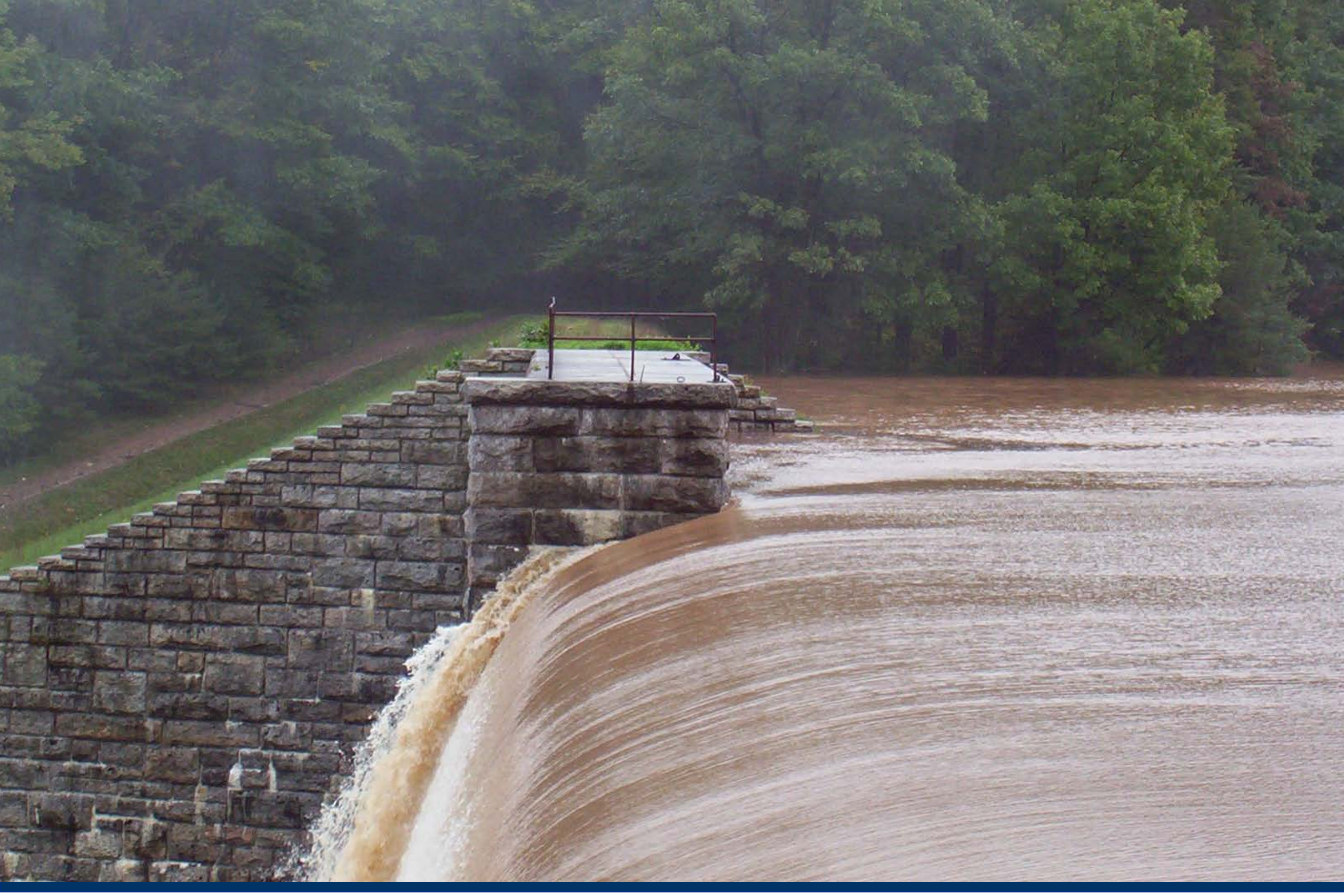

Summary of Existing Guidelines for Hydrologic Safety of Dams

FEMA P-919 / July 2012

FEMA

Preface

In September 2010, the Federal Emergency Management Agency's National Dam Safety Program sponsored development of this document under the supervision of James E. Demby, Jr., P.E. The primary authors of this document are Dr. Arthur Miller, P.E. (AECOM); and Paul Schweiger, P.E.; Amanda Hess, P.E.; Rod Holderbaum, P.E.; Bob Kline, P.E.; Don Roarabaugh, P.E.; and Gregory Richards, E.I.T. (Gannett Fleming).

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Executive Summary

Background

There is a need for updated guidelines for evaluating the hydrologic safety of dams, and in particular, for determining the appropriate Inflow Design Flood (IDF) and freeboard requirements. The existing hydrologic guidelines of some states and federal agencies were written in the late 1970s. Since that time, significant technological and analytical advances have been made along with better watershed and rainfall information that improve the analysis of extreme floods and quantification of incremental dam failure consequences. Many existing dams that were constructed before dam safety rules existed still do not meet regulatory guidelines for safely passing the IDF. Existing guidelines often do not treat new and existing dams the same in recognition of the fact that upgrading older dams to pass the IDF can be difficult and expensive.

There continues to be much debate with the current criteria, both within the engineering profession and among dam owners and others involved with dam safety. Several states and federal agencies have recently updated their dam regulations, including the sections relating to hydrologic safety; however, there appears to be considerable inconsistencies and non-uniformity in the dam classification systems and spillway capacity criteria being specified.

The overriding purpose of this report is to document the available data and to present the state of the practice for evaluating the hydrologic safety of dams, including inventorying current practices used by state and federal agencies. This work included a review of hydrologic guidelines currently used in each state and federal agency that regulates dams, and was guided by an independent steering committee and reviewed by the Research Work Group. A subsequent publication will include new federal guidelines for the evaluation of the hydrologic safety of dams that could be applied nationwide.

United States Dam Inventory

The current National Inventory of Dams, developed and maintained by the U.S. Army Corps of Engineers (USACE), contains data on nearly 84,000 dams within the United States. Approximately 11,000 of these dams are considered High Hazard, another 11,000 dams are considered Significant Hazard, and the remaining are considered Low Hazard. Most of the dams (over 65,000) are regulated by the states and owned by a variety of private or municipal entities. Federal agencies own or regulate approximately 6 percent of dams [FEMA, 2010].

Evolution of Design Flood Selection for Spillways

An understanding of the timeframe of the development of the methodologies for selecting the Spillway Design Flood (SDF) in the United States is helpful to understanding the history of dam safety guidelines since each type of design flood selection methodology must first be introduced and evaluated by the dam safety community before it becomes accepted and included in the guidelines. While laws related to the performance of dams have existed since before 1700 BC, dam designs during the early period of dam building in the United States were based solely on the judgment of the engineer. By about 1900, however, the field of surface water measurement had advanced enough to support the development of empirical equations to transpose maximum regional discharges to the drainage area of interest in order to predict peak flood discharges.

Systematic nationwide collection of surface water data began in earnest by the U.S. Geologic Survey in 1934 when the New Deal Federal Public Works Administration obtained funds to perform detailed studies of floods, rainfall, and runoff. The 1930s and 1940s saw many significant advances in hydrology including the innovation of the unit hydrograph which made it possible to estimate flood flows from storm rainfall.

The years following 1950 saw the development of elegant theoretical and mathematical approaches to solve hydrologic problems. This along with the advancement of computers to perform computationally demanding analyses led to greater use of watershed modeling using unit hydrographs and precipitation. During this period, engineers turned to meteorologists to establish limiting rates of precipitation for design purposes. Between 1963 and 1984, a series of Hydrometeorological Reports were subsequently developed to establish Probable Maximum Precipitation (PMP) estimates for the majority of the country.

While deterministic approaches to the hydrologic design of dams have been overwhelmingly supported over the past few decades, there has also been an increased interest in the application of risk analysis. The U.S. Bureau of Reclamation (Reclamation) appears to be the first agency to seriously apply risk-based decision making to dam safety. Beginning around 1995, Reclamation adopted the use of risk analysis as the primary support to their dam safety decision-making.
In 1997, the USACE replaced the Probable Maximum Flood standard with an incremental procedure to provide a framework for evaluating the benefits of mitigating hazards presented by hydrologic deficiencies in high hazard situations.

