum wave
The highest wave in a wave group.

Minimum operating level
The lowest level to which the reservoir is drawn down under normal operating conditions.

Observation well
A hole used to observe the groundwater surface at atmospheric pressure within soil or rock.

Outlet
An opening through which water can be discharged.

Outlet works
A device to provide controlled releases from a reservoir.

Parapet wall
A solid wall built along the top of a dam (upstream or downstream edge) used for ornamentation, for safety of vehicles and pedestrians, or to prevent overtopping caused by wave runup.

Penstock
A pressurized pipeline or shaft between the reservoir and hydraulic machinery.

Phreatic surface
The free surface of water seeping at atmospheric pressure through soil or rock.

Piezometer
An instrument used for measuring fluid pressure (air or water) within soil, rock, or concrete.

Piping
The progressive development of internal erosion by seepage.

Plunge pool
A natural or artificially created pool that dissipates the energy of free falling water.

Pore water pressure
The interstitial water pressure within a mass of soil, rock, or concrete.

Probability
The likelihood of an event occurring.

Probable Maximum Precipitation (PMP)
Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location.

Pumped storage reservoir
A reservoir filled entirely or mainly with water pumped from outside its natural drainage area.

Quality (as related to construction)
Conformance to properly developed requirements.

Quality Assurance (QA)
The procedure by which the Government fulfills its responsibility to be certain the contractors' quality control is functioning and the specified end product is realized.

Quality Management
All control and assurance activities instituted to achieve the product quality established by the contract requirements

Reservoir
A body of water impounded by a dam and in which water can be stored.

Reservoir regulation (or operating) procedure

Operating procedures that govern reservoir storage and releases.

Reservoir surface area
The area covered by a reservoir when filled to a specified level.

Riprap
A layer of large uncoursed stone, precast blocks, bags of cement, or other suitable material, generally placed on the upstream slopes of an embankment or along a watercourse as protection against wave action, erosion, or scour. Riprap is usually placed by dumping or other mechanical methods and in some cases is hand placed. It consists of pieces of relatively large size as distinguished from a gravel blanket. Also known as stone slope protection.

Risk
The relationship between the consequences resulting from an adverse event and its probability of occurrence.

Risk assessment
As applied to dam safety, the process of identifying the likelihood and consequences of dam failure to provide the basis for informed decisions on a course of action.

Rock anchor
A steel rod or cable placed in a hole drilled in rock, held in position by grout, mechanical means, or both. In principle, the same as a rock bolt, but usually the rock anchor is more than 4 meters long.

Rock bolt
A steel rod placed in a hole drilled in rock, held in position by grout, mechanical means, or both. A rock bolt can be pretensioned.

Runup
The vertical distance above the setup that the rush of water reaches when a wave breaks on the dam embankment.

Seepage
The interstitial movement of water that may take place through a dam, its foundation, or its abutments.

Significant wave height
The average height of the one-third highest waves of a given wave group.

Sill
A submerged structure across a river to control the water level upstream. The crest of a spillway. A horizontal gate seating, made of wood, stone, concrete, or metal at the invert of any opening or gap in a structure; hence, the expressions “gate sill” and “stoplog sill.”

Slope
Inclination from the horizontal. Sometimes referred to as batter when measured from vertical.

Sluice
An opening for releasing water from below the static head elevation.

Spillway
A structure over or through which flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway.

Spillway, auxiliary
Any secondary spillway, which is designed to be operated very infrequently and possibly in anticipation of some degree of structural damage or erosion to the spillway during operation.

Spillway, primary (or service)
A spillway designed to provide continuous or frequent releases from a reservoir without significant damage to either the dam or its appurtenant structures.

Spillway Design Flood (SDF)
See Flood, Inflow Design.

Spillway channel
An open channel or closed conduit conveying water from the spillway inlet downstream.

Spillway chute

A steeply sloping spillway channel that conveys discharges at supercritical velocities.

Spillway crest
The lowest level at which water can flow over or through the spillway.

Spillway, fuse plug
A form of auxiliary spillway consisting of a low embankment designed to be overtopped and washed away during an exceptionally large flood.

Spillway, shaft
A vertical or inclined shaft into which water spills and then is conveyed through, under, or around a dam by means of a conduit or tunnel. If the upper part of the shaft is splayed cut and terminates in a circular horizontal weir, it is termed a bellmouth or morning glory spillway.

Stilling basin
A basin constructed to dissipate the energy of rapidly. flowing water, e.g., from a spillway or outlet, and to protect the riverbed from erosion.

Stoplogs
Large logs, timbers, metal beams, or metal frames placed on top of each other with their ends held in guides on each side of a channel or conduit so as to provide a cheaper or more easily handled means of temporary closure than a bulkhead gate.

Storage
The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel. Definitions of specific types of storage in reservoirs are:

a. Dead storage. The storage that lies below the invert of the lowest outlet and that, therefore, cannot readily be withdrawn from the reservoir.

b. Inactive storage. The storage volume of a reservoir between the crest of the invert of the lowest outlet and the minimum operating level.

c. Active storage. The volume of the reservoir that is available for some use such as power generation, irrigation, flood control, or water supply. The bottom elevation is the minimum operating level.

d. Live storage. The sum of the active and the inactive storage.

e. Reservoir capacity. The sum of the dead and live storage of the reservoir.

f. Flood surcharge. The storage volume between the top of the active storage and the design water level.

Surcharge
Any storage above the full pool.

Tailrace
The tunnel, channel, or conduit that conveys the discharge from the turbine to the river; hence, the terms “tailrace tunnel” and “tailrace canal.”

Tailwater level
The level of water in the tailrace at the nearest free surface to the turbine or in the discharge channel immediately downstream of the dam.

Threshold Flood
The flood that fully utilizes the existing dam, i.e., the flood that just exceeds the design maximum water surface elevation at the dam.

Thrust block
A massive block of concrete built to withstand a thrust or pull.

Toe of dam
The junction of the face of a dam with the ground surface. For concrete dams, see heel.

Top thickness (top width)
The thickness or width of a dam at the level of the top of dam (excluding corbels or parapets). In general, the term thickness is used for gravity and arch dams, and width is used for other dams.

Top of dam
The elevation of the uppermost surface of a dam, usually a road or walkway excluding any parapet wall, railing, etc.

Trashrack
A device located at an intake to prevent floating or submerged debris from entering the intake.

Tunnel
A long underground excavation with two or more openings to the surface, usually having a uniform cross section used for access, conveying flows, etc.

Uplift
The uplift pressure in the pores of a material (interstitial pressure) or on the base of a structure.

Upstream blanket
An impervious blanket placed on the reservoir floor and abutments upstream of a dam. For an embankment dam, the blanket may be connected to the core.

Valve
A device fitted to a pipeline or orifice in which the closure member is either rotated or moved transversely or longitudinally in the waterway so as to control or stop the flow. .

a Hollow jet valve. A device for regulating high-pressure outlets. Essentially, it is half a needle valve in which the needle closure member moves upstream toward the inlet end of the valve to shut off flow. As there is no convergence at the outlet end, the flow emerges in the form of an annular cylinder, segmented by several splitter ribs for admitting air into the jet interior to prevent jet instability.

b. Regulating sleeve valve. **A** valve for regulating high-pressure outlets and ensuring energy dissipation. Inside the valve there is a fixed-cone, pointed upstream, which ensures dispersion of the jet. Outside the valve a cylindrical sleeve moves downstream to shut off flow by sealing on the periphery of the cone.

Volume of dam
The total space occupied by the materials forming the dam structure computed between abutments and from top to bottom of dam. No deduction is made for small openings such as galleries, adits, tunnels, and operating chambers within the dam structure. Portions of powerplants, locks, spillway, etc., should be included only if they are necessary for the structural stability of the dam.

Watershed divide
The divide or boundary between catchment areas (or drainage areas).

Waterstop
A strip of metal, rubber, or other material used to prevent leakage through joints between adjacent sections of concrete.

Wave runup
Vertical height above the stillwater level to which water from a specific wave will run up the face of a structure or embankment.

Weir
A notch of regular form through which water flows.

a. Weir, broad-crested. An overflow structure on which the nappe is supported for an appreciable length in the direction of flow.

b. Weir, measuring. A device for measuring the rate of flow of water. It generally consists of a rectangular, trapezoidal, triangular, or other shaped notch, located in a vertical, thin plate over which water flows. The height of water above the weir crest is used to determine the rate of flow.

c. Weir, ogee. A reverse curve, shaped like an elongated letter “S.” The downstream faces of overflow spillways are often made to this shape.

Wind setup
The vertical rise in the stillwater level at the face of a structure or embankment caused by

wind stresses on the surface of the water.

APPENDIX C

Dam Safety in the Corps of Engineers

C-1 Background.

The safety of dams has been a major concern of the Corps of Engineers since it began building dams in the 1840's. As part of the flood control development of the Muskingum River in the 1930's, the Corps started a multiple level of review requirement for dam design. This is currently being performed by an independent technical review at the District level. As designers, owners, and operators, USACE retains responsibility and accountability for the continued safe performance of our applicable dams and appurtenant structures, under the full range of anticipated loading conditions. For many years the Corps has made extensive use of experts to consult and advise on unusual and difficult designs. Advisory boards have been helpful in establishing design criteria and standards. Experience gained from the 1938 slide in the embankment of Fort Peck Dam led the Corps to adhere to the highest design standards and comprehensive inspection and testing for construction. The Corps was one of the first agencies to initiate a periodic inspection and evaluation program, and the COE program was used as input to the development of the "Federal Guidelines for Dam Safety" due to its early, comprehensive and effective program.

a. As a result of several dam failures in the mid 1970's, a Presidential Memorandum was issued on 23 April 1977 that required each Federal agency having responsibility for dams to review their practices and activities related to dam safety. This memorandum also directed the Federal Coordinating Council for Science, Engineering and Technology to prepare guidelines for management practices and procedures to ensure dam safety. "Federal Guidelines for Dam Safety" was published in June 1979, and with a memorandum dated 4 October 1979, President Carter asked each Federal agency having responsibility for dams to adopt and implement these guidelines and report their progress to the Federal Emergency Management Agency (FEMA) on a biennial basis. Executive Order 12148 gives FEMA the responsibility to coordinate dam safety in the nation. The purpose of these guidelines is to enhance national dam safety and to encourage high safety standards in the management procedures and technical activities of Federal agencies. The guidelines require the head of each Federal agency having responsibility for design, construction, operation and regulation of dams to establish a dam safety office (officer), which reports directly to the head of the agency. The Interagency Committee on Dam Safety (ICODS) was established in 1980 to promote and monitor Federal and State dam safety programs. The Corps of Engineers is the Department of Defense representative on ICODS.

b. On 7 February 1980, the Chief of Engineers appointed the Chief of the Engineering Division, Directorate of Civil Works, as the HQUSACE Dam Safety Officer. This appointment also required that the Dam Safety Officer chair a standing committee composed of individuals having assigned responsibilities for dam safety to include programming and policy functions. The purpose of this committee is to provide surveillance, evaluation, and guidance for the administrative, technical, and regulatory practices within the Corps of Engineers. The Dam Safety Officer is advisory to the Chief of Engineers, through the Director of Civil Works. The HQUSACE Dam Safety Officer is now Chief, Engineering and Construction Division.

c. New Safety of Dams Regulation. On December 14, 1999, HQUSACE authorized and requested that Tulsa District revise and consolidate the regulations on Safety of Dams. The purpose of this request was to consolidate regulations and pamphlets dealing with the Safety of Dams into a single Engineering Regulation (ER). The new ER is titled ER 1110-2-1156, *Safety of Dams - Policy and Procedure.* The new ER incorporates the following ER's and EP's:

EP 1110-2-13, *Dam Safety Preparedness*
ER 1110-2-50, *Engineering and Design - Low Level Discharge Facilities for Drawdown of Impoundments*
ER 1110-2-100, *Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures*
ER 1110-2-101, *Reporting of Evidence of Distress of Civil Works Structures*
ER 1110-1-110, *Instrumentation for Safety-Evaluations of Civil Works Projects*
ER 1110-2-1155, *Dam Safety Assurance Program*
ER 1110-2-1156, *Dam Safety - Organization, Responsibilities, and Activities*
ER 1110-2-1451, *Acquisition of Lands Downstream from Spillways for Hydrologic Safety Purposes*
ER 1165-2-119, *Water Resources Policies and Authorities - Modifications to Completed Projects* (only sections involving Safety of Dams)

Other regulations, manuals, and pamphlets as appropriate

The work was coordinated with the Dam Safety Team in Engineering and Construction Division, Directorate of Civil Works, and with the Corps of Engineers Dam Safety Program Management Team (CEDSPMT). The CEDSPMT, as defined in paragraph 3-2, consists of the MSC Dam Safety Program Managers, the HQUSACE Dam Safety Team, and field personnel.

C-2 Introduction.

It is difficult to quantify the overall safety of a dam, however the way to achieve maximum dam safety is to apply the utmost care and competence to every aspect of design, construction, operation, and maintenance. The most important prerequisite for dam safety is the professional competence of persons associated with the dam over its life span. A dam with a record of safe performance may still experience failure from undetected deficiencies within the dam structure or in the foundation. Dam safety must take precedence over all other considerations (International Commission on Large Dams 1987, reference 42; National Research Council 1985, reference 48; Jansen 1983 and 1988b, references 44 and 45).

C-3 History of Dam Safety.

a. Early Development of Dams. History indicates that dams have been vital to civilization for more than 5,000 years. The early United States settlers constructed dams in the 1600's for water supply and to power gristmills and sawmills. The oldest Corps of Engineers' dams are six locks and dams on the Green and Kentucky Rivers built between 1836 and 1844 (Reed 1987, reference 52; Walz 1990a, reference 62).

b. Dam Safety. Although construction of dams dates back many years, the history of dam safety covers a much shorter time span. Only a limited number of states had any laws regulating dam safety prior to 1900. The failure of the South Fork Dam in 1889 at Johnstown, Pennsylvania, resulting in 2,209 deaths, had limited influence on dam safety programs. California initiated a dam safety program following failure of the St. Francis dam in 1928. Failure of the Buffalo Creek Dam in West Virginia and the Canyon Lake Dam in South Dakota in 1972 contributed to Congress passing "The National Dam Inspection Act" in 1972. Failure of Teton Dam in Idaho in 1976 was followed by "The Reclamation Safety of Dams Act" in 1977. Failure of the Laurel Run Dam in Pennsylvania and the Kelly Barnes Dam in Georgia in 1977 set in motion the development of the "Federal Guidelines for Dam Safety" issued in 1979 by the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) (Federal Emergency Management Agency 1979, reference 33).

c. Interagency Committee on Dam Safety. Although the Interagency Committee on Dam Safety (ICODS) was created in 1980, the Water Resources Development Act (WRDA) of 1996 codified it as a permanent forum for the various government agencies to advise FEMA on institutional, managerial, technical, legislative, and policy issues affecting national dam safety. The following Federal agencies serve on ICODS:

Department of Agriculture
Department of Defense
Department of Energy
Department of Interior
Department of Labor
Federal Emergency Management Agency
Federal Energy Regulatory Commission
International Boundary and Water Commission (U.S. Section)
Nuclear Regulatory Commission
Tennessee Valley Authority

ICODS encourages the establishment and maintenance of effective Federal programs, policies, and guidelines intended to enhance dam safety for the protection of human life and property. This is accomplished through (1) coordination and information exchange among Federal agencies and State dam safety agencies; (2) coordination and information exchange among Federal agencies concerning implementation of the "Federal Guidelines for Dam Safety"; (3) Federal activities that foster State efforts to develop and implement effective programs for the safety of dams; (4) improved techniques, historical experience, and equipment for rapid and effective dam construction, rehabilitation, and inspection; and (5) devices for the continued monitoring of the safety of dams. ICODS has an Operations Subcommittee, which focuses on activities essential to carrying out the operating activities of ICODS.

