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	Engineering and Design DAM SAFETY ASSURANCE PROGRAM	
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DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

CECW-EP

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Regulation
No. 1110-2-1155

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Engineering and Design
DAM SAFETY ASSURANCE PROGRAM

1. Purpose

This regulation provides guidance and procedures for the investigation and justification of modifications for dam safety assurance at completed Corps of Engineers projects, under the authority of Section 1203 of the Water Resources Development Act of 1986 (P.L.99-662).

2. Applicability

This regulation applies to HQUSACE elements, major subordinate commands (MSC), districts, and field operating activities having responsibility for civil works projects.

3. References

See Appendix A for references.

4. Distribution

Approved for public release, distribution is unlimited.

5. Program Parameters

a. The Dam Safety Assurance Program provides for modification of completed Corps of Engineers dams and related facilities, when deemed necessary for safety purposes due to new hydrologic or seismic data or changes in the state-of-the-art design or construction criteria.

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). 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, following the

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guidance in Chapter 2 of reference 8. 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.

6. Eligibility

a. Examples of project features eligible for modification under this program follow:

(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), reference 18.

(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 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 should 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 should 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.

7. 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 should 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 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. The recommended plan, except when circumstances noted in paragraph 7c(3) below apply, should 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 7b(3)(b) and 7c(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 utilizes the existing structure up to the Probable Maximum Flood (PMF). Selection of a BSC predicated on the hazard to life from dam failure requires supporting information to demonstrate that the safety of the population would actually be threatened. The evaluation should distinguish between total population downstream of a dam and the population that would likely be in a life threatening situation given the extent of prefailure 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 hydrometerological 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 should 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 23. 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 should also reflect traditional concerns for economy. Modification costs in the vicinity of the scale of improvement identified as the BSC should be examined for sudden increases in the cost/scale of

improvement relationship. This type of change could occur, for instance, when a 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 with versus without dam failure is achieved.

(4) Conduct of the analysis will require careful application of professional judgement 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 proceed beyond the BSC. The information should be displayed in a format that assists the decision maker when evaluating the important trade-offs involved.

8. 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 should 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 judgement 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 11 and Appendix B or Appendix F of this regulation.

(3) Strong motion accelerometers placed on or around Corps 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 IAW 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, where necessary to provide for the dam safety policy of subparagraph 8a 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.

9. 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 7 and 8 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.

10. Policy on Cost Sharing

a. *Legislation.* **Section 1203 of WRDA 1986 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.**

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 is 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 should 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].

(3) Projects without a Formal Cost Allocation or a Signed Project or Local Cooperation Agreement. In most cases where there is no signed agreement, there was some sort of a letter of intent at the time of construction which indicated what local interests would provide, such as lands, easements, rights-of-way or

relocations. These projects will require a review of letters of intent or other documentation of arrangements for provision of relocations, etc., or of cash contributions by a sponsor at the time of project construction. If a sponsor accomplished some portion of the required work, such as relocations, or made a cash contribution, the value of the work or the contribution should be converted to a percent of total project initial cost. Fifteen percent of the cost of dam safety modification will be shared in the same percentage as the percentage of total project initial cost, computing the non-Federal share as the percent of contribution to total cost. The percentage should be computed based on actual rather than estimated costs of construction, if available. For example, if the actual construction cost was $50,000,000, and non-Federal interests contributed LERRD (Lands, easements, rights-of-way, relocations and disposal areas) valued at $500,000, the non-Federal share of initial construction was 1%. In this case the non-Federal share of a $15 million dam safety assurance modification would be $22,500 [($15,000,000 x 0.15) x 0.01].