Today, many professionals consider risk assessment to be a useful way to ensure dam safety as it requires dam owners to investigate failure modes in detail and understand where the greatest risks lie. However, the main drawback of this approach is that it is technically challenging, time consuming, and difficult to administer, and so the traditional standards based approach is generally still adopted by the states.

Origins of Dam Safety Design Guidelines

Thus far, the methodology used to determine spillway adequacy has been described without regard for the actual regulatory framework. Prior to 1950, regulatory guidelines and design standards for the hydrologic safety of dams were based mainly on judgment and experience. As of 1964, a fourth of the states exercised no supervision over dams at all, and a third exercised no responsibility over operation and maintenance of a dam once it was constructed. This same year, Franklin F. Snyder, Hydraulic Engineer with the Office of the Chief of Engineers, published a dam classification and spillway design flood matrix that considered dam height, storage, and damage potential.

In the early 1970s a series of dam safety incidents occurred resulting in significant loss of life including the failure of Buffalo Creek Dam (West Virginia) in February 1972 and Canyon Lake Dam (South Dakota) in June 1972. Following these events, the Congress enacted the National Dam Inspection Act (PL 92-367) which became law on August 8, 1972. The Mine Safety and Health Administration (MSHA) also gained regulatory jurisdiction of coal refuse impoundments at this time. In the early 1970s, many states did not have laws regarding dam safety and often did not require a review of the dam design prior to construction or require construction inspection or post-construction inspection. It was also found that dam safety in most states was inadequate with a wide variation of practices, regulations and capabilities of all agencies supervising dam safety. There was also little or no overall coordination of dam safety efforts.

Dams subject to PL 92-367 were those having a height 25 feet or greater, or a maximum impounding capacity greater than 50-acre-feet. Dams less than six feet high or storing less than 15 acre-feet were excluded. Congress charged the USACE with implementing the provisions of the Act. In addition to carrying out a national program of inspection of dams for the purpose of protecting human life and property, the act also required: (1) an inventory of all dams located in the United States; (2) a review of each inspection made; and (3) recommendations for a comprehensive national program for the inspection and regulation of dams, and the respective responsibilities which should be assumed by Federal, State, and local governments and by public and private interests.

Because of the scale of the program, the USACE developed a classification system to screen the adequacy of spillway capacity. The selected classification system was quite similar to that proposed by Snyder in 1964 and closely resembles the current classification criteria used by many states.

In 1979, the Federal Emergency Management Agency (FEMA) and the *ad hoc* Interagency Committee on Dam Safety issued “Federal Guidelines for Dam Safety.” This document provided the first guidelines for federal agency dam owners and dam owners regulated by federal agencies. For flood selection design or evaluation, the federal guidelines supported the use of risk analysis. The guidelines were clear, however, that the spillway design standard to be adopted for dams where loss of life or major property damage could be significant was the Probable Maximum Flood (PMF).

In 1986, FEMA published “Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams” as a supplement to the “Federal Guidelines for Dam Safety.” The primary purpose of the document was to provide general guidelines on procedures for selecting and accommodating inflow design floods for use by federal agencies in developing agency criteria and to ensure more nationwide uniformity in application.

Several other guidance documents relating to the hydrologic safety of dams were published in the decades that followed by agencies such as FEMA, the American Society of Civil Engineers (ASCE), and the National Research Council. These documents included numerous recommendations supporting both deterministic and risk-based approaches to spillway design. The guidance documents also identified several inconsistencies in the state-of-the-practice.

Pertinent International Guidelines

While the scope of this study specifically addresses guidelines for hydrologic safety of dams within the United States, there are several developments in the international arena that are particularly relevant to the study. Recently updated guidelines in Australia and Canada were reviewed and are summarized to provide a glimpse of how other countries' guidelines are changing. The Australian National Committee on Large Dams (ANCOLD) led the way internationally in the development of acceptable risk criteria in dam safety and published *Guidelines on Risk Assessment* in 1994. This was followed with *ANCOLD Guidelines on Selection of Acceptable Flood Capacity for Dams* which was published in 2000 to provide more appropriate and consistent guidance within a risk process for dam safety evaluation under floods. These guidelines provided a basis for integrating risk assessment into dam safety. Guidelines published by the Canadian Dam Association (CDA) in 2007 include a dam classification system based on failure consequences and discuss both the traditional standards-based approach and the risk-based approach to dam safety decision making. Selecting the IDF using quantitative risk analyses is not discussed in CDA's guidelines and appears to be discouraged because of the inability to accurately assign a probability to extreme floods.

2011 Hydrologic Safety of Dams Survey and Summary of State and Federal Guidelines

In order to document the present state of the practice for evaluating the hydrologic safety of dams and inventory current practices used by state and federal agencies within the United States, a detailed questionnaire was prepared and distributed to all state dam safety agencies as well as any federal agencies which own, regulate, or assist in the design of dams. The questionnaire addressed many important issues related to the hydrologic safety of dams including dam classification criteria, determination of the spillway design flood, allowable methodologies and software, consideration of future development, incremental damage assessment, use of early warning systems, current practices related to risk analysis, and agencies' ability and receptiveness to perform risk analysis.

Surveys were completed by the appropriate dam safety agency from all 50 states as well as Puerto Rico with exception of Alabama and Florida. Of the federal agencies, respondents included the Bureau of Indian Affairs, Federal Energy Regulatory Commission (FERC), Mine Safety and Health Administration, Natural Resources Conservation Service, Tennessee Valley Authority (TVA), U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, U.S. Forest Service, and the U.S. Fish and Wildlife Service. A comparison of survey results with past documented surveys allows the identification of trends and changes related to the hydrologic safety of dams over the past 40 years.

The Current State of the Practice

The existing hydrologic guidelines of many states and federal agencies were written in the 1970s or 1980s. Since that time, significant technological and analytical advances have been made along with better watershed and rainfall information that have improved the analysis of extreme floods and quantification of incremental dam failure consequences. Review of the published policy and guidelines for each state as well as the responses to the detailed survey completed as part of this study have revealed several important findings that can be used to define the current state of the practice regarding the hydrologic safety of dams.

In general, the guidelines for the hydrologic safety of dams are not consistent and vary widely from state-to-state and between federal agencies in many respects. Although some states and agencies have recently updated their guidelines, many states and agencies have not significantly changed their guidelines since their development. Some of those who have changed their guidelines have incorporated some form of risk-based analyses, but the requirements and methodology differ widely.

Some of the most notable inconsistencies in the existing guidelines relate to classification systems. From the most basic criteria for what defines a regulatory or a jurisdictional dam to whether the dam is classified by size, hazard, or not at all, there is no overwhelming majority of configuration for these classification systems. While size classification is used by many states and hazard classification is used by all states, the number of classifications and the distinctions between the classes vary. There is also no consensus on distinctions between new dams and existing dams.

In determining the magnitude of the SDF, most states follow a prescriptive approach in which the design flood is specified based upon the dam's classification (size, hazard, or both). Both probabilistic and deterministic (based on PMP or PMF estimates) criteria are used for the prescriptive approach by the states and agencies. Many of the criteria in prescriptive approaches are arbitrary with no apparent scientific rationale, and the prescribed SDFs for identical dams in different states have varying magnitudes.

Historically, a few important federal agencies have led the way in the development of dam safety regulations and design standards, and the trend among these agencies is toward incorporating a risk-based approach rather than the prescriptive approach. The USACE is currently partnering with Reclamation, FERC, and TVA to achieve a common risk management framework and guidelines. This trend toward risk-based design is also apparent in the international practice.

The transition to risk-based analyses in some states has also begun. The methodologies developed by California, Washington, and Montana reflect an initial movement to make site-specific, cost-effective, and risk-based designs. They also demonstrate how the complexities of risk analysis can be applied in a simplified, standard-based system. Comparison of these three recently developed, risk-based approaches indicates a lack of consistency regarding the criteria used among the systems, the weights assigned to the criteria, and the resultant risk tolerances.

Although the trend appears to be the incorporation of risk-based approaches into guidelines for the hydrologic safety of dams, there are many obstacles to widespread acceptance by state regulatory agencies. The budgets, staff availability, and technical ability of many dam safety state agencies are very limited. Many respondents indicated that they have concerns regarding risk-based analyses to determine spillway capacity requirements due to review requirements and the lack of widely acceptable and defensible guidelines.