The Director of the Federal Emergency Management Agency was designated coordinator of the National Dam Safety Program in WRDA96, and is the Chair of the ICODS and the National Dam Safety Review Board.

d. National Dam Safety Review Board. The Water Resources Development Act of 1996 established the National Dam Safety Review Board (NDSRB). The NDSRB monitor state implementation of dam safety programs, and advises the Director of FEMA in national dam safety policy. The Director of FEMA based on their dam safety expertise selects nominees to the NDSRB. The USACE Dam Safety Officer recommends a qualified individual to serve on the NDSRB. Five subcommittees serve under NDSRB and focus on activities essential to carrying out the goals of the Program. These subcommittees are:

Dam Safety Research Subcommittee
Dam Safety Training Subcommittee
National Inventory of Dams Subcommittee
Guidelines Development Subcommittee
National Dam Safety Coordination Subcommittee

APPENDIX D

Corps of Engineers Dam Safety Program Management Team

D-1 Authority and Responsibilities.

The Team is empowered to develop and implement a strategic plan and a long-range plan for the USACE Dam Safety Program, including a mission statement, goals, objectives, and performance measures. The Team shall establish USACE Dam Safety Standards and monitor district compliance with these standards. The Team shall function in accordance with requirements of the Project Management Business Process (PMBP).

D-2 Definitions.

a. Federal Guidelines for Dam Safety. Guidelines adopted by the Federal agency members of the Interagency Committee on Dam Safety to provide management practices for dam safety of all Federal agencies responsible for the planning, design, construction, operation, or regulation of dams.

b. Interagency Committee on Dam Safety (ICODS). Committee consisting of 10 Federal Agencies involved with Dam Safety and established by the National Dam Safety Program Act (P.L. 104-303).

c. National Dam Safety Review Board. Advisory board for the National Dam Safety Program consisting of 5 Federal members, 5 State members, and one public sector Dam Safety member.

d. USACE Dam Safety Program. The USACE Dam Safety Program encompasses the planning, design, construction, operation, maintenance, evaluation, and oversight of dams designed, built, owned, and/or operated by USACE. USACE District, MSC, and HQUSACE elements are corporately responsible to ensure continued safe performance of Corps' owned dams assuring protection of human life and property in accordance with the Federal Guidelines for Dam Safety.

e. HQUSACE Dam Safety Proponents. The USACE Dam Safety Officer and the individuals within HQUSACE Directorate Civil Works Divisions (Engineering and Construction Division, CECW-E; Operations Division CECW-O; and Programs Division, CECW-B) designated to address the needs and concerns of the Corps of Engineers Dam Safety Program.

D-3 Objective.

The objective of the Team is to provide a formal USACE structure to develop policies, practices, and relationships to effectively facilitate dam safety practices and accomplishments. The Team maintains a consistent and accountable nationwide dam safety program. The Team works with other agencies to improve the USACE Dam Safety Program. The Team affirms accountability

for dam safety to all elements within the Command chain, monitors performance, and inculcates dam safety as a fundamental USACE mission. The goals of the Team are:

a. Participate in development of USACE-wide guidance when requested by the USACE DSO.

b. Make recommendations to USACE DSO for studies, investigations, and research designed to improve the safety of dams.

c. Render consulting service and advice on specific safety of dams issues and problems as requested by various elements of USACE or other agencies.

d. Maintain a continuing evaluation of the state-of-the-art for the safety of dams.

e. Serve as a liaison for the dam safety process between HQUSACE and MSC/Districts and disseminate pertinent information throughout USACE.

f. Promote Dam Safety engineering career development.

D-4 Scope of Team Activities.

The Team will provide recommendations to the USACE DSO on all topics in the areas of safety of dams such as roles and responsibilities, training, career development, automated systems and software, guide specifications, uniformity of project specifications, uniformity of process, research and development, and interface with other elements within USACE, other agencies, and professional organizations.

D-5 Composition.

The team members are full-time civilian employees of USACE. The Team shall seek to maintain a diversity of civil works dam safety experience as well as a diversity of the engineering disciplines. A current list of members will be posted on the Safety of Dams web site (to be established). Officers shall be team leader, alternate team leader, and recording secretary. The Special Assistant for Dam Safety shall serve as the team leader. The HQUSACE Dam Safety Program Manager shall serve as recording secretary. The Team shall elect the alternate team leader. The Team shall be composed of seventeen (17) members as follows:

a. HQUSACE Members. Four (4) HQUSACE individuals, who will be the Special Assistant for Dam Safety (CECW-E), the Dam Safety Program Manager (CECW-E), one member from Operations Division (CECW-O), and one member from Programs Division (CECW-B).

b. Major Subordinate Command (MSC) Members. Eight (8) individuals comprised of the Dam Safety Program Manager from each MSC.

c. Engineering Research and Development Center (ERDC) Member. One (1) ERDC individual appointed by the ERDC Dam Safety Officer.

d. District Members. Four (4) district representatives with experience in the safety of dams who shall be elected by the Team as at-large members. At least one of the district representatives shall be from an operating element.

e. Alternate Members. In the event that a member of the Team cannot attend a Team meeting, the member may designate an alternate to serve in his capacity. The member shall provide the name of the alternate to the team leader prior to the meeting.

D-6 General.

The Team will carry out its objective in accordance with the following:

a. Oversight**.** The Team functions under the general direction of the USACE DSO.

b. Meetings. The team leader will call meetings as required to carry out the Team's objective; normally meetings will be held semi-annually. Advance notice, agenda, and minutes of each meeting will be furnished to team members and pertinent USACE commands.

c. Funding. HQUSACE, MSC, and ERDC members will be funded by their respective organizations for team activities. District members' salary, travel and per diem expenses will be funded by HQUSACE for team activities based on the availability of funds.

d. Operating Procedures. The Team shall establish its own procedures for conducting business and presenting recommendations. The procedures are subject to approval by the USACE DSO.

e. Voting. The Team shall seek to reach consensus on each issue. When voting the Team has twelve (12) votes. ERDC, CECW-E, CECW-O, and CECW-B shall have one vote each. Each MSC shall have one vote. The MSC member and the District member(s) from the MSC shall consult with each other to cast the MSC vote. The team leader shall vote only to break ties.

APPENDIX E

Dam Safety Program Management Tools

E-1 Introduction.

The Dam Safety Program Management Tools (DSPMT) consist of a set of interactive software programs which provide a resource to the Dam Safety Data owners, managers, and data providers. The software is under continual development and is evolving as needs are expressed by users. The DSPMT currently includes three distinct functional software programs:

a. Dam Safety Program Performance Measures (DSPPM),

b. National Inventory of Dams (NID) Electronic Submittal Workflow, and

c. Palm or Pocket PC-based Inspection Checklists.

Each of these programs is applicable to all levels of a Dam Safety organization. Output from the DSPPM at each level can be used individually and/or collectively as input at the next higher level to evaluate program performance on broader and broader scales (e.g., district, division, agency, State). By utilizing the tools provided by the DSPMT, data managers and providers can achieve the one-time-only data entry objective while maintaining an up-to-date, error-checked, consistent format database of dam inventory and program performance information.

E-2 Background.

The software was originally named Dam Safety Program Performance Measures (DSPPM) since it started as an effort to develop a few simple, unbiased, generic performance measures (or indicators). The goal of the performance indicators was to help dam safety program managers answer questions such as:

a. How well are our dam safety programs being implemented?
b. Are we doing too much in some areas and not enough in others?
c. Are we spending our scarce resources in the right places?
d. Are we improving?

Since the inventory of dams is a natural extension of the DSPPM, the NID Electronic Submittal Workflow software easily became an integral part of the DSPMT to help users provide a consistent, error-checked electronic submittal of inventory information. The software name was then changed to Dam Safety Program Management Tools (DSPMT). Subsequently, the Palm and Pocket PC-based Inspection Checklist software was incorporated. It consists of a standardized application for the collection and updating of performance measure information, NID information, and a number of flexible and configurable "plug-in" applications for dam safety inspection checklists.

E-3 Discussion.

The overall objective of the DSPMT is to enable each user to have a stand-alone computer program that interacts with the NID, local databases, and other external cooperative databases in a one-time-only data entry environment. The vision is to eventually achieve:

a. One-time data entry for programs targeted at the different aspects of dam safety
b. Efficient data extraction from local state and federal databases into a consistent user-friendly and user-managed inventory and performance measure database
c. Automated error checking and identification of conflicting data
d. Simple online exports of local inventory and performance measure (or indicator) data and import of national level data to/from a centralized server
e. Updating and reporting of inventory, performance measure, and incident information as frequently as desired

The objectives of the DSPPM are also to provide simple, unbiased, quantitative data that are useful separately and/or collectively as metrics to help users:

a. Evaluate how well their dam safety programs are being implemented
b. Determine whether they accomplished what they set out to accomplish
c. Proactively “tell” their dam safety stories to others, both internal and external to their organizations
d. Encourage uniform and consistent application of laws, policies, and regulations.

E-4 DSPMT Overview.

a. DSPPM. The DSPPM is currently divided into seven subject areas:

(1) Dam Safety Program Management Authorities and Practices
(2) Dam Safety Staff Size and Relevant Experience
(3) Inspections and Evaluations
(4) Identification and Remediation of Deficient Dams
(5) Project Response Preparedness
(6) Agency and Public Response Preparedness
(7) Unscheduled Dam Safety Program Actions

b. NID Submittal Workflow. The NID electronic submittal software provides tools for data owners to efficiently collect, access and manage NID data. The workflow starts by importing a state or Federal agency's local inventory of dams, which can be in a variety of database formats. Interactive graphical tools provided by the DSPMT are then utilized to check for data errors in numeric values and spelling errors or inconsistencies in text values. The NID inclusion rules are then applied. The data submittal is checked for differences between the candidate and the current NID, and is then electronically sent to the Corps for review and incorporation into the NID.

c. Palm or Pocket PC-Based DSPMT Inspection Checklists. Utilization of Palm or Pocket PC-based computing technology is optional. Its usage would further allow the one-time-only data entry objective to become a reality. Field Inspectors can download NID and DSPPM information from their desktop DSPMT program to the handheld computer which can then be utilized in the field for collecting data. The software consists of a single standardized application for the review, collection, and update of DSPPM and NID information, and a number of flexible and configurable "plug-in" applications for dam safety inspection checklists. These plug-in applications are currently available for some organization-specific checklists such as FERC, BOR and a few individual State's safe dams programs. Inspection checklists are also available which are targeted at particular aspects of dams such as the checklist for Earth-fill Dams, Concrete Dams, Spillways, Powerhouses, Water Conveyance Structures, or Instrumentation. User's can easily configure the application to only present the inspection checklists utilized by the user's organization. This software configuration provides for standardized, consistent, one-time-only data entry of DSPPM and NID information while providing maximum flexibility for utilizing/ configuring the inspection checklists pertinent to the dam's in a users local inventory.

E-5 USACE DSPMT Implementation Specifics.

This section provides specific guidance to USACE regarding implementation of the dam inventory data, database maintenance, data collection, and submittal workflows currently provided by the DSPMT software.

a. Getting Started. This section describes how to obtain the DSPMT software, what to do the first time the program is run to identify the District/Division, how to load the initial inventory of dams, and how to initialize 'starting' values for selected performance measure for all dams in the District.

(1) The DSPMT software may be obtained/downloaded from the DSPMT web site which is currently located at www.safedams.org. The website provides descriptions of the various aspects of the DSPMT, what the specific performance measures are, various configurations for using the program, and provides download areas for program installation files and User's Manual. Installation files are available for either Windows 2000 Professional or Windows 9x operating systems. Windows 2000 Professional operating systems include Windows NT and Windows 2000 Professional. Windows 9x operating systems include Windows 95, 98, Me, and XP. After downloading the installation files to any directory on the User's hard drive, run setup.exe to install the program.

(2) When the program is run for the first time, users are asked to identify themselves by manually entering their 5-letter organization code. Even though there is a default list of organizations provided on a pulldown list on the form interface which contains all of the States and Federal Agency names, they should not be used by USACE. For USACE, use of the District or Division organization name is required and must be manually entered/typed into the list-box blank field. It is very important that the name be the five letter District, MSC, or HQ designation only. Values such as "CESAD" or "CESWT" are expected. Do not elaborate on the organization code by using values such as "CEMVM-ED-DS". The program only expects the 5-letter organization code value.

(3) To load the local (district) inventory of dams, the DSPMT is used to connect to the centralized network server which contains pre-loaded initial inventory data for all of the USACE districts. Use the DSPMT User's manual for detailed specifics on how to accomplish the following. From the DSPMT main form, go to Executive Review, then DSPPM Review Functions, then Organizational level download. From this interface, press the "Download Submittal Data from TEC FTP Site". This will bring up an interface which connects to the centralized network server. A password is required to access the files on this site. Each USACE district and division has been assigned a unique password. The USACE Division dam safety program managers are aware of what the current passwords are for each district, and they should be contacted for this information. Passwords must be guarded and not disclosed. After entering the password, a list of files shows the inventory data available from the site. There are files for each State, several Federal Agencies, and each USACE district. The USACE district filenames are constructed using the 5-letter district or division name followed by a ".mdb" extension. "CENWK.mdb" and "CESAM.mdb" would be included in this list, for example. The initial inventory file may then be highlighted, downloaded, and then imported into the local DSPMT program using the detailed procedures described in the DSPMT User's manual.

(4) For first-time users only, after downloading and importing the initial district inventory information into the DSPMT, each district shall initialize standard default performance measure values for all, or selected, dams in the local inventory. These starting (default) performance measure values are for items such as inspection frequency, whether a seismic evaluation is required, whether an EAP is required, etc., and are selected based on hazard potential classifications. The DSPMT User's manual provides specific detailed procedures for initializing these items using the performance measures spreadsheet capabilities of the expert user interface.

b. Maintaining the Database. Since the dam safety program managers at the district level should be most familiar with the details of the individual projects in their inventory, they shall have the primary burden of maintaining up-to-date information on the dams in the database. As inspections are completed, the DSPMT shall be updated to include any modifications to NID information on the dam, and to include the results of the inspection and any impacts on the performance measures such as inspection date, identified deficiencies, estimated costs of remediation, priority ratings, etc. The updates should then be uploaded to the central server. The MSC shall be responsible for providing quality assurance and review functions on district submittal information on a periodic basis. This is accomplished at the MSC level by first deleting all dams from their local inventory of dams and then downloading and importing the latest district submittal data files from the centralized network server. A 'live update' capability has been incorporated for both data and software version so that users at all levels can download the most current information and software versions. Instructions for accomplishing these updates are described in the DSPMT User's manual. If questions, data conflicts, or errors are noticed in district inventory information, they shall not be corrected or modified at the Division level or HQ level. It shall be the District responsibility to resolve the question or implement the correction in the District database and a new data upload shall then be provided by the District.

c. Providing Submittal/Inventory Information. Data submittal and inventory information shall be provided on an as-available, as-requested, and periodic basis. Data submittals can be in the form of very standardized NID electronic submittals or in the form of very specific non-standard data requests by the MSC, HQ, other Agencies or organizations. The DSPMT provides workflows for easily generating both types of submittal information. Inventory and other data may also be exported at any time using the Excel output capability of the DSPMT. For example, capability has been provided for creating a customized Excel spreadsheet of selected NID and performance measure fields to be generated for all dams or only for dams which meet a specified query criteria. This Excel spreadsheet may then be provided to the requesting organization. Detailed procedures for generating this customized Excel spreadsheet are included in the DSPMT User's manual.

APPENDIX F

Periodic Inspection Program - Inspection and Evaluation Procedures

F-1 Project Documentation.