(4) Contract for Storage. In some cases water supply storage may have been reallocated from conservation or from flood control storage. The agreement for the reallocation of storage is a contract. The terms of the contract will specify what storage capacity is provided in return for the payment amount. The contract usually defines how the amount paid by the contract holder was computed and shows the basis for the assignment of costs. The share of cost to be paid for the dam safety modification should be allocated in the same percent as the cost of joint use facilities was allocated. In such a case, the contract will need to be modified if it does not include a provision for payment of the proposed work.

d. *Cost Recovery*. Recovery of the non-Federal share of the dam safety assurance modification cost will be determined by the current arrangement for project cost recovery. For costs which are reimbursable through the sale of power, the share of dam safety cost will be reported to the power marketing agency for recovery in the same manner as major rehabilitation costs. For cost sharing based on a project cooperation agreement which does not have a provision for dam safety cost sharing, the agreement will need to be modified to include the dam safety costs, or a new agreement will be required. Where the project cost sharing was based on a letter of intent, an agreement will be negotiated with the sponsor. In the case of water supply, the existing contract may need

to be modified, or a new contract signed to cover the dam safety cost sharing. If no current agreement addresses this cost, the sponsor may elect to repay the cost, with interest, over a period up to 30 years in accordance with provisions of Section 1203(a)(2) of the Water Resources Development Act of 1986. If a sponsor is unwilling or unable to cost share the modification, the district/division will either seek authorization to terminate the project or perform the dam safety modification at 100% Federal cost and seek reimbursement from the sponsor through litigation.

11. 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 Appendix C. 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 Appendix B. The structural section will be prepared in accordance with Appendix F. 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 should be identified in the report. A plan of study and cost estimate for these special efforts should be included. See paragraph 15a 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.**

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

a. Ten copies of the report will be transmitted by the district, after a rigorous technical review, to HQUSACE (CECW-AR) for policy compliance review and approval. One copy of this decision package will also be sent to the HQUSACE Dam Safety Officer (CECW-E) and one copy to the MSC Dam Safety Officer. Once the report is transmitted, further work on the project may be accomplished only upon approval from HQUSACE.

b. The HQUSACE Dam Safety Officer has approval authority on these reports. The Dam Safety Officer will notify OASA(CW) of report approvals.

c. Following report approval, the district may use available Operation and Maintenance (O&M), General funds to proceed with engineering and design activities, which will begin

with the preparation of a design memorandum. The district may also budget for construction new start funds under the Construction, General appropriation. Refer to paragraph 15 for additional funding guidance, including information on the Mississippi River and Tributaries account.

13. Design Memorandum.

Preparation of DMs will follow the guidance in reference 11. The format of the DM should be in accordance with Appendix D.

14. Plans and Specifications.

Plans and specifications will be prepared in accordance with the requirements of reference 11.

15. 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, and based on the schedule of recommended work in the evaluation report, the O&M, General account 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) prior to receipt of construction funds.

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 the DM has been approved, construction funds have been specifically allocated for the required work, and a project cooperation agreement or amendment has been executed. 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.

16. Hazard Potential Classification.

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

FOR THE COMMANDER:

OTIS WILLIAMS
Colonel, Corps of Engineers
Chief of Staff

6 Appendices

APP A – References
APP B – Seismic Safety Evaluation Process for Embankment Dams and Foundations
APP C – Format and Contents of Evaluation Report
APP D – Content of Design Memorandum
APP E – Hazard Potential Classification
APP F – Seismic Safety Evaluation Process for Concrete Structures and Foundations

APPENDIX A
REFERENCES

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

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

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

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

5. ER 11-2-240, Civil Works Activities, Construction and Design.

6. ER 200-2-2, Procedures for Implementing NEPA.

7. ER 405-1-12, Real Estate Handbook, Chapter 12.

8. ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies.

9. ER 1110-2-100, Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures.

10. ER 1110-2-101, Reporting of Evidence of Distress of Civil Works Structures.

11. ER 1110-2-1150, Engineering and Design for Civil Works Projects.

12. ER 1110-2-1156, Dam Safety - Organization, Responsibilities, and Activities.

13. ER 1110-2-1200, Plans and Specifications for Civil Works Projects.

14. ER 1110-2-1302, Civil Works Cost Estimating.

15. ER 1110-2-1451, Acquisition of Lands Downstream from Spillways for Hydrologic Safety Purposes.

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

17. EM 1110-2-2200, Gravity Dam Design.

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

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

20. ER 1165-2-119, Modifications to Completed Projects.

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

22. Hydrologic Engineering Center publication dated June 1980. Titled “Flood Emergency Plans Guidelines for Corps Dams,” available from Hydrologic Engineering Center, 609 2nd Street, Davis, California 95616.