It should also be noted that the federal agencies who have led the way in developing risk analysis procedures and tolerances are owners of a significant number of dams. These agencies have been able to utilize the prioritization and ranking aspects of risk analysis to manage their respective portfolios in addition to using quantitative risk analysis in design. The administrative processes and reviews of regulatory agencies, such as FERC, MSHA, and most of the states, differ significantly from that of dam owners like USACE and Reclamation. The application of quantitative risk analysis for dam design in regulatory agencies may be burdensome or even unnecessary. The state dam regulatory agencies of California, Washington and Montana have recently developed risk-based indices to determine acceptable flood capacity; however, none of the states use quantitative risk assessment.

There are many differing opinions regarding the need for uniformity of design criteria between states and federal agencies. It is generally recognized that the implementation of strictly uniform criteria is not a possibility. Instead, a flexible framework of criteria may be required to provide for the specific requirements, budget, and technical ability of each state. While leading federal agencies and a few states have recently transitioned from strictly prescriptive to risk-based criteria, it is evident that a large portion of the dam safety community has significant reservations concerning the validity and practicality of risk analysis. Having one set of federal dam safety standards for risk determination may help to promote the use of risk-based analysis by states and potentially encourage increased uniformity of state guidelines.

The survey responses also indicate that a significant portion of the dam safety community is unaware of current and even long-standing landmark publications regarding guidelines for the hydrologic safety of dams. A quarter of respondents were unaware of FEMA's 2004 federal guidelines for "Selecting and Accommodating Inflow Design Floods for Dams," and approximately half were not familiar with the most recently published USACE, Reclamation, and ASCE inflow design and dam safety guidelines. It is therefore apparent that any attempt to encourage the adoption of more uniform guidelines and consideration of adopting risk-based criteria will require a more effective outreach and educational effort.

Although the literature search identified several studies that provided information on state practices related to selecting inflow design floods for dams, none of the studies provided a comprehensive compilation of this data. In addition to providing background information for developing new federal guidelines for the hydrologic safety of dams, this report and the associated database provide a comprehensive compilation of current federal and state guidelines that can be used by individual states to evaluate and compare their current guidelines with those of other agencies. As individual states revise their guidelines, this information will provide them with important information that will help them to make informed decisions that should result in more uniformity.

1. Introduction

1.1. Authorization

There is a need for updated guidelines for evaluating the hydrologic safety of dams, and in particular, for determining the appropriate Inflow Design Flood (also referred to as Spillway Design Flood) and freeboard requirements. The existing hydrologic guidelines of many states and federal agencies were written in the late 1970s. Since that time, significant technological and analytical advances have been made along with better watershed and rainfall information that improve the analysis of extreme floods and quantification of incremental dam failure consequences. Many existing dams that were constructed before dam safety rules existed still do not meet regulatory guidelines for safely passing the Inflow Design Flood (IDF). Existing guidelines often do not treat new dams and existing dams the same in recognition of the fact that upgrading older dams to pass the IDF can be difficult and expensive.

There continues to be much debate with the current criteria, both within the engineering profession and among dam owners and others involved with dam safety. Several states and federal agencies have recently updated their dam regulations, including the sections relating to hydrologic safety, however, there appears to be considerable inconsistencies and non-uniformity in the dam classification systems and spillway capacity criteria being specified.

In September 2010, the Federal Emergency Management Agency (FEMA) authorized a new study titled: "*Development of Guidelines for the Evaluation of Risk-Based Hydrologic Safety of Dams.*" The objective of this study is to develop and publish a guidance document for the evaluation of the hydrologic safety of dams, including guidelines for determining the IDF for new and existing dams that could be applied nationwide. This project is being completed under the direction of Dr. Art Miller with management and execution of the project by the BakerAECOM Risk MAP Professional Technical Services (PTS) Team comprised of Gannett Fleming, AECOM, Michael Baker, Jr., Inc., and Taylor Engineering. The project team includes an Independent Steering Committee comprised of Dan Mahoney (FERC), John Moyle (NJ), Brian Long (WV), Jim Gallagher (NH), and Lawrence Siroky (MT).

1.2. Purpose

Prior to developing the guidance document for the risk-based evaluation of the hydrologic safety of dams, the study team was tasked with reviewing and documenting the hydrologic guidelines currently used by each state and federal agency that regulates dams. Previous publications and technical papers that contain hydrologic safety guidelines for dams were reviewed. Organizations dealing with dam safety were contacted to determine what guidelines and support materials exist, including the Australian National Committee on Large Dams (ANCOLD), the American Society of Civil Engineers (ASCE), the Association of State Dam Safety Officials (ASDSO), the Canadian

Dam Association (CDA), FEMA, the Interagency Committee on Dam Safety (ICODS), the National Research Council (NRC), U.S. Society on Dams (USSD), and others. This initial task also included conducting a survey to gather information from every state dam safety program and federal agency that owns or regulates dams.

The overriding purpose of this report is to document the available data and to present the state of the practice for evaluating the hydrologic safety of dams, including inventorying current practices used by state and federal agencies.

1.3. Scope of Work

The scope of work for developing the guidelines for the hydrologic safety of dams was divided into five tasks. Tasks 1 and 2 relate to the current document which summarizes the existing guidelines while Tasks 3 and 4 relate to preparing the new guidance document. Task 5 relates to monthly reporting. The scope of work for the first two tasks, covering the primary purpose and scope of this reports' effort, is as follows:

> *"Task 1: Data Search – The contractor will review and gather the hydrologic guidelines currently used in each state and federal agency that regulate dams. The contractor shall also review the ASCE publication titled, 'Evaluation Procedures for Hydrologic Safety of Dams,' as well as identifying and reviewing other publications that may contain hydrologic safety guidelines. The contractor shall also contact organizations dealing with dam safety to determine what existing guidelines may exist, such as ICODS, ASDSO and its 'Model State Dam Safety Program,' and FEMA's 'Selecting and Accommodating Inflow Design Floods for Dams.'*
>
> *"Task 2: Compile Data – Within 6 months of contract start-up, the contractor will compile available data and present a draft report which incorporates findings from Task 1. The draft report should include a state of the practice of evaluating the hydrologic safety of dams. The draft report will be submitted to the Research Work Group and an independent steering committee recommended by the contractor and approved by the Research Work Group for review. The Research Work Group and steering committee will provide comments on the draft report within 30 days of submission. The contractor will submit a revised Report incorporating the comments within 30 days of receipt of comments."*

2. United States Dam Inventory Data

2.1. Background

The purpose of this section is to provide a summary of basic information related to the inventory of dams within the United States. This data is helpful for establishing new guidelines for the hydrologic safety of existing and new dams as it provides general information on the location, age, ownership, hazard classification and size of dams in the United States. This summary of dams is based on information cataloged and reported by the Association of State Dam Safety Officials (ASDSO), the US Army Corps of Engineers (USACE), the American Society of Civil Engineers (ASCE) and the Federal Emergency Management Agency (FEMA) as described in the following paragraphs. Data from each of these entities does vary; therefore, there are inconsistencies in the data presented from various sources in this chapter.

National Inventory of Dams

The National Inventory of Dams (NID) is a database of dams in the United States which was developed and is maintained by the USACE. Congress authorized the USACE to inventory dams as part of the 1972 National Dam Inspection Act. Several subsequent acts have authorized maintenance of the NID and provided funding. The USACE collaborates with FEMA and state regulatory offices to collect data on dams. The goal of the NID is to include all dams in the United States which meet at least one of the following criteria:

1. High hazard classification - loss of at least one human life is likely if the dam fails
2. Significant hazard classification - possible loss of human life and likely significant property or environmental destruction
3. Equal or exceed 25 feet in height and exceed 15 acre-feet in storage
4. Equal or exceed 50 acre-feet storage and exceed 6 feet in height

Low hazard dams which do not meet the criteria specified in number 3 or 4 are not included in the NID even if they are regulated according to state criteria. In some states, the number of these dams is several times the number of dams included in the NID.