All engineering data relating to project structures inspected shall be collected and permanently retained in appropriate files at the project site for availability to the inspection team and readily accessible for emergencies response. Formal Inspection Reports shall indicate which items are not available, and describe attempts to locate such records or documents. Project engineering data shall also be retained at the district office. In the absence of on-site administrative headquarters, the data shall be retained at the nearest field office. These documents and drawings shall be considered as permanent engineering data, subject to retirement or disposal only upon termination of operation of the project. These data shall consist of but not be limited to the following:

a. All previous Periodic Inspection Reports.

b. Records of inspections by project personnel and interim inspections by district personnel.

c. Design Memoranda or Design Documentation Reports to include principal design assumptions and stability and stress analysis, slope stability, seepage and settlement analyses, consolidation, shear, permeability, compaction, classification tests or summaries thereof, and contract plans and specifications.

d. Typical as-built plans, elevation, and sections.

e. Selected as-built drawings of important project features, to include details such as instrumentation, internal drainage, transition zones, or relief wells, and reports of any special investigations.

f. Foundation data and geological features, including boring profiles, foundation mapping, and subsurface exploration results.

g. Location of borrow areas and identification of embankment, filter, riprap, large stone sources.

h. Laboratory Reports:

(1) As-built properties of foundation and embankment materials, such as shear strength, unit weight, and water content and classification. The number of control tests and undisturbed record sample tests shall be included.

(2) Physical, chemical, and thermal properties of concrete and concrete materials.

(3) Summary of concrete mixture proportions and control procedures.

i. Project Geotechnical and Concrete Materials Completion Report.

j. Construction history records, including diversion schemes and construction sequences shown on appropriate drawings.

k. Details of the overall instrumentation program to include predicted performance and record of actual observations, and annual updated evaluations.

l. Operations and Maintenance Manual.

m. Water Control Manual.

n. Copy of PCA.

o. Dam Safety Information:

(1). Project copy of "Federal Guidelines for Dam Safety".

(2). Emergency Action Plans - complete with the emergency identification subplan (Federal), emergency operations and repair subplan (Federal), full scale inundation maps (Federal), notification subplan (Federal and non-Federal) and evacuation subplan (non-Federal), if available.

(3). Records of dam safety training for project personnel.

(4). Surveillance plan of the project that includes events and threshold reservoir levels that initiate observations and/or inspections and reporting procedures.

(5). List of local contractors and construction materials available for use in emergency situations.

(6) Physical security plan for the project.

p. Manufacturers data for purchased items.

F-2 Inspection Program.

a. Initial Pre-inspection Brochure. A technical brochure shall be prepared in advance of the first project inspection to familiarize inspection team members with general project features. This brochure shall include a technical summary of the structural, material, and foundation conditions, instrumentation data, including settlement monuments, location of instrumentation and description of reservoir operations procedures, if pertinent. The brochure shall also include appropriate pertinent project data, project layout and typical section drawings, Federal and non-Federal responsibilities for OMRR&R, summaries of sub-surface soil profiles and boring logs,

and the checklist developed for conducting the inspection. Pre-inspection brochures shall be completed and distributed to inspection team members at least 30 days prior to the inspection date.

b. Pre-inspection Packets. A technical pre-inspection packet shall be prepared in advance of all subsequent project inspections to familiarize inspection team members with general project features and history. This packet shall include a project access map, history of project deficiencies and remedial measures, technical summaries of the structural, material, and foundation conditions, and description of reservoir operations procedures, if pertinent. Also include evaluation and plots of most recent instrumentation data, including settlement monuments, and location of instrumentation. Also, as appropriate, the packet shall include project data, layout and typical section drawings, Federal and non-Federal responsibilities for OMRR&R, summaries of sub-surface soil profiles and boring logs, and the checklist developed for conducting the inspection. Packets may be tailored to each discipline to avoid excessive reproduction. Pre-inspection packets shall be completed and distributed to inspection team members at least 15 days prior to the inspection date.

c. Inspection Procedures. A systematic plan will be established for the inspection and operation of those features related to the safety and stability of the structure and to the operational adequacy of the project. Operational adequacy means the inspecting, testing, operating, and evaluation of those components of the project whose failure or failure to operate properly could impair the operational capability and/or usability of the structure. Where the operation of these components is vital to the safe operation of the project under emergency conditions, these components will be operated by emergency power at least annually and these operations recorded in a project log. Emergency generators shall be tested under load on more frequent intervals to maintain their integrity. In addition, standby emergency generating systems shall be reviewed and tested during the scheduled inspection to assure the inspection team that all critical project features can be operated under emergency conditions or in the absence of the normal source of power. The testing of emergency power shall include the maximum power demand that could be expected in emergency situations. As much as possible the operation and or inspection of all the features shall be conducted during the scheduled inspection. The inspection of the remaining features may be conducted any time prior to completion of the inspection report, but, no earlier than occurrence of the last major flood event for the project. However, if possible, the inspection of features such as stilling basin dewatering, tainter gate inspections, operability inspections, etc. shall be completed before the periodic inspection so that the team can review the inspection reports during the periodic inspection. If appropriate, a video of the event could document pertinent results of the pre-inspection for showing at the regularly scheduled inspection. The systematic inspection plan shall also provide as appropriate, the examination and the operation of, but not be limited to, the following:

(1) Hydraulic Steel Structures (HSS), as defined in ER 1110-2-8157,*Responsibility for Hydraulic Steel Structures*, which include flood and outlet control gates (including flood gates in levees or flood walls), navigation lock gates and valves, emergency closure gates, spillway tainter gates, stoplogs and bulkheads, and associated lifting beams; hoists and operating machinery (including safety devices such as limit switches and fail-safe interlocks)**;** flood control pumps and related equipment**;** and cathodic protection systems.

(2) Structural details of roadways, parapets, training walls, spray walls, dam outlet conduits, intake towers, bridges to gate towers, piers, monoliths, steel sheet pile features.

(3) Concrete surfaces.

(4) Structural cracking and deterioration of material.

(5) Joints and joint materials, including relative movement at joints between structures or portions of structures.

(6) Water passages.

(7) Foundation drains, joint drains, face drains.

(8) Spillways, spillway buckets and stilling basins and outlet channels including submerged features as necessary.

(9) Embankment cracks, bulging, and sliding; condition of abutment and embankment junctions; and vertical and horizontal alignment of the embankment or structure crest, slope, or toe area.

(10) Unusual movement or cracking at or beyond the embankment or slope toe.

(11) Seepage through or under embankment or abutment slopes.

(12) Sloughing or erosion of embankment or abutment slopes.

(13) Condition of riprap, armor or other slope protection.

(14) Scour protection stone and below water surface erosion control features.

(15) Reservoir rim conditions. (Can be limited to areas impacting the operation or stability of the dam).

(16) Conditions of relief wells, collector pipes, inspection manholes, or other features of seepage control systems. (ER 1110-2-1942, *Inspection, Monitoring and Maintenance of Relief Wells,* reference 27).

(17) Conditions of instrumentation, and most recent measurements prior to the inspection. (Chapter 7 of this regulation).

(18) Condition and location of any known embedded utilities, including gas, water, and sewer lines in the embankment, abutments, or toe of the dam.

(19) Seepage, depressions, sinkholes, and soft, marshy areas downstream of the dam.

(20) Tailrace area, for muddy flows.

d. A detailed checklist of elements relative to the structural stability and operational adequacy of the project shall be developed for each structure in order to ensure an adequate examination coverage for each feature. The facility's instrumentation shall be included in the checklist to ensure that data are regularly collected and analyzed and to ascertain whether the instruments are in proper operating condition.

e. Photographs. In order to more accurately portray conditions and changes in conditions of surfaces and structural details, color photographs are encouraged. In addition to photographs, video film is encouraged for use in monitoring areas of concern. This is especially useful for comparing movement, water leakages, wave action, etc.

f. Examination of Deteriorated Concrete Structures. If the inspection reveals the need for any type of in-depth evaluation to determine the cause of deterioration or malfunction and to make sound recommendations for remediation, the need for the investigation shall be stated in the periodic inspection report. Guidance on repair of concrete is given in EM 1110-2-2002.

g. Steel Structures. Steel structures shall be visually inspected for structural and operational adequacy. The inspection shall be sufficient to identify major defects such as visible cracks. Those structures involved directly in the safety of the project shall receive special consideration. Fracture critical members, where failure would result in probable loss of life, shall initially be inspected by additional means, such as ultrasonic or other nondestructive testing. HSS inspection reports shall be prepared in accordance with ER 1110-2-8157, and shall be included in the Periodic Inspection Report. Reference EM 1110-2-6054 for additional information on these structures.

h. Riprap. The quantity, size and location of riprap, sand, gravel, clay, sand bags, geotextiles, and other related materials and available equipment required to place these materials under any weather conditions shall be stated. Material sources that have unsatisfactory performance records shall be identified, reported and eliminated from further use.

i. Security. The project shall be inspected to determine whether the features are safe from vandalism, sabotage, acts of terrorism, or any other acts that could cause the project to fail to function properly and safely for its intended purpose.

F-3 Composition and Qualifications of the Inspection Team.

Inspection team personnel shall consist of individuals qualified by experience in the design, construction, inspection, and operation of the project, and of individuals with appropriate specialized knowledge in structural, mechanical, electrical, hydraulic, geotechnical (embankment design), geology, soil mechanics, concrete materials, and construction procedures. A representative(s) of the sponsor shall be invited to be part of this team. In every case, the inspection team qualifications may vary with the complexity of the facility and with the level of inspection. All team members shall receive training in the inspection procedures. Training Aids

for Dam Safety (TADS) modules are recommended as a minimum for each team member, as well as a thorough understanding of this regulation. The Dam Safety Officer of each district is responsible for scheduling this training. Where appropriate, inspection personnel shall be trained for confined space entry.

F-4 Inspection Report Content.

The periodic inspection report shall present the results of each general project inspection. The title of this report shall indicate the name of the project, watercourse, state, project features, and inspection number and date, in that order. An example of an appropriate title is: "Beech Fork Lake Project; Twelvepole Creek, West Virginia; Dam, Outlet Works and Spillway; Periodic Inspection Report No. 1, September 1992". Report No. 1 (report of initial inspection) shall provide a general project description and present the results of the initial inspection. Reports of subsequent inspections shall be supplementary to the initial report and will be numbered sequentially with the initial report; i.e., Report No. 2 would describe inspection number 2, etc.

a. Initial Report. To the extent possible, major elements of this report are:

(1) An executive summary of the major items found in the inspection, including a statement regarding the project's ability to continue acceptable and safe operation.

(2) A general project description including layouts and typical section for the purpose of familiarization with general features of the project.

(3) List of project documents, and engineering data that identifies the status and location of the project documents.

(4) Results of examination for each feature, including a statement as to its ability to function as designed and copy of the completed inspection checklist.

(5) Evaluation and summaries of the observations and inspection of instrumentation (Chapter 7 of this regulation) and relief wells (ER 1110-2-1942) with comparison to design predictions and actual conditions that signal changes in the structure's performance.

(6) Where appropriate, statements, or exhibits summarizing the duration and frequency of spillway and control gate operations, including heads or velocities, and number of lock filling and emptying operations.

(7) Technical assessment of the causes of distress, of abnormal conditions, and evaluation of the behavior, movement, deformation, and loading of the structure and its individual components. If such assessment cannot be accomplished within the time allotted to complete the inspection report, a preliminary assessment shall be discussed with a plan scheduled to complete the assessment.

(8) Color photographs with an appropriate caption, including the date taken.

(9) A discussion of the deficiencies, the proposed remedial measures, with sketches if appropriate, related maintenance operations and both the cost estimates and a proposed completion schedule.

(10) A discussion of the overall structural and individual project components stability, safety, and operational adequacy compared to its intended purpose(s) for the conditions with and without the recommended remedial measures.

(11) Each recommendation should include the priority level for the recommended action in accordance with the following table:

Dam Safety Work Item Funding Priority Levels and Description		
Priority Funding Level	DSPMT Code	Descriptions
CY	1	Serious dam safety deficiency exists that needs remediation immediately. If not corrected, item has an unacceptable dam safety risk. May require operational restrictions placed on the project. Reprogramming funds is appropriate.
BY	2	Remediation should be initiated within 12 months. May require operational restrictions placed on the project. Reprogramming funds is appropriate.
BY+1	3	Study and remediation (as applicable) should be initiated within 24 months.
BY+ 2	4	Study and remediation (as applicable) should be initiated within next budget cycle or 36 months.
BY+ 3	5	Study and remediation (as applicable) should be initiated within next budget cycle or 48 months.
BY+4	6	Needs to be resolved within 5 years. This work will probably not get funded unless the deficiency worsens. Monitoring is appropriate.

Note: The structures, features or related appurtenances currently identified as part of existing WORK CATEGORY CODE 61211 are covered under this new WORK CATEGORY 61213 if they meet the above definition.

Definitions: CY = Current Fiscal Year, BY = Budget Year usually CY +2 for O&M, BY+1 = Budget Year plus one year.
DSPMT = Dam Safety Program Management Tools software will be used to track status of all dam safety item works

(12) Views of the non-Federal sponsor on any of the above shall be included (if applicable).

(13) Exhibits shall include, as appropriate: trip reports; plots of instrumentation data; inspection checklist; summaries of crack surveys; correspondence that documents the performance of the project; the results of special investigations; and the status and location of the project documents required by this document and ER 1130-2-530.

(14) A discussion of the need for updating the project design parameters (hydraulic, seismic, HSS, etc.), if applicable.

(15) A discussion of the project security, including any recommendations for updating or increasing security measures.

b. Subsequent Reports. Subsequent reports shall generally include the items stated in paragraph 6-11a above and shall follow the requirements of paragraph 6-12a below, however they shall also include:

(1) A general description of the facility.

(2) Brief summary of past performance and problems and concentrate on the new and continuing conditions that affect or may affect the overall safety and operational capability of the structure. This summary shall not be merely a reference to a previous report.

(3) A discussion on maintenance and remedial activities to include materials used, application techniques, and performance.

(4) A discussion on recommended remedial measures not completed since the previous inspection report, as well as a proposed schedule to accomplish the remedial measures.

(5) Copies of selected drawings; however, extensive reproduction of previously published drawings shall be avoided. As a minimum, a location and vicinity map which also show project access shall be included, as well as a general plan that shows each feature discussed in the report. The names and stationing shall be consistent on the drawings, narrative, and photograph captions.

(6) A summary of the project's bridge inspections that may impact project safety or access during emergency conditions shall be included. ER 1110-2-111, *Periodic Safety Inspection and Continuing Evaluation of USACE Bridges*, reference 21, provides guidance on bridge inspections.

F-5 Inspection Report Format .

The following paragraphs describe the requirements for hard-copy reports. Reports may be submitted electronically, as approved by the respective MSC, and shall be prepared in the same format as stated herein.

a. Reports shall generally be organized as follows:

Table of Contents

1. Executive Summary, including a statement regarding the status of project safety for continued operation, and Certification of Independent Technical Review.

2. General Statement of Inspection Program (include statement on hazard potential classification and report approval authority).

3. Description of the Project.

4. Brief Project Summary.

(a) Construction conditions.
(b) Project characteristics.
(c) History of remedial measures.
(d) Deficiencies corrected since last inspection.
(e) Past deficiencies not yet corrected, and explanation for not correcting.
(f) Non-Federal sponsor OMRR&R responsibilities (if applicable).

5. Inspection Results. (Reference to trip reports or appendices is not acceptable). A summary table (in addition to text) is recommended for documenting deficiencies, repair/evaluation recommendations, estimated costs, schedules, responsible office, and current status.

6. Recommendations.

Exhibits

I Figures.

II History of Remedial Measures.

III Photographs.

IV Inspection Checklist.

V Summary of Inspection Notes.

VI Summary of Intermediate Inspection Reports (documentation only, not to replace the narrative in the body of the report).

VII Instrumentation Data and/or Plots. Data shall contain all figures since the last inspection and have sufficient background data to support the report discussion, conclusions and recommendations. Reproduce the plan of instrument locations in each report. Where appropriate, cross-sections showing piezometric data shall show design uplift assumptions along with the current pressure line. Plots of piezometric elevation versus pool elevation and plots of relief well or drain flow versus pool elevation shall be included. In each case, upper limit

correlation lines should be drawn (to help eliminate time lag effects) and when possible, extrapolations should be made to maximum possible pool elevations. A summary of analyses of all instrumentation should be set forth. Where possible, threshold values for key instruments should be established. Threshold values should also be entered into the project emergency operations plans.