23. “Guidelines for Evaluating Modifications of Existing Dams Related to Hydrologic Deficiencies,” IWR Report 86-R-7, October 1986.

APPENDIX B
SEISMIC SAFETY EVALUATION PROCESS FOR EMBANKMENT DAMS AND FOUNDATIONS

B-1. Introduction.

a. Purpose. This Appendix 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 IAW provisions of the Dam Safety Assurance Program as defined in the main text of this ER.

c. Background. The seismic safety of many existing embankment dams must be evaluated or re-evaluated IAW requirements in ER 1110-2-1806. 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.

B-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 Appendix (Figure B-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 PCCRs 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 which 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 11 in the main body and in Appendix C of this 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 15 in the main body of this 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, IAW paragraph 15 in the main text of this 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 which must be approved by HQUSACE before budgeting for Construction General funds.

B-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, Para. 5.d.

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 IAW 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, should 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 should 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 which causes loss of life as a result of the project being subjected to the design earthquake, then a Phase I Special Study should be recommended. Where specialized expertise is needed, subject matter experts, either USACE or external, should participate in the examination and analysis as early as practical in the evaluation process.

The level of effort to accomplish the SSR should 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 E, 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 should 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) should 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 should 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 should also attend. A PCCR is not needed if the results of the SSR indicates that the dam is seismically adequate. The PCCR should summarize the examination and screening and should provide a recommendation with justification for the initiation of Phase I studies. Supporting documentation should be presented. If a Phase I study is recommended, then a scope of work, cost estimate and schedule for the Phase I study should be presented. If the SSR is done in conjunction with a periodic inspection, the results of the SSR should be incorporated into the Periodic Inspection Report. As a minimum, the District should 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-EP & EG).

B-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 should 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 should 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 should 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 should 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 should be estimated taking into account residual excess pore pressures. Post-earthquake shear strengths for zones which are indicated to liquefy should 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.

B-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 should 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 should 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 should 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 restrict 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 should 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 B-5.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

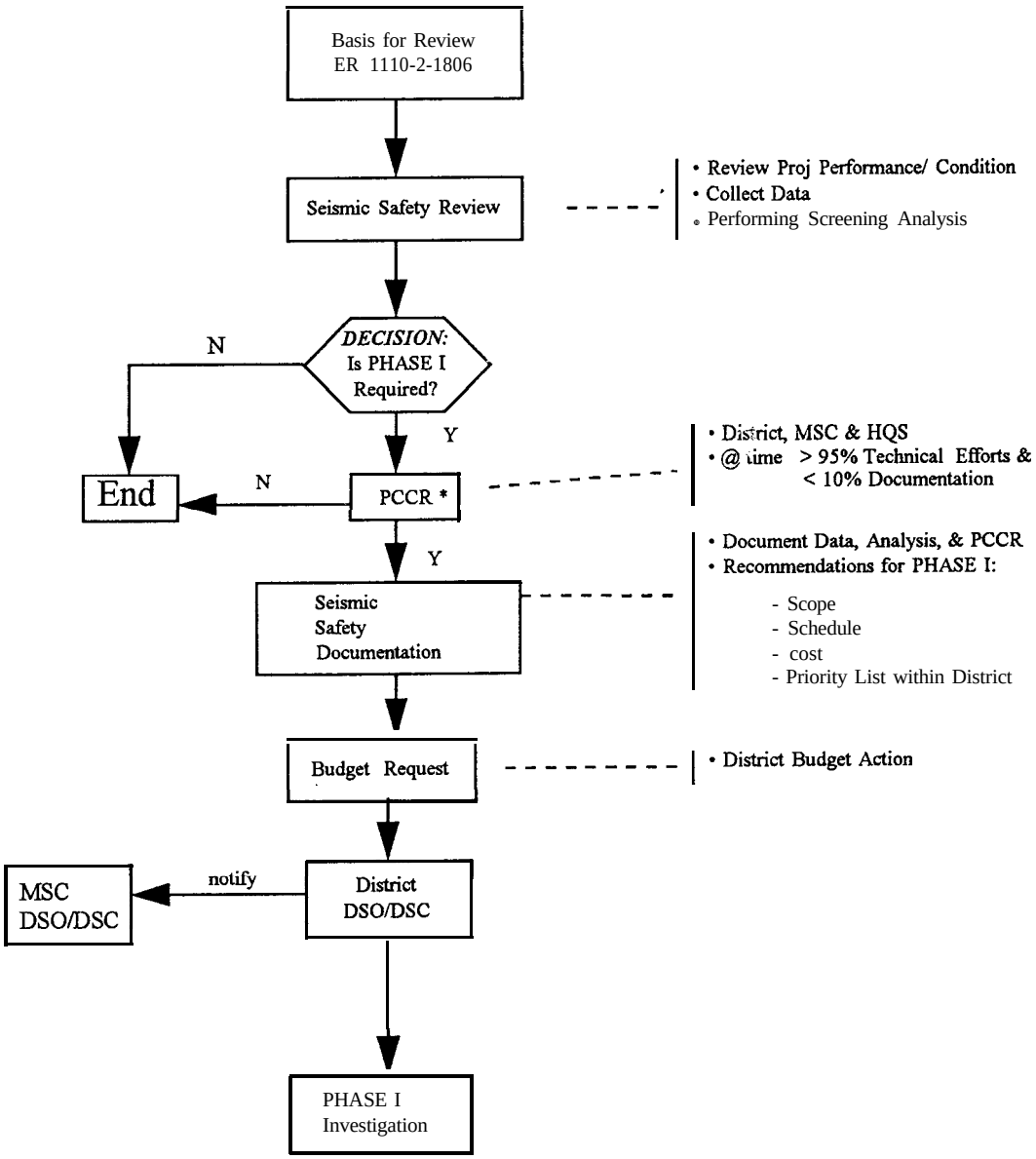
(9). Summary.