Association of State Dam Safety Officials

In addition to using information collected as part of the NID, ASDSO annually collects additional information on dams in the United States by survey for their State Dam Safety Program Performance Information Report. ASDSO data focuses on dams within the jurisdiction of each state regardless of whether or not they are included in the NID.

American Society of Civil Engineers

Since 1998, ASCE has issued four reports titled “Report Card for America’s Infrastructure.” These reports depict the condition and performance of the nation’s infrastructure, including dams, and were prepared by an advisory panel of the nation's leading civil engineers. This panel analyzed hundreds of reports and studies in the process of assigning grades as well as surveying thousands of engineers.

Federal Emergency Management Agency

As part of the U.S. Department of Homeland Security, FEMA also has an interest in dam safety in the United States. In their 2010 biennial report to Congress, "Dam Safety in the United States, A Progress Report on the National Dam Safety Program," FEMA describes the achievements of the states, the federal agencies, and their partners in Fiscal Year (FY) 2008 and FY 2009 in meeting the vision, mission, and objectives of the National Dam Safety Program. This document contains many interesting statistics and graphics that are useful in summarizing the dam inventory of the United States.

2.2. Summary of Significant Statistics for Dams in the United States

Dam construction in the United States began in earnest in the second half of the 19^{th} century and peaked with the surge in the American economy and population following World War II. The current NID contains data on nearly 84,000 dams. The average age of these dams is over 50 years. Figure 2.1 shows the relative construction date of dams based on data in the NID.

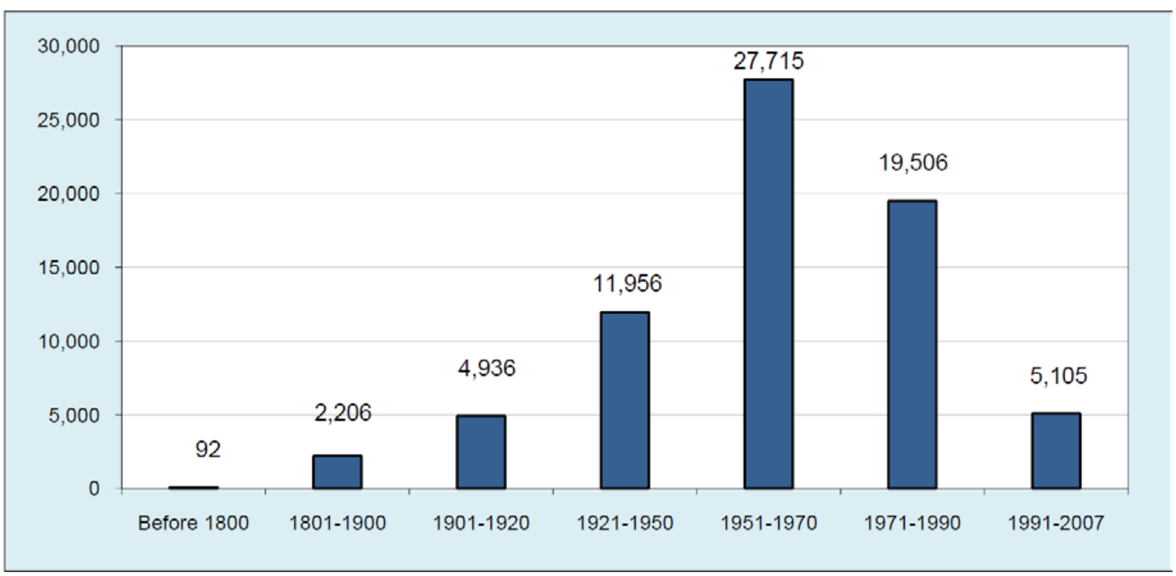


Figure 2.1 Year Dams Were Completed in the United States [USACE, 2009]

The 2009 Report Card for America's Infrastructure on Dams, prepared by ASCE, indicates that age has a two-fold effect on the determination of deficiency of a dam. First, the age of a dam contributes to deterioration. Second, design criteria and loadings which were considered appropriate at the time of design, may now be considered insufficient, leading to dams being considered unsafe or deficient. The same publication reports that the number of dams determined to be unsafe or deficient is rising and now stands at more than 4,400 dams. ASCE's 2009 Report Card states, "Over the past six years, for every deficient, high hazard potential dam repaired, nearly two more were declared deficient."

Not only are dams in the United States aging and being declared deficient, but, at the same time, the number of high hazard potential dams is also increasing at a significant rate. According to statistics maintained by ASDSO, for the 10-year period from 2000 through 2009, the number of dams listed in the NID increased by about 9 percent. During this same period, the number of high-hazard, state-regulated dams increased by almost 14 percent. ASCE's 2009 Report Card on Dams states that the trend of increasing number of high hazard dams is a result of higher consequences of failure spurred by new downstream development. Development both upstream and downstream of dams is a widespread concern.

Within the United States, dams are owned and regulated by a variety of organizations. Most dams are privately or municipally-owned and are state-regulated. Figure 2.2 is a map of the United States showing the distribution of low, significant and high hazard potential dams. Figure 2.3 is a similar map showing only state-regulated high hazard potential dams.

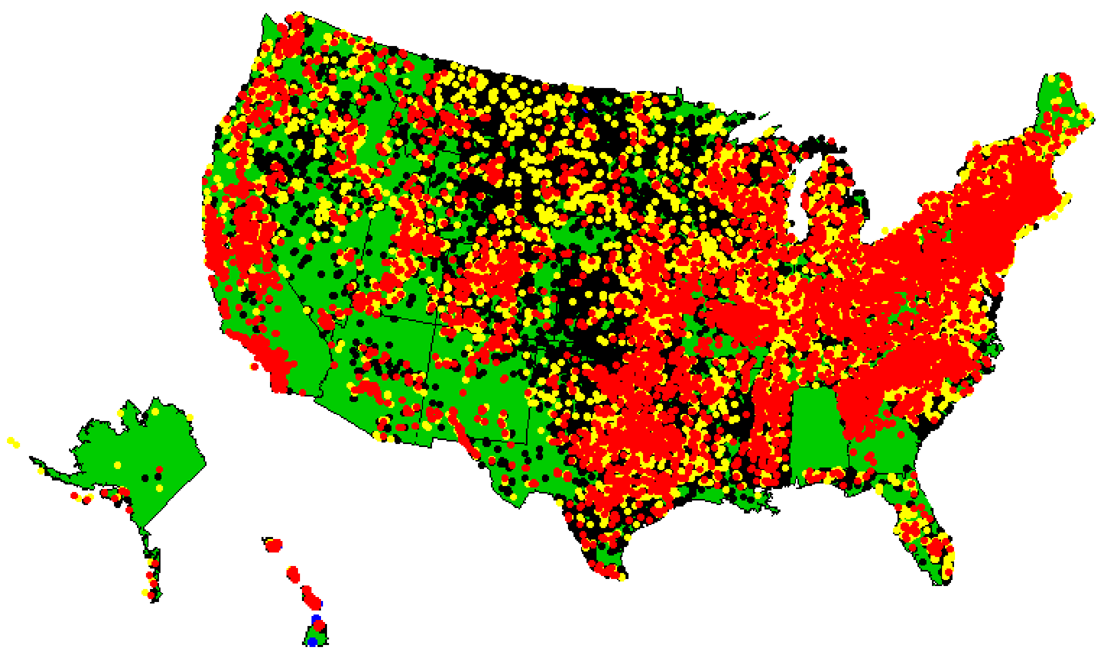


Figure 2.2 State-Regulated Dams in the United States According to Hazard Potential [FEMA, 2010]