VIII Summary of Crack Surveys.

IX Listing of the status of engineering and operation design data, manuals, reports and correspondence as required by this document, ER 1130-2-530, and others as deemed necessary to provide comprehensive project documentation.

X Status of Dam Safety training. (ER 1130-2-530). Status of Emergency Action Plans and their updates

XI Summary of Security Review and Recommendations (for internal use only; do not release to the public).

XII Independent Technical Review Comments

b. Text. All sections and paragraphs shall be numbered and lettered and shall be on 8 1/2 by 11-inch paper with sufficient margin on the left side for binding. Reproduction shall be any available process with printing done head-to-head, if possible.

c. Drawings. Drawings or plates shall normally be 8 1/2 by 11-inch with sufficient margin on the left for binding. Foldouts normally shall not exceed 11 inches by 17 inches. Drawings and photos may be included in the text or placed entirely in the Appendix. However, any figure or drawing in the text shall support the written material.

d. Binding and cover. Reports shall have flexible paper or card stock, hidden-hinge covers with fasteners that facilitate removal and insertion of pages and drawings. Information to be on the cover will be as described in paragraph 5 above. Also, the name of the preparing agency and the date of inspection shall be shown on the cover.

F-6 Distribution of Approved Inspection Reports.

a. Upon approval of the inspection report, one copy together with a copy of all correspondence bound under the front cover, will be sent by the originating district directly to:

Engineer Research and Development Center (ERDC)
ATTN: Research Center Library
3909 Halls Ferry Road
Vicksburg, Mississippi 39180-6199

(A copy of the transmittal letter to ERDC is to be provided to the MSC.)

b. The district shall submit a draft electronic Executive Summary of each Periodic (Comprehensive) Inspection Report to HQ-DamSafety@hq02.usace.army.mil within 90 days of the completion of the on-site inspection. Once the Dam Safety Program Management Tools (DSPMT) software is finalized, additional instructions will be issued for entering the information into the DSPMT instead of transmitting the summary as an email message. The electronic executive summary should be limited in length to two to four pages and shall contain the following information.

(1) A brief description of the project that was inspected.

(2) A statement concerning the current inspection and major findings.

(3) A statement regarding the project's safety status for continued operation.

(4) A general periodic inspection schedule including the dates of the previous, current, and next scheduled inspections of the project.

(5) A statement concerning any uncorrected deficiencies from the previous inspection.

(6) A list of major deficiencies found during the inspection and recommendations to correct the deficiencies.

(7) The conclusions paragraph from the formal inspection report.

c. The MSC's and the districts shall determine the distribution of completed reports within their respective offices, to include the project site, local sponsor, military installation, and other federal agency and/or state agency, as deemed appropriate. Security evaluation summaries should be removed from reports distributed outside the USACE.

F-7 Statement of Project Capability to Fulfill Initial Design Purpose(s).

A form (ENG FORM 4822-R, Apr 88) is available for reporting the capability of the project to fulfill its initial design purpose and is recommended to be used for this purpose. A copy of the form is shown below.

STATEMENT OF PROJECT CAPABILITY TO FULFILL INITIAL DESIGN PURPOSE(S)
(ER 1110-2-100)

THRU: *(Division Office Dam Safety Officer)*	TO:	FROM: *(District Office Symbol or Division Office Symbol for CENED and CEPOD)*

1. PROJECT NAME	2. DATE OF INSPECTION

3. All project features involved in the impoundment and/or control of water were inspected and evaluated. Remedial measures necessary and schedule of accomplishments follow (if any).

3a. REMEDIAL MEASURES NECESSARY

3b. REMEDIAL MEASURES ACCOMPLISHED TO DATE

3c. SCHEDULE FOR REMAINING REMEDIAL MEASURES

4.

- ☐ a. The project is capable of fulfilling its design purpose(s).
- ☐ b. The project is capable of fulfilling its design purpose(s). The identified remedial measures will maintain this capability.
- ☐ c. Upon completion of the identified remedial measures, the project will be capable of fulfilling its design purpose(s).

5. TYPED NAME/GRADE OF RESPONSIBLE OFFICIAL	6. SIGNATURE	7. DATE

ENG FORM 4822-R, Apr 88 EDITION OF MAR 83 IS OBSELETE (Proponent CEEC-88)

APPENDIX G

Dam Safety Assurance Program Studies and Reports

PART I - SEISMIC SAFETY EVALUATION PROCESS FOR EMBANKMENT DAMS AND FOUNDATIONS

G-1 Introduction.

a. Purpose. This part of the chapter provides detailed guidance for evaluating the seismic safety of existing USACE embankment dams and foundations. The process ensures: (a) that seismic evaluations/re-evaluations for embankment dams and foundations are accurately identified and conducted with minimum expenditure of project funds, manpower or delay and (b) that embankment dams and/or foundations not requiring modifications are accurately identified and removed from further study at the earliest possible point in the evaluation process.

b. Scope. This guidance is to be used in evaluating the seismic safety of existing USACE Civil Works embankment dams in accordance with provisions of the Dam Safety Assurance Program as defined in Part I of this chapter..

c. Background. The seismic safety of many existing embankment dams must be evaluated or re-evaluated in accordance with requirements in ER 1110-2-1806 (reference 26). Seismic safety evaluation of major civil works projects, particularly embankment dams, is typically a complex, multi-stage process. It generally requires progressively more detailed definition of certain project characteristics and analysis of project response to the design earthquake ground motions at each subsequent stage. This process can be expensive and manpower intensive, and may take many months to several years to complete.

G-2 Seismic Safety Evaluation Process.

a. Evaluation Process. Stages of the seismic safety evaluation process are designated as (a) Seismic Safety Review, (b) Phase I Special Studies, and (c) Phase II Special Studies. The stages are described in the following paragraphs. A multi-page flow chart illustrating the process is located at the end of this part of this chapter (Figure 8-1). The evaluation process is structured to validate technical conclusions and policy compliance as an integral part of each stage of the process. This is accomplished during appropriately timed Policy Compliance & Criteria Reviews (PCCR). The PCCR's eliminate the need for several report submission and approval cycles preceding the development of an official decision document. The evaluation process leads either to negative findings (i.e., that critical project features are likely to perform in an acceptable manner during and following the design earthquake) resulting in removal of the dam from further evaluation, or to the conclusion that modifications are required to the embankment dam and/or its foundation to ensure acceptable performance when subjected to the design earthquake. Negative conclusions at any stage beyond the initial screening at the Seismic Safety Review stage require validation during a PCCR. Negative conclusions at any stage of evaluation require only minimal formal documentation. Conclusions that indicate additional studies are required or that the project requires some form of remediation or modification must be validated during a

PCCR. Additionally, the evaluation process and resultant conclusions must be documented for record prior to proceeding into the next phase. An information copy of the memorandum for record must be provided to both the MSC and HQUSACE (CECW-EP & EG). If studies through the Phase II level lead to the conclusion that some form of remediation is required, the results of the evaluation process, recommended remediation or modifications and justification are presented in an official decision document designated the Dam Safety Assurance Program (DSAP) Evaluation Report.

b. DSAP Evaluation Report. The DSAP Evaluation Report documents the entire evaluation process and recommendation for remediation or modification. It is the only formal report required prior to proceeding into detailed design and subsequent development of plans and specifications for seismic modifications. It has a specific format for documenting and presenting the evaluation, analyses, conclusions, economic justification and recommendations for modifying the dam and/or other project features. A detailed description of the required content and format is contained in paragraph 8-7a and in Part III of this chapter of the ER. The DSAP Evaluation Report is the formal decision document, which must be approved by HQUSACE before proceeding into detailed design and subsequent development of plans and specifications.

c. Phase III/Detailed Design. Following official approval of the DSAP Evaluation Report, Phase III work should proceed in accordance with the approved schedule. This includes detailed design for the seismic modifications approved in the DSAP Evaluation Report as well as preparation of the plans and specifications for those measures. In accordance with current guidance, Phase III work may be carried out using Operations and Maintenance, General appropriations or the maintenance portion of the FC, MR&T account, as described in paragraph 8-11 in Chapter 8 of the ER.

d. Funding. Consistent with current guidance, all work for the Seismic Safety Review, the Phase I Special Studies, the Phase II Special Studies and the DSAP Evaluation Report are to be carried out using project O&M funds or the maintenance portion of the Flood Control, Mississippi Rivers and Tributaries (FC,MR&T) account, in accordance with paragraph 8-11 in Part I of this chapter of the ER. Budgeting for this work should normally be covered in the annual budget EC for Civil Works activities. The DSAP Evaluation Report is the formal decision document that must be approved by HQUSACE before budgeting for Construction General funds.

G-3 Seismic Safety Review.

a. Basis for Review. A Seismic Safety Review (SSR) is required when certain conditions exist as described in ER 1110-2-1806, *Earthquake Design and Evaluation of Civil Works Projects*, Para. 5d.

b. Purpose and Scope. The purpose of the SSR is to review and document conclusions about the seismic safety of embankment dams and foundations for civil works projects in accordance with ER 1110-2-1806. This review will conclude whether or not a Phase I Special Study is required. The SSR is normally limited to office examination and screening of available data and the results of the most recent Periodic Inspection. In this review, available information,

such as geologic maps, boring logs, seismic zone maps, acceleration contour maps, existing field investigation reports, as-built project records, and previous seismic evaluation reports, shall be used. If the initial screening indicates that the embankment dam and/or its foundation may require remediation/modification for seismic adequacy, then limited, simple preliminary analyses using existing available data shall be performed as part of the SSR. If these analyses indicate that there is potential for sudden, uncontrolled loss of reservoir pool or other form of unacceptable performance that causes loss of life as a result of the project being subjected to the design earthquake, then a Phase I Special Study shall be recommended. Where specialized expertise is needed, subject matter experts, either USACE or external, shall participate in the examination and analysis as early as practical in the evaluation process. The level of effort to accomplish the SSR shall be the minimum required to resolve whether or not seismic safety issues exist which require a Phase I Special Study. (The level of effort and associated cost are estimated to be on the order of a few man-weeks of office effort with costs in the range of $25-50K.)

c. Seismic Safety Issues. Issues that are relevant to the determination of seismic safety and the need for further investigations may include some or all of the following:

(1) Project Hazard Potential Classification, as described in Appendix 8E, which reflects the criticality of the project in terms of threat to public safety in the event of failure. It is USACE policy that seismic safety of USACE embankment dams, where failure would result in loss of life, must be assured. For embankment dams and other features for which the consequences of failure are economic and no loss of life is expected, the decisions about further investigations or other actions shall be justified on an economic basis.

(2) Adequacy of past seismic evaluations, if any; including the adequacy of procedures used in selection of design ground motions and the appropriateness and adequacy of methods of analysis used, in light of the present state-of-the-practice.

(3) Proximity to seismic source zones.

(4) Changes in the state of knowledge of regional or local seismicity since the last review.

(5) Existence of soils that are potentially unstable due to buildup of excess residual pore pressures or degradation of strength from cyclic loading in either the embankment or foundation.

(6) Existence of slopes that may be seismically unstable, including embankment slopes, the abutments or the reservoir rims.

(7) Existence of project features that may become critical to safety after small deformations of the embankment dam (i.e., outlet works becoming non-operational or thin filter zones within the embankment being disrupted).

d. Policy Compliance and Criteria Review. A Policy Compliance & Criteria Review (PCCR) shall be held after 95% completion of the technical examination and analysis for the SSR, but prior to forwarding a recommendation to the District Dam Safety Committee. The PCCR shall include geotechnical representatives from HQUSACE and the MSC as well as

District representatives including representatives from Engineering and Operations. The Dam Safety Officer or a designated representative shall also attend. A PCCR is not needed if the results of the SSR indicate that the dam is seismically adequate. The PCCR shall summarize the examination and screening and shall provide a recommendation with justification for the initiation of Phase I studies. Supporting documentation shall be presented. If a Phase I study is recommended, then a scope of work, cost estimate and schedule for the Phase I study shall be presented. If the SSR is done in conjunction with a periodic inspection, the results of the SSR shall be incorporated into the Periodic Inspection Report. As a minimum, the District shall document the SSR as well as the results and conclusions of the PCCR in a memorandum for record to project files. No formal report or documentation is required to be submitted to the MSC or HQUSACE for review and approval; the PCCR replaces the MSC and HQUSACE review and approval process for the SSR. An information copy of the memorandum for record must be provided to both the MSC and HQUSACE (CECW-E).

G-4 Phase I Special Study.

a. General. A Phase I Special Study is necessary when the PCCR for the SSR concludes that potential deficiencies exist in an embankment dam or foundation which could lead to sudden, uncontrolled loss of reservoir pool or other form of unacceptable performance likely to cause loss of life if the project were subjected to the Maximum Credible Earthquake (MCE), as defined in ER 1110-2-1806, or a lesser event.

b. Purpose. The purpose of Phase I study is as follows:

(1) develop site-specific ground motions appropriate for seismic evaluation of all project features to be evaluated,

(2) perform limited field investigations and laboratory studies, and,

(3) perform preliminary analyses, based on the ground motions, field data and laboratory testing results, to determine the response of the dam to seismic loading and to identify potential problem areas, which may need more detailed analyses.

c. Content. The type and level of study required in the Phase I study will be project dependent; however, the content of a Phase I study normally includes the following:

(1) Project Description. Provide a brief description of the project, including type of dam, major structures or other critical feature. Provide tabulated pertinent project data. Describe design and current project operations. Identify key operational pool levels such as conservation pool, power pool, seasonal pool levels, spillway crest, flood pool and maximum pool. Other relevant pool information shall include reservoir pool history elevation versus time, average yearly maximum pool, and the reservoir pool elevation versus frequency relationship based on historical data supplemented with flood routing analyses for less frequent flood events as required.

(2) Purpose and Scope. Describe the purpose and scope of the study and the deficiency(s) identified in the SSR. (Estimating the level of effort and cost to perform a Phase I study is difficult to address on other than a project specific basis but are likely to range from many man-months to a few man-years of effort and involve expenditures in the range of $300-800K. Phase I duration shall be limited to the shortest possible time period consistent with project complexity, manpower, funding and quality considerations.)

(3) Site Characterization. Perform limited field and laboratory investigations to define the soil and rock stratigraphy and to further clarify location and extent of potential problem areas. These investigations shall be sufficient to develop preliminary soil and rock cross sections of the dam and foundation in areas, which have potentially unstable soils. These investigations may include Standard Penetration Tests (SPT), Cone Penetration Tests (CPT), shear wave velocity, permeability, Becker Penetration Tests (BPT), conventional undisturbed sampling, and trenching in areas of much lateral heterogeneity or anisotropy.

(4) Seismotectonic Evaluation. Develop a detailed evaluation of the geology, tectonics and seismic history of the area, and the proximity of the dam to active seismic zones. Provide fault study and related field investigations and laboratory testing where necessary.

(5) Seismicity and Ground Motions. Select the final design earthquake ground motions and develop the ground motion parameters to which the project could be subjected. For all critical projects or features, these input ground motions will be obtained from a deterministic analysis of historic seismicity and active fault systems or seismic source zones and their activity. Develop several accelerograms for site response computations. The accelerograms should contain energy, frequency and duration components appropriate for the source, the region and the feature being evaluated. Caution is advised to avoid undue conservatism in selection of ground motions for use in analyses. Selection of specific accelerograms or the manipulation of accelerograms to generate records with specific time histories not representative of the characteristic ground motion records within the region of the project should be strongly justified and well documented. Of particular concern is that accelerograms be developed with energy content and occurrence of the peak energy representative of the seismological setting of the feature(s) being evaluated. For effective stress analyses, where site permeability profiles and boundaries are accurately known and seismic generated residual excess pore water pressures will be simultaneously dissipated, input motion time histories should not be manipulated to shift the energy content to the end of shaking to minimize pore pressure dissipation and thereby maximize excess residual pore pressures during modeling of post earthquake response unless justified from seismological investigations and by expert seismologists. Selection of ground motions should be made with input from qualified seismologists, geologists and geotechnical engineers.