(10). Conclusions and Recommendations.

(11). References.

(12). Attachments.

Seismic Analysis Process
Liquefaction/Deformation Evaluation



* Policy and Criteria Compliance Review (PCCR)

Figure B-l

Seismic Analysis Process

Liquefaction/Deformation Evaluation -Continued

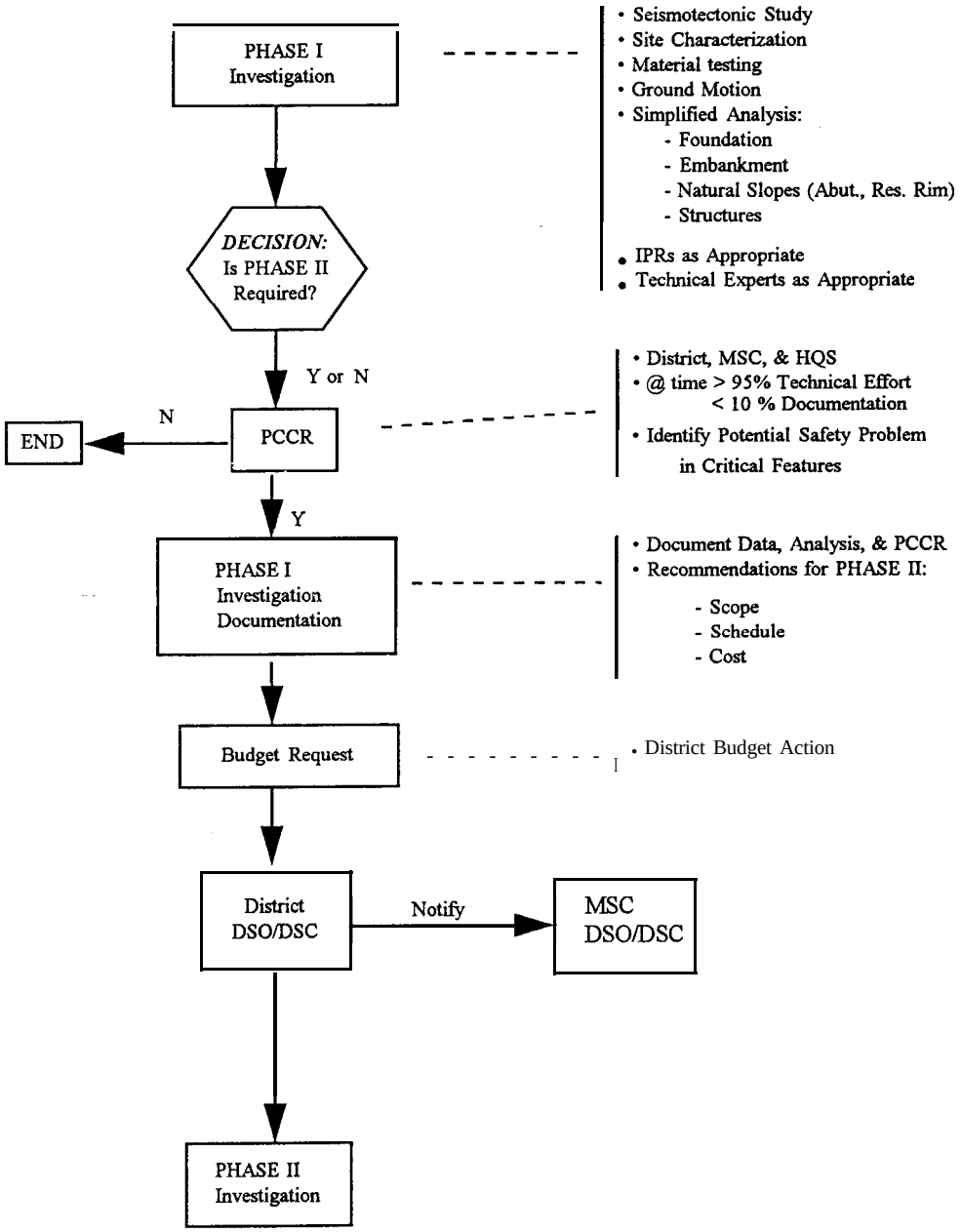


Figure B-l (Continued)