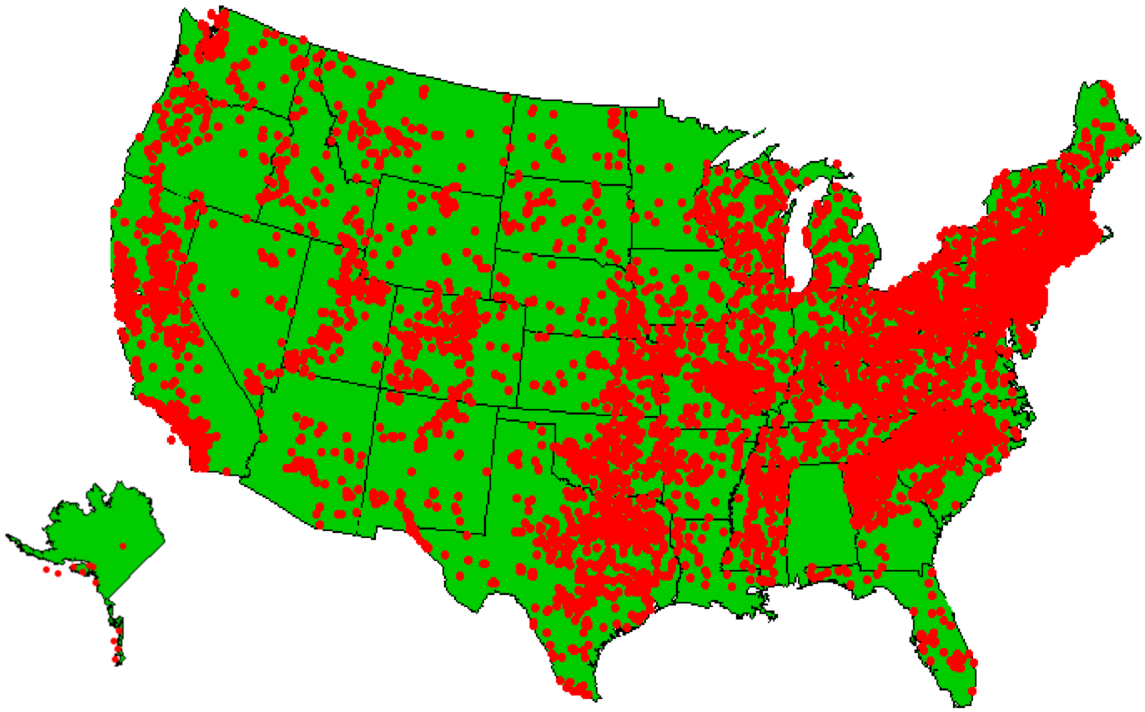


Figure 2.3 Map Showing Only State-Regulated High-Hazard Potential Dams [FEMA, 2010]

According to the FEMA biennial report to Congress, the federal government owns or regulates approximately 6 percent of the dams in the United States, and many of these dams are considerable in terms of size, function and hazard potential. The rest of the dams are within the jurisdiction of state dam safety programs. A summary of dams by state and hazard classification are summarized in Table 2-1 and Table 2-2. Figure 2.4 is a map showing the location of dams reported to the NID by the federal agencies. Table 2-3 is a summary of federal dam ownership by hazard classification.

Table 2-1 Dam Safety Statistics from the NID [USACE, 2009; ASDSO, 2008]

Hazard Potential	State Regulated Dams Listed in the NID	Total State Regulated Dams
High	10,856	10,993
Significant	11,163	10,931
Low	45,142	66,112
Total	67,161	88,036

Table 2-2 State Dam Safety Program Statistics [ASDSO, 2008]

State	State Regulated Dams				NID Dams			
	High Hazard	Significant Hazard	Low Hazard	Total	High Hazard	Significant Hazard	Low Hazard	Total
Alabama	0	0	0	0	0	0	0	0
Alaska	18	33	32	83	18	32	27	77
Arizona	100	36	116	252	93	39	120	252
Arkansas	103	95	208	406	102	92	209	403
California	688	274	285	1,247	334	708	211	1,253
Colorado	352	322	1,261	1,935	335	312	1,233	1,880
Connecticut	226	462	499	1,187	226	452	28	706
Delaware	58	5	0	63	9	27	1	37
Florida	72	330	472	874	72	321	412	805
Georgia	474	0	3,452	3,926	437	0	3,424	3,861
Hawaii	123	3	12	138	96	22	17	135
Idaho	107	149	313	569	94	129	140	363
Illinois	187	299	999	1,485	184	297	801	1,282
Indiana	240	249	599	1,088	241	250	500	991
Iowa	83	193	3,049	3,325	78	191	3,043	3,312
Kansas	202	238	5,618	6,058	183	247	5,474	5,904
Kentucky	178	217	671	1,066	161	193	600	954
Louisiana	31	69	443	543	28	65	440	533
Maine	28	67	573	668	25	80	545	650
Maryland	68	87	227	382	66	80	207	353
Massachusetts	308	746	536	1,590	324	741	554	1,619
Michigan	84	138	812	1,034	81	137	553	771
Minnesota	23	126	1,012	1,161	39	147	747	933
Mississippi	261	84	3,390	3,735	310	81	3,083	3,474
Missouri	469	137	68	674	455	132	66	653
Montana	105	152	2,636	2,893	102	131	2,377	2,610
Nebraska	124	212	1,972	2,308	129	212	1,886	2,227
Nevada	162	143	461	766	127	118	180	425
New Hampshire	122	174	2,779	3,075	89	193	344	626
New Jersey	215	338	1,168	1,721	202	366	226	794
New Mexico	181	88	129	398	170	92	96	358
New York	390	750	4,484	5,624	384	757	720	1,861
North Carolina	1,078	649	2,824	4,551	1,006	657	1,092	2,755
North Dakota	30	94	1,041	1,165	28	91	707	826
Ohio	375	543	679	1,597	411	559	558	1,528
Oklahoma	315	166	3,957	4,438	187	82	4,191	4,460
Oregon	126	197	995	1,318	122	181	530	833

Table 2-2 (continued) State Dam Safety Program Statistics [ASDSO, 2008]

State	State Regulated Dams				NID Dams			
	High Hazard	Significant Hazard	Low Hazard	Total	High Hazard	Significant Hazard	Low Hazard	Total
Pennsylvania	782	277	2,154	3,213	785	257	350	1,392
Puerto Rico	34	0	1	35	34	1	0	35
Rhode Island	97	83	470	650	17	41	136	194
South Carolina	153	481	1,683	2,317	153	481	1,683	2,317
South Dakota	47	144	2,158	2,349	47	144	2,158	2,349
Tennessee	150	210	302	662	266	330	465	1061
Texas	964	779	5,406	7,149	867	794	6,491	8,152
Utah	192	202	211	605	188	203	184	575
Vermont	57	136	379	572	57	133	161	351
Virginia	130	191	313	634	136	278	1,007	1,421
Washington	160	201	626	987	145	196	270	611
West Virginia	253	80	22	355	267	75	17	359
Wisconsin	189	170	3,294	3,653	196	138	604	938
Wyoming	79	112	1,321	1,512	79	116	1,153	1,348
Totals	**10,993**	**10,931**	**66,112**	**88,036**	**10,185**	**11,401**	**50,021**	**71,607**