(6) Seismic Evaluations and Analyses.

(a) Liquefaction Potential. Evaluate the potential for liquefaction or development of excess pore pressure in soils of the embankment and foundation using standard methods. This shall consist of using an appropriate empirical method linking documented field performance with site characteristics using field investigations. Use a 1-D analysis, such as SHAKE, to model propagation of earthquake induced rock motions through the foundation and the embankment.

(b) Post Earthquake Stability. Evaluate post-earthquake limit equilibrium slope stability for the reach(es) of the embankment where liquefaction of the embankment and/or foundation is indicated. Post-earthquake shear strengths for zones not indicated to liquefy shall be estimated taking into account residual excess pore pressures. Post-earthquake shear strengths for zones, which are indicated, to liquefy shall be selected based on residual strengths back calculated for well documented liquefaction induced failures. The further reduction in shear resistance below the residual level is not justified.

(7) Post Earthquake Deformed Shape. Assess the shape and amount of deformation in the embankment after sliding or slumping for the cross section where inadequate factors of safety are indicated by limit equilibrium slope stability analyses. Similar cautions noted for selection of strength and pore pressure values in evaluating limit equilibrium stability are to be observed in evaluating the post earthquake deformed shape of an embankment or other slope.

(8) Conclusions and Recommendations. Develop conclusions and recommendations on the need for a Phase II seismic evaluation or departure from requirements of ER 1110-2-1806.

(9) Cost Estimate and Schedule. If Phase II studies are recommended, develop a detailed scope, cost estimate and schedule for the proposed Phase II studies.

(10) Phase I PCCR. Conduct a PCCR for the Phase I study.

G-5 Phase II Special Study.

a. General. A Phase II Special Study is necessary when the PCCR for the Phase I concludes that potential deficiencies exist in an embankment dam or foundation which could lead to sudden, uncontrolled loss of reservoir pool or other form of unacceptable performance likely to cause loss of life if the project were subjected to the design earthquake. The Phase II study shall be detailed and sufficiently comprehensive such that conclusions reached concerning the seismic adequacy of the dam in question are definitive and constitute the basis for selection, detailed design and construction of modifications or other form of remediation required to ensure seismic safety of the project.

b. Purpose and Scope. The purpose and scope of Phase II study are as follows:

(1) Perform comprehensive detailed analyses to evaluate performance of the critical project features when subjected to the ground motions identified in Phase I.

(2) Determine if the dam is seismically adequate or if remediation/modifications are required to ensure acceptable seismic performance.

(3) Establish remediation requirements.

(4) Evaluate various alternative remedial techniques and select the most appropriate alternative.

(5) Prepare cost estimates, scope, and schedule for design documentation, plans and specifications, and construction.

c. Methods of Analysis. The recommended engineering approach to analysis of an embankment dam and foundation for seismic stability generally consists of assessing both post earthquake static limit equilibrium slope stability and deformation response of the dam using, as appropriate, detailed 2D and 3D numerical analyses. The steps involved in a Phase II seismic analyses for earth dams normally include:

(1) Use the recommended design earthquake ground motions and accelerograms developed in the Phase I study for site response computations. For all critical projects or features, these input ground motions will be obtained from a deterministic analysis. The selected accelerograms shall be used in the application of an appropriate, validated dynamic finite element program used for modeling the deformation process in response to an imposed earthquake ground motion time history.

(2) Perform detailed field investigations which may include SPT, BPT, CPT, field vane shear tests, field permeability, ground water observation wells, conventional undisturbed sampling, geophysical evaluations, and laboratory testing, to develop a detailed understanding of site conditions, including stratigraphy, geometry, hydrology, material properties and their variability, and the areal extent of potential problem zones.

(3) Determine the pre-earthquake vertical effective shear stresses, and the initial static shear stresses on horizontal planes throughout the dam and its foundation.

(4) Determine the dynamic shear moduli of the soils in the dam and foundation.

(5) Using an appropriate dynamic finite element analysis procedure, determine the stresses induced in the embankment and foundation when subjected to the accelerograms selected for the design earthquake. Pore water pressure dissipation shall be properly accounted for in determining pore pressure behavior during shaking and residual excess pore pressure level after shaking stops. Consider relevant soil properties and stratigraphy including permeabilities in soil layers adjacent to the liquefiable soil layer, which restricts pore pressure dissipation.

(6) Determine the liquefaction resistance of the embankment and foundation soils and the maximum potential residual excess pore water pressure that can be generated by the earthquake using corrected penetration data from in-situ tests such as SPT, CPT, BPT, and laboratory index tests.

(7) Map the areal extent of all suspect materials. Determine post earthquake shear strength of relevant soils. Prepare several generalized cross sections of the dam and foundation for final analysis to determine seismic response.

(8) Perform static limit equilibrium slope stability analyses of the generalized cross sections to assess post earthquake stability and to identify potential zones of the dam and foundation, which may require remediation.

(9) Estimate the deformation response of the embankment dam and the post earthquake shape of the embankment by using an appropriate 2D and/or 3D finite element or other appropriate deformation analysis program.

(10) Remediation shall be recommended when the embankment dam is (a) found to have inadequate limit equilibrium slope stability factors of safety and/or (b) projected to experience unacceptable deformations when subjected to the design earthquake and it is concluded that either situation would result in sudden, uncontrolled loss of the reservoir pool and loss of life. If remedial measures are recommended, establish the remediation requirements, evaluate various remediation alternatives, and select the most appropriate alternative.

(11) Perform additional post earthquake limit equilibrium slope stability and finite element analysis to determine preliminary remediation needs such as extent and location of remediation required, strength/resistance required and to determine the level of protection to be obtained by remediation.

(12) Evaluate various preliminary remediation alternatives and select the most appropriate alternatives for cost estimating purposes.

(13) Perform additional finite element deformation analyses to determine expected deformations in both remediated and non-remediated sections of the dam. Determine overall dam response and differential deformation.

(14) Develop detailed scope, cost, and schedule for PED phase (Preconstruction Engineering and Design) which includes preparation of design documentation and plans and specifications (P&S).

(15) Conduct a PCCR for the Phase II study.

(16) Prepare the Phase II study summary. This is the basis for a technical appendix to the DSAP Evaluation Report. The suggested format and content for the Phase II summary is described in paragraph d below.

d. Phase II Study Documentation. There is no specific requirement for documenting the Phase II Special Study prior to development of the DSAP Evaluation Report, however, a detailed summary of the entire evaluation process including the Phase II study must be included as a Technical Appendix to the DSAP Evaluation Report. To facilitate the Phase II PCCR, a summary should be developed and presented at the PCCR in the general format and scope indicated as follows:

(1) Introduction.

(a) Authorization
(b) Purpose
(c) Project Description
(d) Method of Analysis

(2) Static Stress Analyses.

(a) General
(b) Development of Static Properties of the Dam
(c) Results of Static Stress Analyses

(3) Design Earthquake Motions.

(a) General
(b) Design Earthquake and Ground Motions
- Response Spectra
- Time Histories

(4) Dynamic Response Analyses.

(a) General
(b) Field and Laboratory Tests and Results
(c) Development of Dynamic Properties
(d) Dynamic Analyses
(e) Dynamic Response

(5) Seismic Stability Assessment.

(a) Evaluation of Dynamic Strengths
- Laboratory Data
- Field Data
(b) Dynamic Response and Stability
(c) Earthquake Induced Deformation Analyses

(6) Post Earthquake Stability Analyses.

(a) General
(b) Post Earthquake Strength Properties
(c) Slope Stability
(d) Post Earthquake Deformed Condition

(7) Deformation Response Analyses.

(a) General
(b) Deformation analyses of Remediated Sections
(c) Deformation Analyses of Unremediated Sections

(8) Remediation Alternatives.

(a) General
(b) Potential Remediation Alternatives
(c) Cost Estimates for Potential Remediation Alternatives
(d) Estimated Construction Sequence, Schedule, Duration for Alternatives

(9) Summary.

(10) Conclusions and Recommendations.

(11) References.

(12) Attachments.

FIGURE G-1
SEISMIC ANALYSIS PROCESS

Liquefaction/Deformation Evaluation

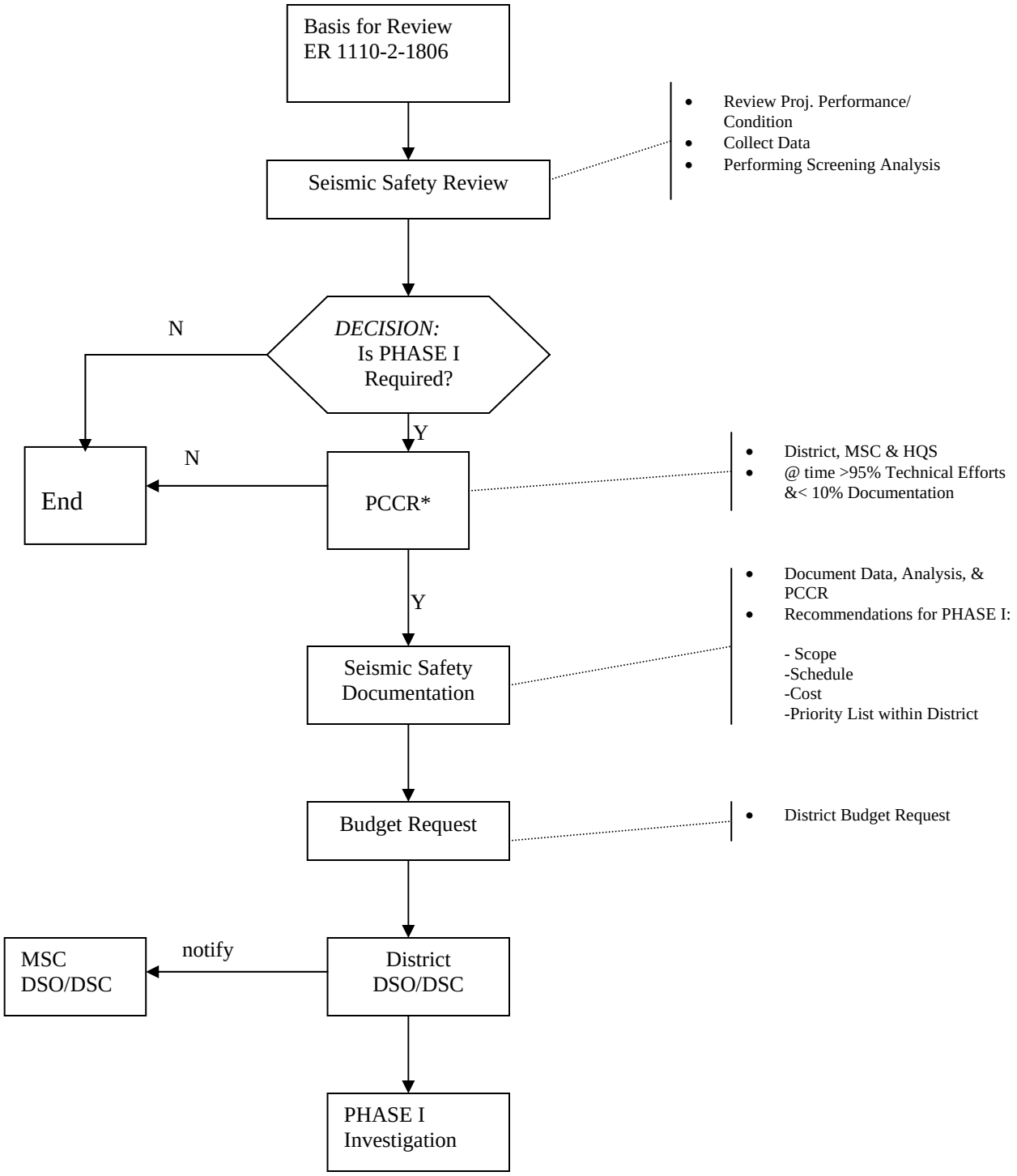


FIGURE G-1 (CONT)
SEISMIC ANALYSIS PROCESS

Liquefaction/Deformation Evaluation (Continued)