Seismic Analysis Process

Liquefaction/Deformation Evaluation -continued

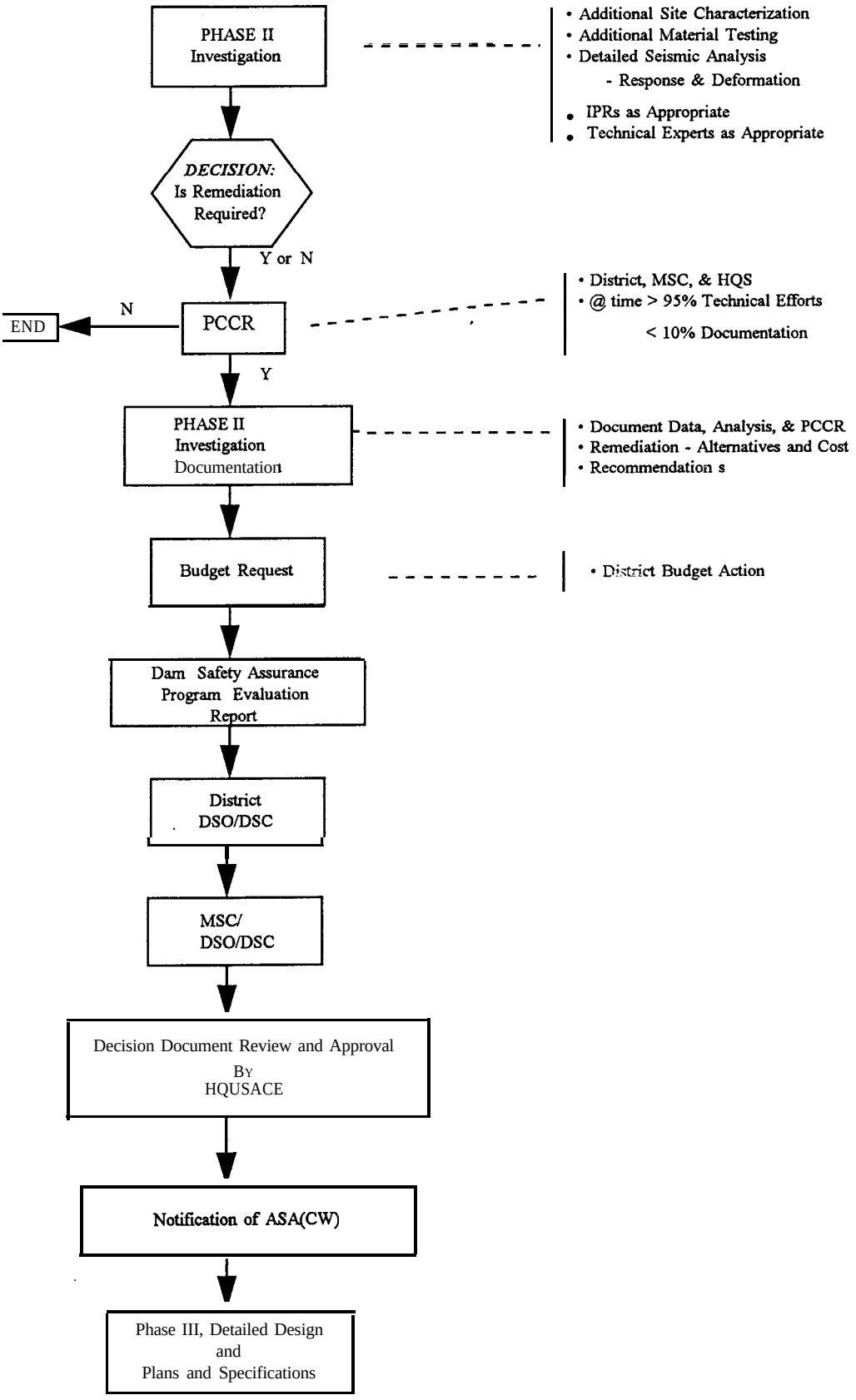


Figure B-l (Continued)

APPENDIX C
FORMAT AND CONTENT OF EVALUATION REPORT

Each report will include the requirements contained in the following paragraphs. The report format should also follow the order as presented below.

C-1. Project Authorization. Provide pertinent information on the project authorization, including any modifications, and quote verbatim the requirements of local cooperation.

C-2. 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-3. Current Condition. Describe the current condition of the project features. Give the reason(s) which justify the need for modification for dam safety purposes, reference paragraph 5a of this regulation, and describe the scope of the problem in quantifiable terms.

C-4. 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.

C-5. 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.

C-6. Consequences of No Dam Safety Modifications. Explain what may occur if the problem described in paragraph C-3 is not corrected. Describe the degree of hazard, 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 noninundated 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.

C-7. 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. Dam Safety Assurance Program Evaluation Reports should 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, which 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 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

C-8. Recommended Plan.

a. Provide rationale for the alternative recommended, to include noneconomic considerations such as potential loss of life, public confidence and other nontangible 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 which is authorized. The second stage could involve those items of work which 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 (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 should 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 set 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.

C-9. Appendices. The report should 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 design memoranda that will be prepared.

e. Cost Estimate. A Micro Computer Aided Cost Engineering System (MCACES) cost estimate (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 should be at least to the subfeature 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 should 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.