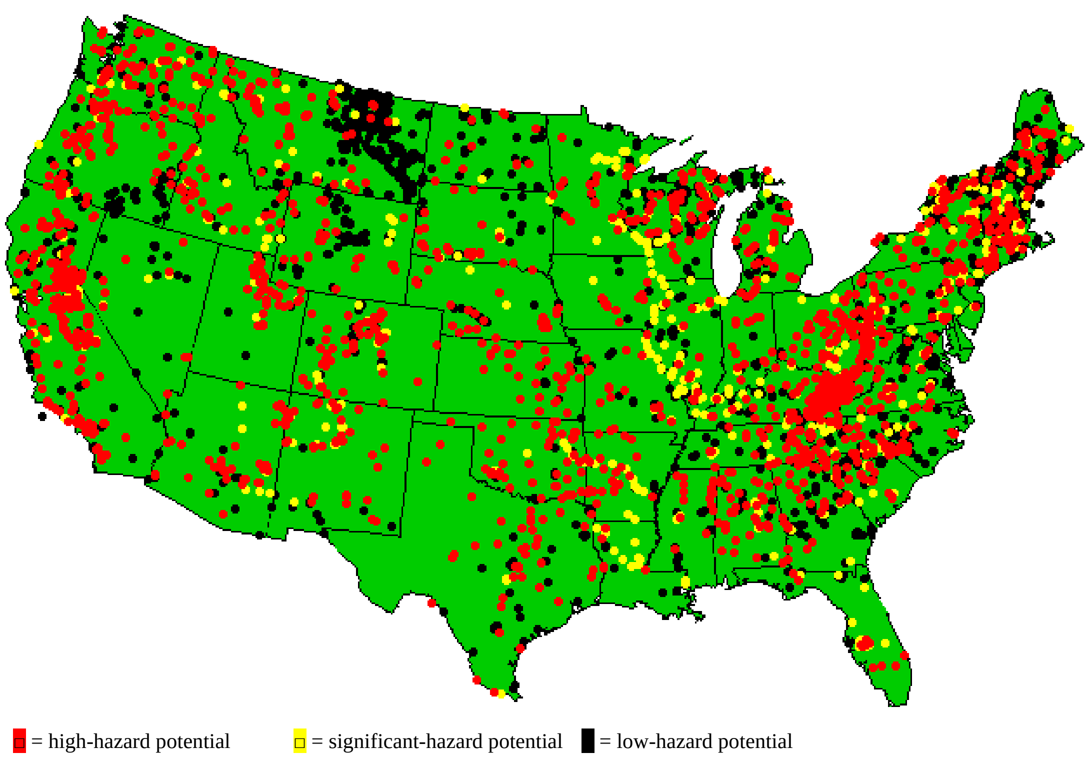


Figure 2.4 Dams Reported to the NID by the Federal Agencies [FEMA, 2010]

Table 2-3 Dams Owned and/or Regulated by Federal Agencies[1] [FEMA, 2010]

Agency	Total	High Hazard	Significant Hazard	Low Hazard
United States Department of Agriculture				
Agricultural Research Service	1	1		
USFS Owned	547	40	109	398
USFS Regulated	580	140	273	167
Natural Resources Conservation Service	27,254	2,233	2,299	22,722
Rural Housing Service[2]	25			
Rural Utilities Service[2]	25			
USDA Total:	**28,462**	**2,413**	**2,631**	**22,387**
Department of Defense				
United States Army Corps of Engineers	669[3]	500	133	31
Army	230	35	20	175
Navy	31[4]	5	3	20
Air Force	22	2	5	15
DOD Total:	**952**	**542**	**161**	**241**
Department of Education	**14**	**2**	**1**	**11**
Department of the Interior				
Bureau of Indian Affairs	895	102	29	764
Bureau of Land Management	609	8	1	600
Bureau of Reclamation	476	332	38	106
United States Fish and Wildlife Service	214	15	20	179
National Park Service	436	17	26	393
Office of Surface Mining	69	10	11	48
United States Geologic Survey	1	1		
DOI Total:	**2,700**	**485**	**125**	**2,090**
Federal Energy Regulatory Commission	**2,524**	**771**	**195**	**1,558**
International Boundary Water Commission	**7**	**3**	**1**	**3**
Mine Safety and Health Administration				
Coal	626	216	63	347
Metal and Nonmetal	1,903	144	175	1,584
MSHA Total:	**2,529**	**360**	**238**	**1,931**
Nuclear Regulatory Commission	**9**			**9**
Tennessee Valley Authority	**49[5]**	**36**	**10**	**3**

[1] Totals provided in Table 2-3 are reported exactly as listed in the source document.
[2] Breakdown of dams by hazard classification not available.
[3] Five USACE dams need to have a hazard classification determined.
[4] Three Navy dams need to have a hazard classification determined.
[5] Includes only main dam projects. Total, including associated saddle dams and dikes, is 84.

3. Evolution of Design Flood Selection for Spillways

3.1. Background

This Chapter focuses on the history and development of various methodologies for selecting the Spillway Design Flood (SDF) in the United States. The regulatory framework of dam safety guidelines and regulations is discussed in Chapter 4. An understanding of the timeframe of the development of the methodologies is helpful to understanding the history of dam safety guidelines since each type of design flood selection methodology must first be introduced and evaluated by the dam safety community before it becomes accepted and included in the guidelines.

3.2. Pre-United States Dam Building

Laws related to the performance of dams have existed since before 1700 BC. The Babylonian Code of Hammurabi is the earliest discovered example of a set of written laws, two of which (Law Nos. 53 and 54) specifically address the responsibility of dam owners to maintain their dams and provide restitution should their dam fail and flood downstream fields [King, 1910]. Engineers up until the 1800s appear to have had no known rationale for their spillway designs [Schnitter, 1994]. Many early Roman dams, mostly of modest height and of masonry with a stepped downstream face, appear to have been designed to be overtopped.

3.3. The Early Period (Before ~1900)

In the United States, few notable dams were constructed until the second half of the 19th century. In this early period, the design engineer had to rely on his own judgment as little or no streamflow or rainfall data were available. Usually the only available information was historical or anecdotal in terms of a past peak flood stage (high water mark) information. The corresponding flood discharge rates at a site were subsequently estimated from the high water mark or from past recorded flood levels transposed from adjacent streams. Early reports seem to provide a sense that the less cautious engineer had a confidence that the flood record was somewhat stable and that nature had shown what could be expected on a particular stream in terms of maximum flood potential in relatively few decades. Others believed the evaluation of major floods was impossible given the accepted techniques and resources available at that time [Myers, 1967].

During this early period, it should be recognized that the consequences of a dam failure were generally less severe than they are today. Early dams were typically constructed to limited heights. They were often constructed using rock-filled timber-cribs, stone masonry, or concrete and were resistant to erosion from overtopping. Many dams were constructed for the purpose of providing irrigation or power in remote areas where downstream development was insignificant. There may also have been an acceptance of the idea that some natural events are so extreme that man is not responsible for their consequences. The degree of conservatism of the design was generally unknown. In 1889, 2,209 lives were lost when South Fork Dam, an earth embankment dam near Johnstown, Pennsylvania, overtopped and breached. The 72-foot-high structure was initially constructed between 1838 and 1853. This man-made catastrophe focused much needed attention on the importance of adequate spillway design capacity.

During the period between 1800 and 1900, several governmental agencies with an interest in hydrology were founded in the United States, including the Army Corps of Engineers (1802), the Fish and Wildlife Service (1871), the Geological Survey (1879), the Weather Bureau under the Department of Agriculture (1891), and the Mississippi River Commission (1893). These organizations helped to advance the field of surface water measurement and ushered in the beginning of stream gauging and precipitation gauging data collection [Chow, 1964]. Significant flow measurements were made in many rivers, and a comprehensive program to perform topographical and hydrographical surveys throughout the United States was initiated. The American Society of Civil Engineers and Architects (1852) was also founded during the Croton Aqueduct project for the City of New York, and soon emerged as a leading organization for organizing lectures and publishing technical papers on dam engineering.

3.4. Period of Empiricism or the Regional Discharge Period (1900-1930)

During the last part of the 19th century and the first 30 years of the 20th century, many formulas were developed to predict peak flood discharge based on the size and hydrologic characteristics of the drainage basin [Schnitter, 1994]. Ven Te Chow notes that although much work on the modernization of hydrology had been started, the development of quantitative hydrology was still immature. He refers to this period as the “Period of Empiricism.” Hundreds of empirical formulas were proposed and the selection of their coefficients and parameters depended mainly on judgment and experience [Chow, 1964].

By analyzing the maximum discharges observed at hundreds of streams regionally rather than at a single stream, regional flood frequency formulas were developed. The concepts of *extrapolation*, *transposition* and *envelopment* were applied in the development of the formulas and recognized the random-chance nature of major storms occurring over a watershed. These concepts also recognized that hydrologic data observed at one location could serve as a basis for estimates at other locations. The most famous and widely used enveloping formula was the Myers’ and Jarvis’ ratings in which peak discharges are proportional to the square root of the drainage area and a coefficient that varies with region and geology. By transposing the largest observed values of peak discharge to drainage area within a particular geological and climatological area, it was assumed that these values approached the largest that could occur, or that they provided an adequate degree of safety [Myers, 1967].

One example of a dam designed during this period is the Gilboa Dam (Schoharie County, New York) which was designed and constructed during the period of 1917 to 1926 to impound a water supply storage reservoir for New York City. With a height of 183.0 feet and a normal pool storage of approximately 60,000 acre-feet, the dam's construction was a noteworthy achievement in dam engineering during this period. For the hydrologic design of Gilboa Dam, regional floods were analyzed and the maximum event was transposed to the 314 square mile drainage area of the dam. This transposed flood event was then multiplied by a factor of three to provide a margin of safety per the engineer's judgment. The resulting flood flow of 168,000 cubic feet per second was referred to in 1917 design documents as the "probable maximum flood." This design flood compares favorably to current industry standards for calculating the probable maximum event [USACE, 1978].