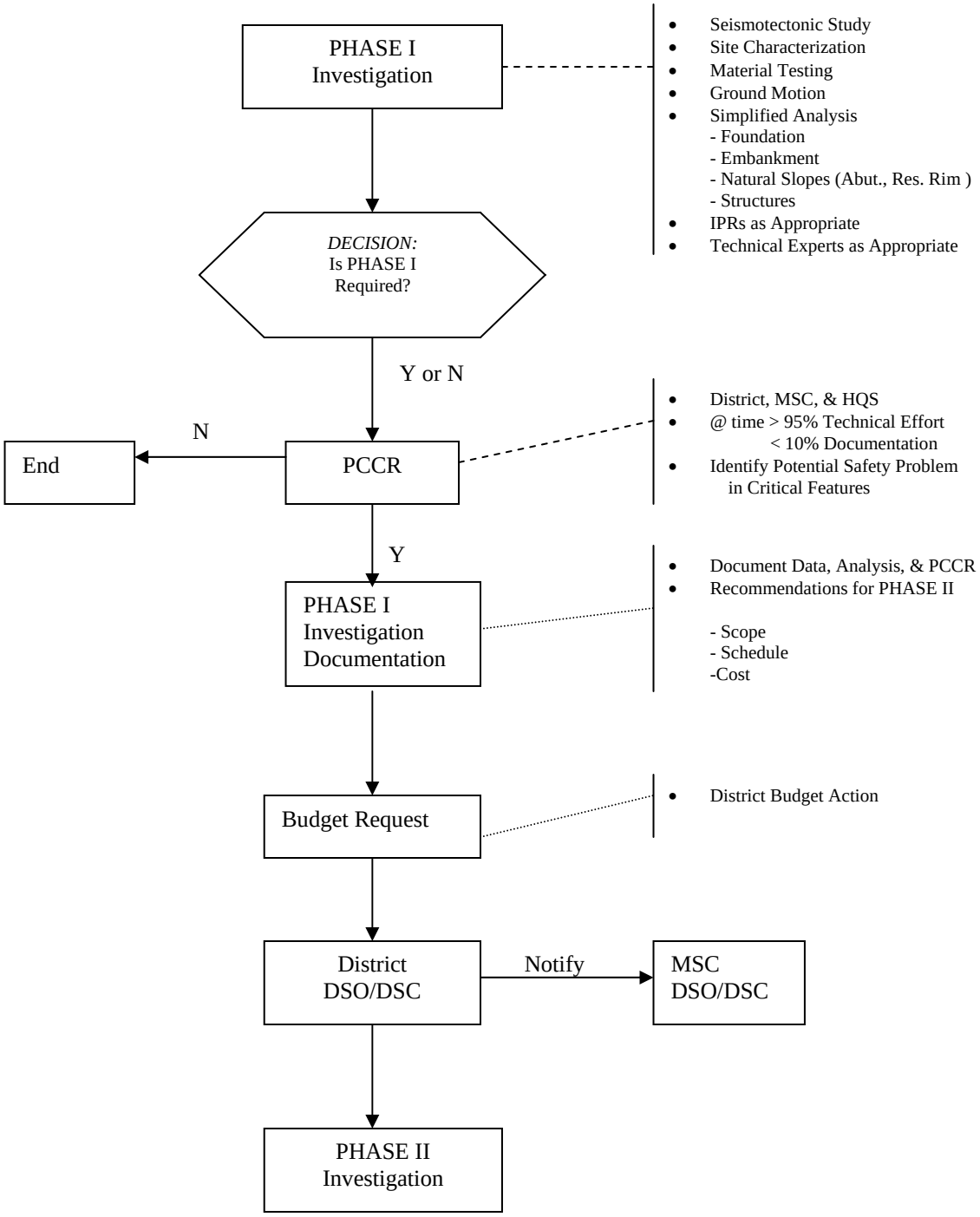
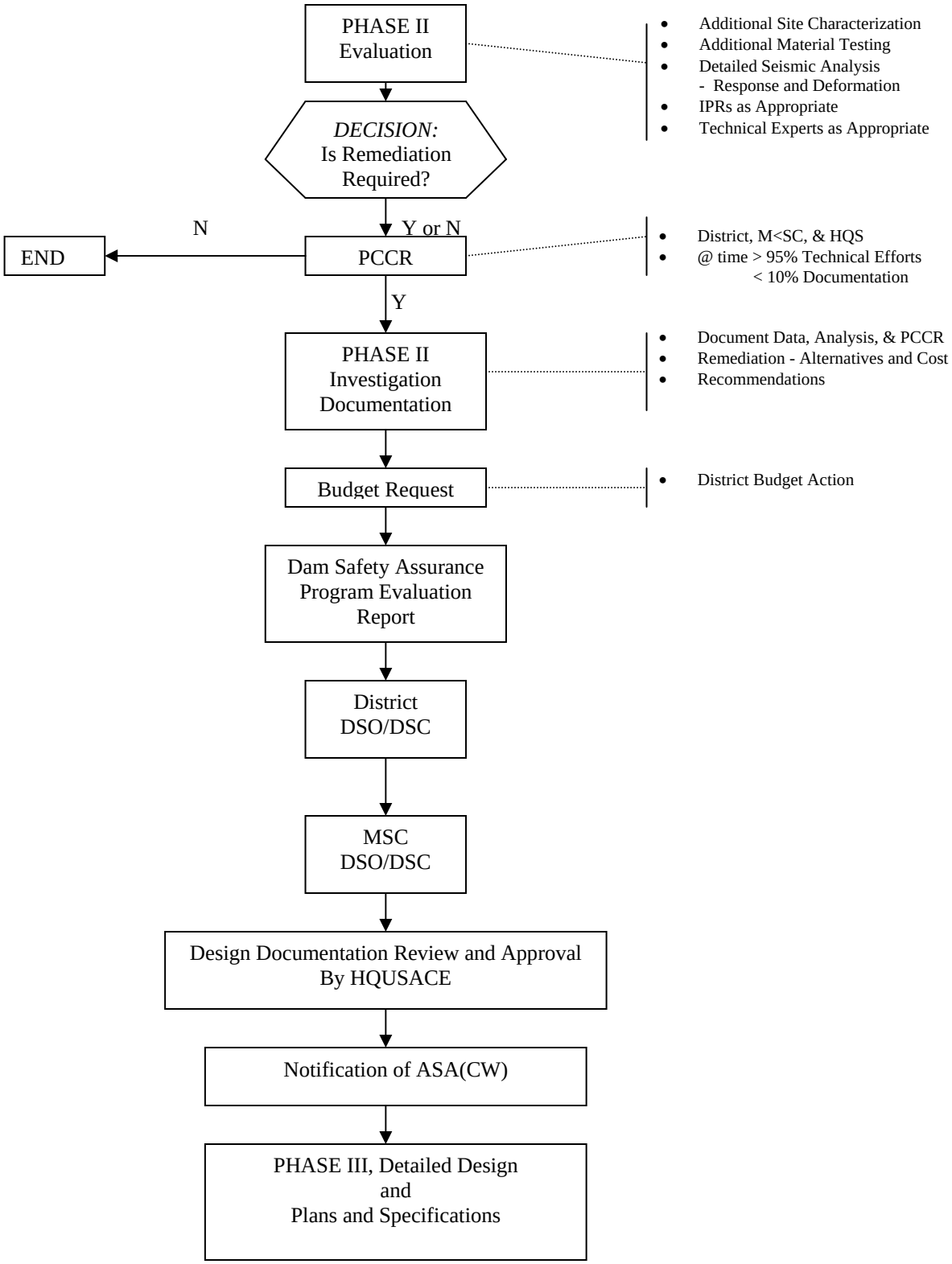


FIGURE G-1 (CONT)
SEISMIC ANALYSIS EVALUATION

Liquefaction/Deformation Evaluation (Continued)



PART II - SEISMIC SAFETY EVALUATION PROCESS FOR CONCRETE STRUCTURES AND FOUNDATIONS

G-6 Seismic Safety Review.

a. General.

(1) Types and levels of programs for seismic evaluation of concrete dams needed at various times and for various purposes start with a Seismic Safety Review (SSR) and may be followed by special studies consisting of preliminary seismologic investigations coupled with simplified seismic evaluations (Phase I), full seismologic investigations and dynamic analysis of the project (Phase II), and preparation of design documents, plans and specifications (Phase III). Flexible guidelines, consistent with the policy in paragraph 5b of ER 1110-2-1806 are needed to permit experienced investigators to do the best practical and economical job for each specific situation. The District Dam Safety Officer is responsible for making the final determination of critical structures for water control projects within his area of responsibility.

(2) A review is required to identify specific problem areas and establish priorities for further study. Generally, Seismic Safety Reviews are based on evaluations of available pertinent data and surface inspections. Seldom do SSR level investigations include extensive exploratory or testing provisions.

b. Project Description. Briefly describe the project, including type of dam or major structure and seismic zone. Enclose a location map and the tabulated pertinent project data. Describe design and current project operations.

c. Geology/Seismicity. Describe site-specific geology and provide current detailed seismicity of the site including faulting, seismic evaluation parameters used in the design and changes or experienced shaking at site based on a search of existing project files and current professional literature. Describe site-specific ground motion data.

d. Structural Investigations. Summarize structural design and results of recent analyses, if available. Describe those analyses used to conduct the evaluation.

e. Evaluation. Provide diagnostic seismic evaluation of the structure and foundation based on the data presented. Evaluate post-seismic stability. Develop a basis for decision on the need for and justification of additional studies or departure from further studies of risk assessment based on probabilities of occurrence of earthquakes, operating pool elevations and structural failure.

f. E&D Cost Estimate and Schedule. Provide scope of recommended studies and associated study costs and schedule.

g. Conclusions and Recommendations. Provide conclusions and specific recommendations based on existing data evaluations. Schedule and conduct the PCCR.

G-7 Phase I Special Study Content.

a. Project Authorization. Reference the Project Guidance Memo (PGM) from the Policy Compliance & Criteria Review (PCCR) of the SSR for the project.

b. Project Description. Briefly describe the project, including type of structures. Provide tabulated pertinent project data. Describe design and current project operations.

c. Purpose and Scope. Describe the purpose of the study, scope, and deficiency identified in the SSR.

d. Seismologic Investigations. Provide detailed seismologic study results, including fault study investigations, related field investigations, and laboratory studies.

e. Seismicity. Develop design earthquakes in relation to active fault systems and their activity.

f. Seismic Evaluation. Provide seismic evaluation of features subjected to design earthquakes. Provide basis for selection of parameters, method of analysis, and rationale for the decision on seismic assessment of the project.

g. Conclusions and Recommendations. Develop conclusions and recommendations for terminating the study or proceeding to a Phase II seismic evaluation in accordance with the requirements of ER 1110-2-1806.

h. Cost Estimate and Schedule. Provide scope, cost estimate, and schedule of recommended Phase II studies. Conduct the PCCR.

G-8 Phase II Special Studies - Guidelines for Dynamic Analysis of Concrete Structures.

a. Design Earthquakes and Ground Motions. Design earthquakes and ground motions for the seismic evaluations of concrete dams and appurtenant structures shall be determined in accordance with ER 1110-2-1806, paragraphs 5h, 6 and 8f. The study scope shall be consistent with the PGM for the Phase I PCCR.

b. Dynamic Analyses of Existing Structures and Proposed Remedial Alternatives.

(1) Review the candidate earthquake, location, and ground motions for most severe conditions to concrete structures.

(2) Select design response spectra.

(3) Select appropriate acceleration-time history records compatible with the design response spectra.

(4) Select dynamic properties for the concrete and foundation.

(5) Analyze and evaluate any cracking.

(6) Follow guidance in the current technical guidance and EM appropriate for that concrete structure.

c. Conclusions and Recommendations. Discuss remedial alternatives in the DSAP Evaluation Report and selection of remediation plan to be developed in Phase III Plans and Specifications. Provide a summary of the Phase II studies in the DSAP.

G-9 Phase II Special Study Content.

a. Introduction

(1) Authorization
(2) Purpose
(3) Project Description
(4) Method of Analysis

b. Static Finite Element Analysis

(1) General
(2) Development of Static Properties
(3) Results of Static FEM Analyses

c. Design Earthquake Motions

(1) General
(2) Design Earthquake and Ground Motions
(3) Response Spectra
(4) Time Histories

d. Dynamic Finite Element Analyses

(1) General
(2) Field and Laboratory Tests & Results
(3) Development of Dynamic Properties
(4) Dynamic Analyses
(5) Dynamic Response
(6) Evaluate Cracking in Concrete Structures
(7) Fracture Mechanics Analysis
(8) Non-Linear Analyses of Concrete Structures

e. Seismic Stability Assessment

(1) Evaluation of Dynamic Strengths
- Laboratory Data
- Field Data

(2) Dynamic Structural Response
(3) Soil Structure
(4) Interaction of backfill, structure and piles
(5) Earthquake Induced Cracking Analyses

f. Post Earthquake Stability Analyses

(1) General
(2) Evaluate Cracking in Concrete structures
(3) Evaluate Structural Stability
(4) Post Earthquake Stability

g. Remediation

(1) General
(2) Alternatives
(3) Cost

h. Summary

i. Conclusions and Recommendations

j. References

k. Attachments

PART III - FORMAT AND CONTENT OF DAM SAFETY ASSURANCE PROGRAM REPORTS

G-10 Format of Dam Safety Assurance Program Evaluation Report.

Each report will include the requirements contained in the following paragraphs and the report format shall follow the order as presented below.

a. Project Authorization. Provide pertinent information on the project authorization, including any modifications, and quote verbatim the requirements of local cooperation.

b. Project Description. Briefly describe the project, including type of dam or major structure and seismic zone and enclose a map to indicate its location.

c. Current Condition. Describe the current condition of the project features. Give the reason(s) that justify the need for modification for dam safety purposes, reference paragraph 8-1a of this chapter of the regulation, and describe the scope of the problem in quantifiable terms.

d. History of Maintenance and Rehabilitation or Modification. Provide a chronology of the expenditures for maintenance on the project since its completion, and a brief description of all previous major rehabilitations or dam safety modifications and their associated costs.

e. Project Use. Provide a narrative description of the use currently being made of the project and the use projected during an appropriate period in the future (e.g., life without and, new life with, recommended modifications for dam safety). Indicate whether the project currently satisfies the authorized project purposes and what impact the proposed modifications for dam safety will have on the project's capability to do so. Provide supporting data, as available from Corps or non-Corps sources.

f. Consequences of No Dam Safety Modifications. Explain what may occur if the problem described in paragraph 8-22c is not corrected. Describe the degree of hazard potential, the mode and magnitude of expected failure, to include the resultant damage to the dam and related structures, and the downstream impact. Under the description of the downstream impact include the potential for loss of life among the threatened population; the extent and types of economic losses; the area inundated and non-inundated areas which would be isolated due to loss of highways, bridges or services; and the impact, if any, on other retention structures. Describe the effectiveness of existing flood warning system and evacuation plans in reducing the potential for loss of life.

g. Evaluation Process. The evaluation process will result in the development and presentation of economic data so that economic considerations may be understood in a context with other important considerations, and have appropriate influence in determining justification for project modifications required to correct problems related to dam safety. Include an economic analysis if the estimated cost of the recommended work is greater than $10 million, or is greater than 25% of the replacement cost of the total project. The economic analysis is to be conducted on a sunk cost basis, i.e., all annual costs associated with the modification would be compared with the total project annual benefits. The results of this analysis will provide some perspective

on the economics of providing the proposed work; however, where there is a significant question of safety, a benefit-to-cost ratio will not be calculated.

G-11 Content of Dam Safety Assurance Program Evaluation Reports.

Dam Safety Assurance Program Evaluation Reports shall contain information on the following:

a. Nature of the dam safety problem.

(1) Hydraulic or Hydrologic Deficiency - Inability to safely pass the probable maximum flood.

(2) Seismic Deficiency - Inability to safely withstand current earthquake design criteria.

(3) Other unsafe conditions not meeting current design or construction criteria or seriously affecting project performance.

b. Extent of deviation from current design and construction criteria.

c. Nature of potential damages and potential for loss of life associated with dam failure. Damages in excess of that expected from the most extreme event, that the project could survive, are pertinent. Also include damages that would be expected if the proposed design criteria are not to current standards and are exceeded after project improvement.

d. Current average annual benefits being provided by the project.

e. Alternatives to be considered and presented:

(1) Do nothing. Indicate potential future costs to the Federal Government in the event of failure (claims and construction costs).

(2) Partial correction. Indicate average annual cost of improvement, remaining deficiencies and potential damages, continuing potential for loss of life, and potential future costs to the Federal Government. Present benefits achieved.

(3) Complete correction. Provide an appropriate discussion of feasible alternatives for the dam safety modification. Indicate what impact these alternatives would have on the project's capability to satisfy authorized project purposes. Show the estimated cost of modification for each item or group of items. Indicate average annual cost of improvement and all benefits achieved.

(4) Remove structure.

(5) Replace structure.

G-12 Recommended Plan.

a. Provide rationale for the alternative recommended, to include non-economic considerations such as potential loss of life, public confidence and other non-tangible aspects. When available information is insufficient to justify the need for modification, recommendations will be made on special engineering investigation(s), which would support a decision. In this case, the most probable plan will be presented, pending the outcome of the proposed investigations.

b. Provide a schedule of funding requirements by fiscal year to accomplish recommended modifications to the project. Indicate which requirements are recommended for funding under Construction, General, and which are recommended for funding under Operation and Maintenance, General. If both authorized and unauthorized work are recommended and the work can stand on its own from an engineering and economic standpoint, a two-stage design and construction procedure may be required. The first stage would consist of work that is authorized. The second stage could involve those items of work that require additional authorization.

c. Provide an assessment/description (for each alternative evaluated) of the impacts on the existing environment. Highlight any significant resources that are likely to be affected as well as any that are covered by a specific law (e.g., endangered species, clean air, clean water, cultural and historical, etc.). Consider potential hazardous, toxic waste and radioactive concerns and conduct appropriate surveys. Identify the location of impacts and explain their significance, the likelihood of being able to mitigate such impacts, and associated cost. Indicate the concurrence or non-concurrence given by resource agencies that mitigation is possible and appropriate. Identify any environmental constraints that would render an alternative infeasible. For the recommended alternative, provide the pertinent correspondence, a summarization of the studies conducted to evaluate the environmental effects of the plan, and the necessary NEPA documentation required in ER 200-2-2 (reference 9) (e.g., EA, FONSI, EIS, or Supplement) and/or Section 404(1)(b) evaluation.

d. Include a general explanation of the cost sharing requirements of WRDA 86 followed by a discussion of the circumstances of the particular project. Show the amount to be cost shared. Explain the determination of cost allocation and cost sharing for the specific project. This will require documentation of pertinent agreements or contracts. The discussion shall include a tabulation of the costs to be paid by the Federal Government and the sponsor(s). Identify the sponsor(s) for the project and their contributions to initial project development, and sponsor(s) subsequently added to the project. Include the sponsor(s) views concerning cost sharing. Include copies of the existing contracts or agreements.

e. When the project includes requirements of local cooperation, indicate the views or concurrence of local interests in the general plan of the proposed work, state whether these views were obtained by conference or public meeting, and provide a letter from local interests, which sets forth their views. Give the best available estimate of required local cooperation cost, a statement of the prospects for fulfillment of the required conditions, and the names, titles, and addresses of the principal officers and representatives responsible for fulfillment. Identify any

differences in local cooperation requirements under existing agreements that should be changed and the basis therefore. Also indicate what will be done to obtain the desirable local cooperation.