APPENDIX D
CONTENT OF DESIGN MEMORANDUM

The content of the design memorandum 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 design memorandum, referring to the approved evaluation report prepared in accordance with Appendix C. 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 should 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 should be summarized in this section. Any additional studies or

investigations accomplished as part of the design process should 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 design memorandum 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.” If the project is cost shared, the non-Federal sponsor would be provided credit in accordance with said Chapter 12.

APPENDIX E
HAZARD POTENTIAL CLASSIFICATION

E-1. 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.

E-2. Classification System. Table E-1 establishes a classification system which groups losses into four general categories: loss of life, property, lifeline and environmental losses. This hazard 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 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 should be classified as <u>high</u> hazard. This certainty should be due to extensive residential or industrial development in the flood plain downstream of the project, and

should 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 rating should 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 should 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 should 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.

E-3. See Table E-1 for classifying Civil Works projects as low, significant,or high hazard.

TABLE E-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
Environ-mental 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 should 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 F
SEISMIC SAFETY EVALUATION PROCESS FOR CONCRETE STRUCTURES AND FOUNDATIONS

F-1. 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 5.b.of ER 1110-2-1806 are needed to permit experienced investigators to do the best practical and economical job for each specific situation.

(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.

F-2. 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.

F-3. 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 5.h., 6 and 8.f. 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.

F-4. 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