Additional major governmental agencies were founded in the United States during this period that relied on hydrologic investigations to perform their functions including the Bureau of Reclamation (1902), the Forest Service (1906), the Miami Conservancy District (1914), and the U.S. Army Engineers Waterways Experiment Station (1928). The National Research Council of the National Academy of Sciences (1919), the Federal Power Commission (1920) the International Commission on Large Dams (1928), and USCOLD (1928), now the United States Society on Dams (2001), were also established during this period.

3.5. Period of Rationalization or Period of Statistical Frequency Analysis and Storm Transposition (1930-1950)

During this period, additional important government agencies were organized in the United States such as the Tennessee Valley Authority (1933), the Soil Conservation Service (1935), now known as the Natural Resources Conservation Service (1994), and the Weather Bureau (1940).

Systematic nationwide collection of surface water data began in earnest by the Geologic Survey in 1934 when the New Deal Federal Public Works Administration obtained funds to perform detailed studies of floods, rainfall, and runoff. The publication *Floods in the United States* provided information on floods, flood peaks, and river discharges for most of the major rivers in the country while the publication *Rainfall and Run-Off in the United States* provided minimum, maximum, and other precipitation statistics from precipitation stations throughout the country. Together, the two volumes covered the major areas of surface water hydrology as it was understood and significantly increased the data available to dam engineers [Reuss, 2002].

Several great hydrologists emerged during this period who used rational analysis instead of empiricism to solve hydrologic problems. In 1932, L. K. Sherman demonstrated the use of the unit hydrograph for translating rainfall excess into a runoff hydrograph. In 1933, R. E. Horton developed an approach to determine rainfall excess based on infiltration theory. In 1941, E. J. Gumbell proposed the use of the extreme-value distribution for frequency analysis of hydrologic data, and along with many others promoted the use of statistics in hydrology [Chow, 1964].

During a brief portion of this period, flood-frequency curves were extrapolated to estimate flood flows with return periods as large as 10,000 years. The flood selected for setting the spillway design capacity depended on the judgment of the engineer [ASCE, 1988]. Developing a SDF for a dam by straight frequency analysis of discharges from a long record initially showed great promise. After several major floods, however, the recorded peak discharges were found to exceed maximum recorded floods by several orders of magnitude and fall far outside of the defined flood frequency relationships. In 1942, the Boston Society of Civil Engineers examined the use of flood frequency relationships developed from flood records extending back 100 years, and concluded that it was difficult and uncertain to assign return periods to extreme observed floods. They also concluded that it would be even more difficult and uncertain to extrapolate to the long return period that would be required for a SDF [Myers, 1967].

Figure 3.1 provides an example of the difficulties in using statistics alone, and shows the maximum annual peak discharge for the Pecos River near Comstock, Texas for the 54-year period from 1900 to 1954. Based on the observed annual peak discharges at this gaging station no one could have predicted the observed peak discharge for the 1954 flood by extrapolating prior flood frequency data (statistics) alone.

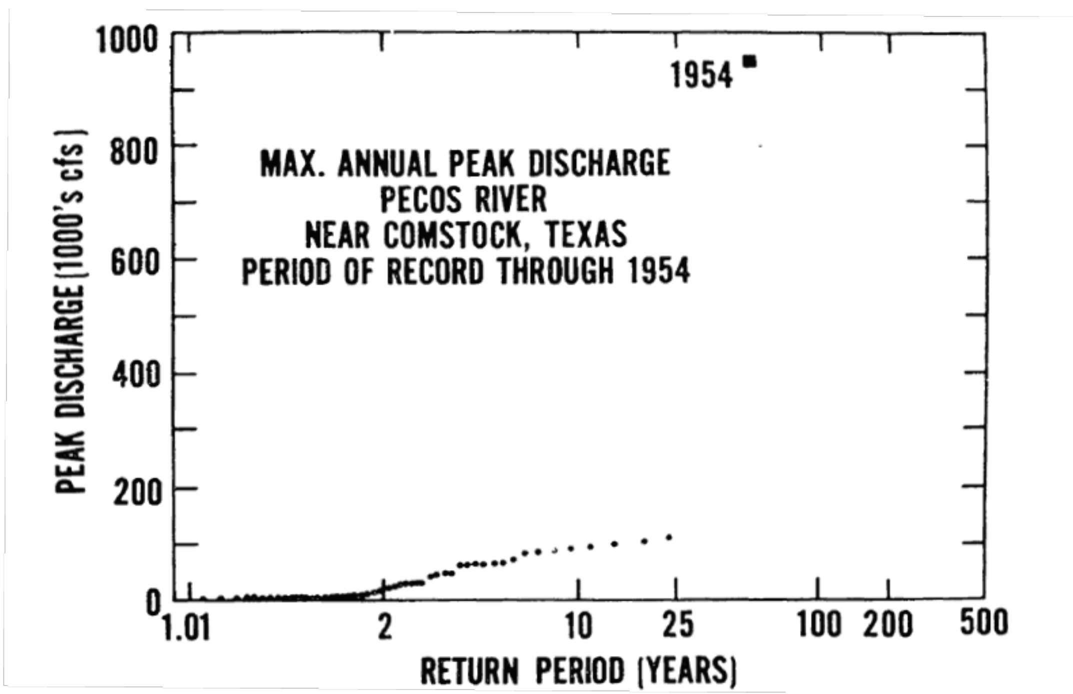


Figure 3.1 Maximum Annual Peak Discharge, Pecos River near Comstock [Myers, 1967]

With the innovation of the unit hydrograph, it became possible to estimate flood flows from storm rainfall. This led to storm transposition whereby precipitation recorded from major storms within a region are transposed or centered over the basin under study. Runoff is then computed using unit hydrograph theory. This method was developed and advocated by members of the Corps of Engineers and Weather Bureau as a powerful tool for engineers in determining events which "could happen" over basins, but cautioned that this does not necessarily yield a "limiting storm." In the late 1930s, the Tennessee Valley Authority used the Myer's rating to establish the peak design discharge (plus generous freeboard) and storm transposition for flood volume [Myers, 1967].

3.6. The Probable Maximum Precipitation Period Using Prescriptive Standards (1950-~2000)

After 1950, the Agricultural Research Service (1953) was established, the Federal Power Commission was reorganized to form the Federal Energy Regulatory Commission (1978), and the federal government's disaster-recovery efforts were consolidated to form the Federal Emergency Management Agency (1979). Under FEMA's leadership, the Interagency Committee on Dam Safety (1980) was formed and the National Dam Safety Program was established (1980). In March 2003, FEMA joined 22 other federal agencies, programs, and offices in becoming the Department of Homeland Security (2003).

The Association of Dam Safety Officials (1983) was also formed during this period and initially had 34 member states. Today ASDSO is a leading non-profit organization with more than 3,000 members representing every state dam safety regulatory agency, federal and local governments, academia, dam owners, consultants, contractors, manufacturers and suppliers.

The development of elegant theoretical and mathematical approaches to solve hydrologic problems along with the advancement of computers to perform computationally demanding analyses led to greater use of watershed modeling using unit hydrographs and precipitation. This period also coincided with a rapid increase in population and the greatest period of dam building in the United States, where dam building passed from a project-by-project emphasis to a continuous program. During this period, engineers turned to meteorologists to establish limiting rates of precipitation for design purposes. By performing air mass analyses, limits on the amount of precipitation from a storm were estimated using humidity of the incoming air, wind velocity, and the percent of water vapor that could be precipitated. In 1959, the definition of the term Probable Maximum Precipitation appeared in the Glossary of Meteorology published by the American Meteorological Society as follows [Meyers, 1967]:

> *"The theoretical greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year"* [American Meteorological Society, 1959].

The resulting Probable Maximum Flood was defined as:

> *"The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the drainage basin under study"* [FEMA, 2004].