G-13 Appendices.

The report shall contain appendices, which contain the following documents.

a. Applicable legislation for the initial construction and subsequent addition of project purposes. Specifically include documentation on cost sharing of added authorized purposes.

b. Copies of existing contracts, agreements or letters of intent from project sponsor(s), cost sharing partners, and users.

c. Special investigations, i.e., seismic, hydrologic/hydraulic, structural, etc. completed in support of the recommended plan.

d. Project Management Plan. Include a schedule of any additional engineering investigations needed in the design phase and all DDR's that will be prepared.

e. Cost Estimate. A Micro Computer Aided Cost Engineering System (MCACES) cost estimate (reference 10) (baseline feasibility estimate) in the Civil Works/HTRW Work Breakdown Structure will be prepared for the recommended plan. The level of the cost detail will vary with the design information available to support the project scope, but shall be at least to the sub-feature level of detail. However, a higher level of detail approaching that of a feasibility report should be the goal in order to more accurately identify the baseline cost estimate. Although this baseline estimate is not subject to reauthorization if the Section 902 limit (WRDA 86) is exceeded, the goal is to make every effort to adhere to the criteria of the 20% growth limitation.

f. Real Estate. A Real Estate Plan shall be prepared at a level of detail commensurate with the scope of the project and the real estate requirements, if any, included in the evaluation report. If no land acquisition or relocation requirements are identified, the appendix shall so state.

g. Hazardous, Toxic, and Radioactive Waste (HTRW). Unless the project will result in additional real estate acquisitions, HTRW should not be a consideration. However, if HTRW is encountered, follow the guidance of ER 1165-2-132, *Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works Projects*, (reference 31).

G-14 Content of the Design Documentation Report for the Dam Safety Assurance Program.

The content of the DDR shall be as outlined below, in accordance with ER 1110-2-1150. Guidance included here is supplemental and shall be complied with, as appropriate to the project.

1. General.

2. Syllabus.

3. Table of Contents.

4. Project Description. Cite the authority for the preparation of the DDR, referring to the approved evaluation report prepared in accordance with Part III of this appendix. Provide a description of the design as originally constructed, and the present condition of the dam and related facilities. Include a discussion on the suitability of the feature or structure as constructed, and whether the design and/or construction has proven sufficient in serving the authorized project purposes. Also discuss the necessity for the proposed modification for dam safety and summarize any information in the evaluation report on the potential risk, damage and economics of the proposed work. Explain required real estate acquisitions. If the cost estimate of the work has increased since the evaluation report to the point that it now exceeds $10 million or is greater than 25% of the replacement cost of the total project, and there is no detailed economic analysis in the evaluation report, present such an analysis here. An Acquisition Plan is also required when a project cost exceeds $10,000,000 and shall be accomplished in accordance with applicable Federal Acquisition Regulations.

5. Pertinent Data. Include a brief description of the feature(s) to be rehabilitated or modified for dam safety, why the modification is required, and a summary of the estimated cost.

6. References.

7. Project Cooperation Agreement. If there will be no non-Federal sponsor for the project, this section can be omitted.

8. Engineering Studies, Investigations, and Design. The results of special investigations completed following the preparation of the evaluation report shall be summarized in this section. Any additional studies of investigations accomplished as part of the design process shall be described to the level of detail set forth in ER 1110-2-1150.

9. Environmental Engineering.

10. Plates.

11. Project Cost Estimate and Associated Sponsorship. Include a brief summary of the cost sharing information contained in the evaluation report, and a revised estimate of costs. Provide the sponsor(s) views and willingness to provide the required cooperation.

12. Economic Analysis. Projects accomplished under the authority of this Dam Safety Assurance Program do not need a benefit-cost ratio calculated. However, the cost and benefits from the proposed modifications need to be set forth.

13. Post-Authorization Changes. Modifications requiring new authorization may be recommended in the evaluation report. However, preparation of the DDR will not commence until such authorization is obtained.

14. Recommendations.

15. Real Estate Plan. If additional real estate is required, then a real estate plan will be developed in accordance with ER 405-1-12, *Real Estate Handbook*, Chapter 12, "Real Estate Roles and Responsibilities for Civil Works: Cost Shared and Full Federal Projects." (reference 12). If the project is cost shared, the non-Federal sponsor would be provided credit in accordance with said Chapter 12.

PART IV - HAZARD POTENTIAL CLASSIFICATION

G-15 Discussion.

The current classification system used to evaluate the hydrologic hazard potential of dams was established in response to several dam failures in the early 1970's which resulted in significant loss of life and property damage. This classification system while useful for the evaluation of hazard to life and property, is deficient in that it does not consider the indirect losses of critical lifelines due to a dam failure. These losses, such as the loss of water supply, loss of key transportation or medical facilities, loss of power generation capability, or loss of navigation and environmental damage can have a significant impact on the public after a major hydrologic or seismic event. Some attempt has been made in the past to consider lifeline and environmental losses as economic losses; however, a standard classification system has not been established. An additional deficiency in the existing classification system is in the potential loss of life posed by the significant and high classifications. The terms "few" under the significant category, and "high potential" under the high category are too vague and subject to interpretation. The following is an attempt to quantify the loss of life associated with each level of hazard potential.

G-16 Classification System.

Table F-1 establishes a classification system, which groups losses into four general categories: loss of life, property, lifeline and environmental losses. This hazard potential classification is related to the functional integrity of the project, not the structural integrity of project features or components. Direct loss of life is quantified as either none, certain (one or more) or uncertain. Economic indirect losses are classified as either direct property, environmental or lifelines losses. Hazard potential ratings are based entirely upon the proximity of the project to population, which would be at risk due to project failure or operation, and the impact upon life, and property of the loss of essential services. A more detailed discussion on each of the four categories follows:

a. Loss of Life. If there is certainty that one or more lives will be lost due to failure or incorrect operation of the project, the project shall be classified as high hazard potential. This certainty shall be due to extensive residential or industrial development in the flood plain downstream of the project, and shall be confirmed by inundation mapping which considers population at risk, time of flood wave travel and warning time. If the loss of life potential is uncertain because the downstream flood plain development is predominately rural or agricultural, or is managed so that the land usage is for transient activities such as with day-use facilities, then a significant hazard potential rating shall be appropriate. Only those projects with no permanent downstream development located in rural or agricultural areas with no expected loss of life can be considered to have a low hazard potential.

b. Property Losses. Property losses are classified as either: direct economic losses due to flood damaged homes, businesses, and infrastructure; or indirect economic losses due to the interruption of services provided by either the failed facility or by damaged property or infrastructure downstream.

Examples of indirect losses include:

(1) Loss of power generation capability at the failed dam (or at an inundated powerhouse downstream).

(2) Loss of navigation due to evacuation of the navigation pool at a failed reservoir (or due to direct damage to a lock).

(3) Loss of water supply due to a reservoir emptied by a failed dam.

c. Lifelines Losses. Disruption of essential lifeline services or access to these services during or following a catastrophic event can result in indirect threats to life. The loss of key transportation links such as bridges or highways would prevent access to medical facilities at a time critically injured people need access the most. Another example would be the loss or damage to medical facilities.

d. Environmental Losses. Damage to the environment caused by project failure or operation can result in the need for mitigative measures, or can cause irreparable damage to the environment. Environmental damage estimates shall consider the damage, which would normally be caused by the flood event under which the project failure occurs. Only the incremental damage caused by the project failure shall be attributed to project failure or operation. Some other examples of environmental impacts are:

(1) Environmental damage caused by the release of a reservoir contaminated by toxic or hazardous mine waste.

(2) Environmental damage caused by sediment released by a reservoir.

G-17 Classification Table.

See Table G-1 for guidance in classifying Civil Works projects as low, significant, or high hazard potential.

TABLE G-1: HAZARD POTENTIAL CLASSIFICATION FOR CIVIL WORKS PROJECTS

CATEGORY[1]	LOW	SIGNIFICANT	HIGH
Direct Loss of Life[2]	None expected (due to rural location with no permanent structures for human habitation)	Uncertain (rural location with few residences and only transient or industrial development)	Certain (one or more extensive residential, commercial or industrial development)
Lifeline Losses[3]	No disruption of services - repairs are cosmetic or rapidly repairable damage	Disruption of essential facilities and access	Disruption of critical facilities and access
Property Losses[4]	Private agricultural lands, equipment and isolated buildings	Major public and private facilities	Extensive public and private facilities
Environmental Losses[5]	Minimal incremental damage	Major mitigation required	Extensive mitigation cost or impossible to mitigate

Notes:

1. Categories are based upon project performance and do not apply to individual structures within a project.

2. Loss of life potential based upon inundation mapping of area downstream of the project. Analyses of loss of life potential shall take into account the extent of development and associated population at risk, time of flood wave travel and warning time.

3. Indirect threats to life caused by the interruption of lifeline services due to project failure, or operation, i.e., direct loss of (or access to) critical medical facilities or loss of water or power supply, communications, power supply, etc.

4. Direct economic impact of value of property damages to project facilities and down stream property and indirect economic impact due to loss of project services, i.e., impact on navigation industry of the loss of a dam and navigation pool, or impact upon a community of the loss of water or power supply.

5. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond which would normally be expected for the magnitude flood event under a without project conditions.

APPENDIX H

Major Rehabilitation Program- Format and Content of Reports

H-1 Format and Content of Evaluation Report.

The Major Rehabilitation Program Evaluation Report shall be in the format and contain the content as follows:

a. Project Authorization. Provide pertinent information on the project authorization, including any modifications, and quote verbatim the requirements of local cooperation.

b. Project Description. Briefly describe the project, including type of dam or major structure and seismic zone and enclose a map to indicate its location.

c. Current Condition. Describe the current condition of the project and give a detailed description of what components currently are in need of rehabilitation or will be in need of rehabilitation in the next five years. Give the estimated cost of repair or modification for each item or group of items, separating the costs into three categories: DDR, plans and specifications, and construction. Provide a cost estimate for replacement of the project if this is a valid alternative.

d. History of Maintenance and Rehabilitation. Provide a chronology of the expenditures for maintenance on the project since its completion, and a brief description of all previous major rehabilitations and their associated costs.

e. Project Use. Provide a narrative description of the use currently being made of the project and the use projected during an appropriate period in the future (e.g., life without and, new life with, recommended rehabilitation). Indicate whether the project currently satisfies the authorized project purposes and what impact the proposed rehabilitation will have on the project's capability to do so. Provide supporting data, as available from Corps or non-Corps sources.

f. Consequences of Not Accomplishing Needed Repairs. Describe what may occur (degree of hazard potential, loss of life, economic loss) if the repairs or modifications (described in paragraph c) are not made. Include a detailed economic analysis if the estimated cost of the recommended work is greater than $10 million, or is greater than 25 percent of the replacement cost of the total project.

g. Schedule of Recommended Work. Provide a schedule of funding requirements by fiscal year to accomplish recommended rehabilitation to the project. Indicate which requirements are recommended for funding under the Major Rehabilitation category of Construction, General, and which are recommended for funding under Operation and Maintenance, General. If both authorized and unauthorized work are recommended and the work can stand on its own from an engineering and economic standpoint, a two-stage design and construction procedure may be required. The first stage would consist of work that is authorized. The second stage could involve those items of work that require additional authorization.

h. Alternatives to Recommended Work. Provide a brief discussion of feasible alternatives to the recommended work. Indicate what impact these alternatives would have on the project's capability to satisfy authorized project purposes.

i. Environmental Considerations. Provide a brief assessment of the impacts of the work on the environment and state whether an Environmental Impact Statement (EIS), or supplement to an EIS currently on file with the Environmental Protection Agency for the project, will be prepared. Also state whether a Section 404(1)(b) Evaluation is required. The assessment shall address environmental absolutes, flood plain development, destruction or modification of wetlands, mitigation of fish and wildlife damages and, if applicable, the benefit/environmental balance, to assist in the evaluation of the proposed work as a Major Rehabilitation New Start. If an EIS or EIS supplement and/or a Section 404(l)(b) Evaluation are required, they must be submitted with the DDR following OCE approval of the Evaluation Report.

j. Schedule of Design. Provide a schedule of design reports, including plans and specifications, on the recommended work and the recommended review and approval level for each. Consideration should be given to submission dates set out in current Major Rehabilitation New Start criteria when scheduling the GDM, Draft and Final EIS and Section 404 Evaluation.

k. Cost Sharing. When the project includes reimbursable purposes, provide an estimate of cost for the rehabilitation to be assigned to reimbursable accounts under existing contracts or power marketing agreements. Include copies of the existing contracts or agreements. Indicate the views of and the expected arrangements with the non-Federal sponsors and users concerning the cost sharing.

l. Local Cooperation. For Major Rehabilitation work, when the project includes requirements of local cooperation, indicate the views or concurrence of local interests in the general plan of the proposed work, state whether these views were obtained by conference or public meeting, and provide a letter from local interests which sets forth their views. Give the best available estimate of required local cooperation cost, a statement of the prospects for fulfillment of the required conditions, and the names, titles, and addresses of the principal officers and representatives responsible for fulfillment. Identify any differences in local cooperation requirements under existing agreements that should be changed and the basis therefore. Also indicate what will be done to obtain the desirable local cooperation.

m. Recommendations. Provide a brief but inclusive description of the recommended plan.

H-2 Format and Content of Design Documentation Report.

The format and content of the Major Rehabilitation Program Design Documentation Report will be as follows:

a. Pertinent Data. Include under this caption a tabular summary of essential data on the basic project, such as project name, purposes, physical features, controlling elevations, design

flows, lock size and hydropower capacity. Also include a brief description of the feature to be rehabilitated, and a summary of the estimated cost.

b. Authorization. Cite the authority for the preparation of the DDR, referring to the evaluation report prepared in accordance with Part II of this chapter.

c. History of the Feature or Structures to Be Rehabilitated. Provide a description of the design as originally constructed, the effects of storm damage and progressive deterioration, repairs previously made, and the present condition of the structure. Include a discussion on the suitability of the feature or structure as constructed, and whether the design and/or construction has proven deficient in serving the authorized project purposes. Also discuss the necessity for the proposed rehabilitation and summarize any information in the Evaluation Report on the economics of the proposed work. If the cost estimate of the work has increased since the Evaluation Report to the point that it now exceeds $10 million or is greater than 25 percent of the replacement cost of the total project, and there is no detailed economic analysis in the Evaluation Report, present such an analysis here.

d. Plan for Rehabilitation. Provide a description of the plan considered most feasible to accomplish the proposed rehabilitation, and refer to appropriate drawings showing the plan. Also provide a description of the alternatives considered during development of the recommended plan. The following subparagraphs set forth the information to be included in support of the recommended plan.

(1) Basic design data and criteria used in the design developed for the feature or structures to be rehabilitated or upgraded, and the maps, drawings, profiles and other graphic materials necessary to illustrate the design.

(2) Results of design investigations, analyses and computations made for essential parts or items of the proposed work. Such data will include, as applicable, the information set forth in paragraphs ld, g and h of Appendix B of ER 1110-2-1150.

(3) Comparison of proposed design with the design originally constructed, with a discussion of advantages expected, if any. Also discuss any anticipated advantages from the standpoint of future operation and maintenance of the rehabilitated or upgraded structure. Specifically identify which features, if any, of the plan are significant deviations from the original design and construction, and which may require a post-authorization change report or new authorization.

(4) Results of physical model studies, if made.

(5) An assessment and evaluation of environmental impacts.

e. Construction Procedure. Briefly describe the construction procedure, diversion plan if any, and construction sequence of each element of the proposed plan. Sufficient hydrologic, hydrographic, topographic, geologic, and soils information shall be included to support the

general features of a diversion plan. Include, as applicable, the information required in ER 1110-2-2901.

f. Construction Materials.

(1) Sources. Describe the known sources, nature, extent of investigation, and indicated suitability of such materials as concrete aggregate, cement, earth and rock borrow material, and riprap. Investigation and testing shall ascertain the sufficiency and suitability of all construction materials. If the materials have been approved for another project, give the name of that project.

(2) Government-furnished Property. When it is proposed to procure equipment, materials or supplies by separate Government supply contract, and to provide such items as Government-furnished property for incorporation into the work under a general construction contract, such proposal must be specifically recommended and must include an explanation justifying the use of this procedure (DAR 13-201).

g. Construction Cost Estimate. Summarize the current estimate of cost, and separate the costs of the main features and subfeatures, as prescribed in ER 11-2-240. Also see EM 1110-2-1301. Estimates of cost will include all features necessary for completion of the rehabilitation. In addition to the summary, give a breakdown of the estimate for each feature and subfeature, showing quantities and unit prices, contingencies, engineering and design, and supervision and administration. Provide in a separate paragraph a comparison of the current estimate with that contained in the evaluation report; significant changes in estimated cost of features and subfeatures will be explained.

h. Cost Sharing. Provide an update of the estimate for any cost to be assigned to reimbursable accounts under existing contracts or power marketing agreements, referring to the evaluation report. Also, indicate current views of the non-Federal sponsors and users concerning the cost sharing.

i. Local Cooperation. Provide an update on the information provided in the evaluation report.

j. Schedules for Plans and Specifications and Construction. State the estimated time required for construction of the project and its principal components. Include a schedule to show the proposed sequence of plans and specifications and construction, and the funds required by fiscal years. Indicate whether construction is planned by contract or hired labor, and justify any hired labor work proposed.

k. Abbreviated Design Documentation Report for Rehabilitation. For work that entails no significant changes in design criteria over that used in design of the original structure, an abbreviated report, including a brief discussion of the subjects listed above, will satisfy the requirements for design documentation.

l. Recommendations. Provide a brief but inclusive description of the recommended plan.

APPENDIX I

Procedures for Preparation of Emergency Action Plans and Emergency Exercises

I-1 Components of an Emergency Action Plan.

The principal components of Emergency Action Plans (including agency responsible for preparation) are as follows (U.S. Army Corps of Engineers, Hydrologic Engineering Center 1980):

a. Emergency Identification subplan (Corps of Engineers). The object of this subplan is to describe procedures and means for ensuring reliable identification and evaluation of existing or potential emergencies. The major elements of the subplan are:

(1) Listing of the conditions that could indicate an existing or potential emergency.

(2) Description of the data and information collection system, monitoring arrangements, inspection procedures, and other provision for early detection of conditions indicating an existing or potential emergency.

(3) Procedures, aids, instructions, and other provisions for interpreting information and data to assess the severity and magnitude of any existing or potential emergency.

b. Emergency operations and repair subplan (Corps of Engineers). The objectives of this subplan are to guide immediate operational decisions in the event of various types of emergencies; identify the need for equipment, material, labor, and other necessities for carrying out emergency repairs; and describe the procedures for securing and employing needed equipment, material, labor, and other necessities. The major elements of the subplan are:

(1) Identification of the appropriate response to the type and severity of existing or potential emergencies.

(2) Emergency gate operation.

(3) Reservoir dewatering plan.

(4) Description of equipment and materials to be stockpiled for use in carrying out emergency operations and repairs.

(5) Assignments of responsibilities for carrying out emergency operations and repairs.

(6) Description of needs for equipment, material, and labor not available at the site that are needed to carry out each type of emergency operation or repair.

(7) Listing of nearby contractors and other sources of needed equipment, material, and labor and description of procedures for securing their assistance on an emergency basis.

c. Notification subplan (Corps of Engineers and non-Federal). The objective of this subplan is to describe the procedures and means for prompt notification of appropriate parties concerning existing or potential emergencies. The major elements of the subplan are:

(1) Inundation maps which show the area likely to be inundated and time of onset of dangerously high flows for each emergency condition for which plans are made (Corps of Engineers).

(2) Listing of vital services and facilities outside the area of inundation that will or may be disrupted by the level of inundation associated with each emergency condition for which plans are made (non-Federal).

(3) Listing of major secondary problems resulting from the level of inundation associated with each emergency condition for which plans are made (non-Federal).

(4) Evacuation maps which show (non-Federal):

(a) All areas which should be evacuated because of inundation, secondary problems, loss of services, isolation, or other reasons which are associated with each emergency condition for which plans are made.

(b) Major evacuation routes.

(c) Areas requiring priority in evacuation.

(d) Potential obstacles to timely evacuation.

(5) Listing of persons to be notified about each emergency condition for which plans are made and procedures for notification including description of primary and secondary means of communication to be used, listing of telephone numbers and addresses, and other information needed for reliable and prompt contact for (Corps of Engineers):

(a) Notification internal to the Corps of Engineers.

(b) Notification from the Corps of Engineers to principal local officials.

(c) Notification from the Corps of Engineers to other Federal officials.

(d) Distribution of warnings from the Corps of Engineers to officials responsible for dissemination to the general public.

(e) Dissemination of warnings by the Corps of Engineers directly to the general public in the immediate vicinity of the dam and reservoir.

(6) Example press releases for each emergency condition for which a plan is prepared and instructions for adaptation before their use to the specifics of an emergency situation including but not limited to (Corps of Engineers):

(a) Exact nature of emergency and degree of danger.

(b) Remedial action under way.

(c) Expected course of events and timing.

(d) Appropriate action for public to take.

(7) Description of the procedure and means for dissemination of warnings directly to the general public in the immediate vicinity of the dam and reservoir (Corps of Engineers).

d. Evacuation subplan (non-Federal). Non-Federal officials are to be encouraged to develop evacuation subplans as a complement to the portion of dam emergency plans prepared by the Corps of Engineers. The objectives of the evacuation subplan are to provide for the timely and safe evacuation of threatened areas and the minimization of property damage. The major elements of the subplan are:

(1) Description of traffic control arrangements to expedite evacuation and passage of emergency vehicles and prevent accidental travel into dangerous areas.

(2) Provisions for any necessary assistance to evacuees such as transportation and aid to invalids.

(3) Arrangements for sheltering, feeding, and other care of evacuees.

(4) Description of actions to be taken to reduce damages and other losses.

(5) Arrangement for security of evacuated areas.

(6) Arrangements addressing other aspects as required for the case at hand.

I-2 Number of Emergency Action Plans Required.

It is obviously impractical to prepare completely separate plans to address each potential emergency condition, which might be postulated. Instead, each major portion of the emergency plan must be considered individually with respect to how many separate versions are necessary (U.S. Army Corps of Engineers, Hydrologic Engineering Center 1980):

a. Emergency identification subplan (Corps of Engineers). Only one emergency identification subplan is required.

b. Emergency operations and repair subplan (Corps of Engineers). The emergency operations and repair subplan consists of guidance and procedures for dealing with a variety of emergencies. One subplan is sufficient. The portion of its contents dealing with emergency responses shall be divided according to the type of emergency addressed or action to be taken as, for example, the following:

(1) Wave erosion
(2) Excess seepage
(3) Piping
(4) High pool conditions
(5) Malfunction of control gates
(6) Failure of discharge facilities
(7) Upstream dam failure
(8) Downstream dam failure

c. Notification subplan (Corps of Engineers and non-Federal). Notification subplans are to be prepared for three basic emergency conditions including: spillway design discharge without failure, spillway design discharge with failure, and failure at normal high pool level (top of flood control pool). Separate notification subplans are required for each emergency condition because:

(1) Identification of the local officials to be notified of an existing or potential emergency depends on the area requiring evacuation, which is associated with each emergency condition.

(2) The need to notify other Federal agencies, the public in the immediate vicinity of the dam and reservoir, and other parties varies according to the nature of the existing or potential emergency.

(3) The appropriate text of news releases depends on the emergency condition for which they are prepared.

d. Evacuation subplan (non-Federal). Evacuation subplans will be prepared for conditions of:

(1) Spillway design flood

(2) Spillway design flood with dam failure

(3) Dam failure with normal high pool level (top of flood control pool).

I-3 Emergency Action Plan Exercises.

a. General. Testing of the Emergency Action Plan involving all participants is necessary to insure that the plan is up-to-date and workable in practice under real-life conditions (Basinger 1990, Mahoney 1990, Gotzmer 1991) (references 1, 46, 41).

b. Corps of Engineers requirements. District Dam Safety Officers shall implement a dam safety training program for O&M personnel, with retraining every four years. Upon completion of initial safety training sessions for each project, operational training exercises for emergency situations shall be developed. These exercises shall be based on the more probable emergency situations that might occur on each major dam feature. A record shall be maintained at the project showing date, subject material, and personnel involved for each exercise conducted.

According to the "Emergency Action Planning Guidelines for Dams" developed by the Interagency Committee on Dam Safety and adopted by the Corps of Engineers (Federal Management Agency 1985a) (reference 34):

> "The dam owner should prepare scenarios for slowly developing, rapidly developing, and instantaneous emergencies and test the state of training and readiness of key personnel responsible for actions during an emergency to assure that they know and understand the procedures to be followed and actions required. Any special procedures required for nighttime, weekends, and holidays should also be included. The tests should include a drill simulating emergency condition. Coordination and consultation with local government, law enforcement officials, and other organizations involved is desirable in order to enhance the realism of the test. Their involvement will perfect the close coordination with agencies necessary for a successful execution of the plan in an actual emergency. The test should be critiqued in writing and the plan should be revised to correct any deficiencies noted."

c. Type of exercises. FEMA has identified five types of exercises that constitute an exercise program, with each one building on the concepts of the previous exercise. These five types of exercises are (Federal Energy Regulatory Commission 1991; Federal Emergency Management Agency 1989a, 1989b; Gotzmer 1991) (references 39, 36, 37, 41):

(1) Orientation seminar. This involves bringing together persons with a role or interest in the Emergency Action Plan for discussion and to initiate plans for the annual drill or more in-depth exercise, and to become familiar with the roles, procedures, and responsibilities of those involved.

(2) Drill. A drill is the lowest level exercise. A drill test develops or maintains skills in a single emergency response procedure. The in-house drill tests the state of training and readiness of key personnel to ensure that they are fully cognizant of the procedures and actions required during an emergency. The drill shall simulate an emergency condition at the dam under which the Emergency Action Plan would be implemented. Special procedures required for nighttime, weekends, and holidays shall also be considered when developing the scenario. Testing of remote sensing instrumentation shall be included. Coordination with local government, law enforcement officials, and other organizations involved is desirable. This will enhance the realism of the drill and ensure the accuracy of telephone numbers of persons to be notified. While a planned drill will allow persons involved to rehearse their roles, a surprise drill can be more educational and expose flaws in the Emergency Action Plan. Immediately

following the drill the responses to the emergency scenario at all levels will be reviewed and a critique prepared. The purpose of the critique is to identify lessons learned and deficiencies in the Emergency Action Plan including notification, priorities, and responsibilities assigned.

(3) Tabletop exercise. The tabletop exercise involves low stress, little attention to real-time, lower level of preparatory effort, and only rough attempts to simulate actual conditions. The tabletop exercise is conducted once a year. The focus is on training and familiarization with roles, procedures, responsibilities, and personalities of the persons involved. The tabletop exercise consists of discussion in a meeting format through one or more facilitators. The facilitator leads the conduct of the tabletop exercise and makes sure every participant responds to at least one message (described below) during the exercise. Effectiveness is determined by the impact of feedback from the participants on evaluating and revising policies, plans, and procedures. There is no deployment of resources or utilization of equipment. A narrative (or scenario) sets the scene for the simulated event by briefly describing what has happened and what is known up to the time of the exercise. The participants are provided with messages as the exercise progresses. The purpose of the messages is to provide updated information to the participants so that they will respond with an action or a decision. Once the exercise is completed, the results will be evaluated. An immediate post-exercise critique shall be held followed by an evaluation report. The critique will be both oral and written and will provide the participants with a forum to gather and share information about what happened during the exercise, to describe what went right, and to identify what went wrong. The formal evaluation of the exercise consists of a written report based on observations and recommendations that come out of the critique, as well as the report(s) of the facilitator(s). Follow-up (the process of implementing the recommendations) is the final and critical stage of the exercise process. The advantage of a tabletop exercise is the modest commitment of time, cost, and resources. It provides an effective method of reviewing plans and implementing procedures and policies, and provides an opportunity for key personnel to become acquainted and review emergency responsibilities and procedures. The disadvantages of a tabletop exercise are that the tabletop lacks realism and does not provide a true test of participants' capabilities.

(4) Functional exercise. The functional exercise is the highest-level test that does not involve full activation of field personnel and facilities. The functional exercise is conducted once every 4 years. The functional exercise tests capabilities of the participants under a stress-induced environment with time constraints. Whereas a tabletop exercise provides opportunities throughout the exercise to stop and discuss actions and responses, the functional exercise is a time constrained test with limited opportunity for discussion. The functional exercise simulates actual emergency situations and responses of the participants without actual field deployment. The exercise is conducted with the participants co-located or located at their own facilities, with communications through expected emergency communication links. The functional exercise is based on a simulation of an emergency including a description of the situation, a master sequence of events list, a timed sequence of messages, and communication between participants and simulators. The following five functions or capabilities shall be included in a functional exercise:

(a) Alert, notification, and warning. This function tests the communication system and the messages to determine if they are appropriate and clearly understood. It verifies names and

phone numbers on the notification list. Remote sensing equipment shall be tested at the start of the exercise.

(b) Direction and control function. This function tests and evaluates the emergency operations capability and timely response. It includes the response to health problems, fire, downed power lines, and loss of life, including drownings.

(c) Evacuation. This capability is a key issue in the exercise as it tests the participants' understanding of the inundation maps. Experience indicates the inundation boundaries and the road names may not always be clear and fully understood (for example, road names used by local officials are often different from those on Geological Survey maps or state route maps). Maps are often revised as a result of this information.

(d) Shelters. This function reveals those shelters that should not be used because they are in the flood plain.

(e) Public information. This function tests the capability to issue accurate information during a dam failure event. Activation of the emergency operations center at the state or local level, as appropriate, shall be encouraged. Apart from the actual participants in the functional exercise there are the exercise controller, exercise simulators, and exercise evaluators. The controller monitors the sequence of events as they unfold, the flow of messages, and the overall conduct of the exercise. The simulators send prescribed messages at the scheduled time, respond to unanticipated actions by participants with spontaneous messages, and maintain contact with the controller during the exercise. The evaluators observe the actions and decisions of the participants during the exercise and contribute, along with the exercise participants, to writing the evaluation report. As with the tabletop exercise, the critique, the evaluation report, and the follow-up to the recommendations in the report are important aspects of the functional exercise.

(5) Full-scale exercise. The full-scale exercise is the most comprehensive test and is intended to evaluate the operational capability of the emergency management system in a stress environment with mobilization of emergency workers, equipment, and resources to demonstrate coordination and response capability. Full-scale exercises draw media and community attention to emergency preparedness; teach by doing; test total coordination, not only among policy and coordination officials, but also field forces; and point out physical resource capabilities and/or limitations. For agencies or local communities, full-scale exercises require considerable preparation and provide practical tests of "first-in" responders, including police, fire, and medical personnel. They test triage (allocation of treatment to disaster victims to maximize the number of survivors) procedures, on-scene management of resources, and coordination and communication through field command posts. As with the functional exercise, the controller is responsible for ensuring that the exercise starts on schedule. Simulators and evaluators keep a log of all significant events. During a full-scale exercise at Garrison Dam, North Dakota, conducted in August 1987, personnel were stationed at several locations in the District Office and at Garrison Dam to monitor and document phone and radio communications, decision-making, and repair efforts (U.S. Army Engineer District, Omaha 1987) (reference 60). Each participant should log his actions as much as possible. Videotaping the exercise and critique is beneficial. The media should be included in any exercise plan to increase realism. At the

conclusion of the full-scale exercise, the critique and evaluation report are important so that necessary follow-up action can be taken.

d. Exercise Frequency. A district Functional Exercise shall be conducted at least once every four years. A project emergency drill should be conducted by the field project staff prior to each flood season.