In the early years the terms “maximum possible precipitation (MPP)” and “maximum possible flood (MPF)” were sometimes used. In 1956 this terminology was changed to probable maximum precipitation (PMP) and probable maximum flood (PMF) to recognize the uncertainties in the precipitation and runoff estimates, and that the worst combination of events was not assumed when translating rainfall into runoff [ASCE, 1988; Tomlinson & Kappel, 2009]. PMP was viewed as an estimate as there remain unknowns and unmeasured atmospheric parameters that are important to extreme rain storms [NRC, 1985]. Similarly, the PMF is less than the maximum possible flood to the extent that the combinations of natural factors assumed in the determination are less than a theoretical maximum, and the reduction tends to vary depending on the person performing the analysis and/or agency or company policy [ASCE, 1988].

Between 1963 and 1984, a series of Hydrometeorological Reports (HMR) were subsequently developed for the Continental United States by the U.S. Weather Bureau, now the National Weather Service (NWS). The oldest of these reports is HMR 39 prepared for Hawaii in 1963. The most recent is HMR 59 for California which was updated in 1999. Figure 3.2 illustrates the coverage of the HMR studies.

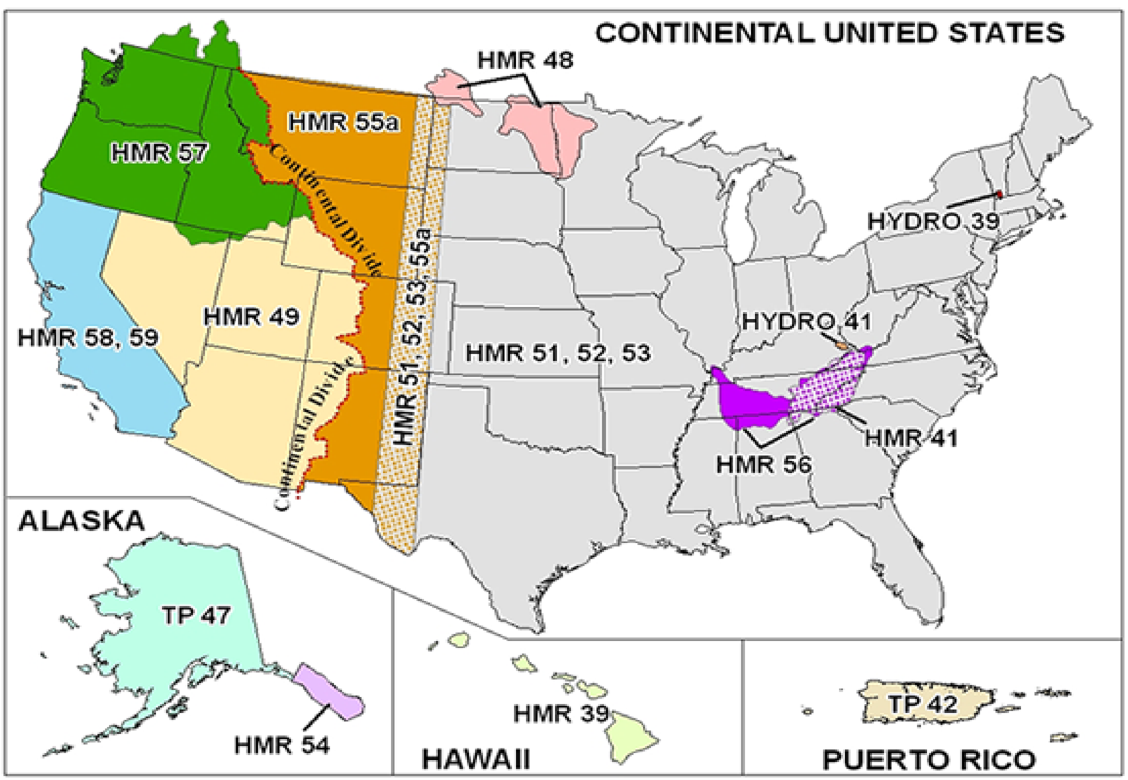


Figure 3.2 Hydrometeorological Reports prepared by the NWS for the Continental United States [NOAA, 2011]

Most of the HMRs use analyses of individual storm depth-area-duration rainfall patterns to evaluate spatial and temporal rainfall distributions and include a multiplication factor to address orographic effects. HMR 51, which covers the eastern two-thirds of the U.S., does not include any orographic adjustments but identifies two “stippled regions” in which the authors of the HMRs acknowledged that terrain effects were not evaluated and suggest that future NWS studies examine these regions more closely.

PMP estimates developed using HMRs and site specific studies in conjunction with watershed models to compute flood runoff, have been widely accepted as the basis for design of spillways for dams where failure of the structure by overtopping cannot be tolerated, and has resulted in progressively more conservative design requirements for spillways. The adoption of this standard has raised difficult questions as to what should be done with existing dams constructed before this standard where the spillways do not satisfy this criterion.

Site specific PMP studies have also been performed by private contractors recognizing the fact that the published HMRs provide generalized rainfall values that are not basin-specific and tend to represent the largest PMP values across broad regions. Many recent site-specific studies have produced PMP values significantly different from the HMR values. Reasons for the differences (mostly reductions) are attributed to using basin characteristics that are specific to the topography and local climate of the watershed being studied, new storm data like NWS NEXRAD, improved analysis procedures, and technology advances such as new computer models, weather radar, and geographic information system (GIS) software to analyze depth-area-duration tables. Site specific PMP study values are generally 5 to 15 percent lower than values from the published HMRs, although some studies have shown minimal reductions. The largest PMP reductions from site specific studies have been for long duration storms for large drainage areas, and have been greater than 50 percent lower [Tomlinson & Kappel, 2009; Applied Weather Associates, 2008].

Statewide studies of extreme storm events have also been performed in an effort to support risk-based design criteria for spillways. The states of Washington, Montana, California and Wisconsin have authorized statewide studies. For example, beginning in 1981, the state of Washington began collecting and analyzing data to define the characteristics of extreme storms for use in developing risk-based criteria for spillway design. This work was led by Dr. Mel Shaefer and resulted in the publication of “*Technical Note 3*” in 1993 which provided engineering guidance for developing design storms for use in computing IDFs using rainfall-runoff computer models. This document was updated in 2009 using more than 700 precipitation gages and high resolution mapping techniques within a GIS framework, and includes probabilistic based procedures for generating precipitation magnitude-frequency relationships for any location within the state [MGS Engineering Consultants, 2009].

In a letter dated June 1, 1984 to the NRC Committee on Safety Criteria for Dams, the NWS provided some additional information regarding the extensive material on PMP estimates and techniques that they developed to provide the basis for the most conservative criteria for spillway design. The following is extracted from their letter to the NRC Committee:

> *"Theoretically the PMP has zero probability of actual occurrence. A report (Riedel, J. T., and Shreiner, L. C. 1980) compares the greatest known storm rainfall depths with generalized PMP estimates for the United States east of the 105th meridian and west of the Continental Divide. This was done for rainfall depths averaged over six area sizes (10, 200, 1,000, 5,000, 10,000, and 20,000 mi^2) each for durations (6, 12, 24, 48 and 72 hours) covering the eastern United States.* A *similar comparison was made for the western United States, but with fewer combinations. A summary of the results is presented in [Table 3-1]."*

Another comparison shows that for the eastern and western United States there were 170 and 66 separate storms that occurred from 1819 to 1979 which had depths exceeding 50% of PMP for at least one area size and duration, respectively. Riedel and Schreiner also pointed out that the greatest rainfall amount in a storm may not have been observed and documented, especially in the west. In a few recorded storms, total rainfall amounts have exceeded 100% of the PMP. These include the Smethport, PA storm of July 17-18, 1942 in which 30.8 inches of rain fell in 4.5 hours, and the Cherry Creek, CO storm of May 30-31, 1935 where 24 inches of rain was observed in a period of less than 6 hours [Huffman, 1999].

Table 3-1 Comparison of Greatest Known Storm Rainfall Depths with Generalized PMP Estimates within the United States [Riedel & Shreiner, 1980]

Location	Number of Storms Exceeding Various Percentages of PMP		
	70%	80%	90%
East of the 105th Meridian	160	49	4
West of the Continental Divide	16	5	0

3.7. Risk-Informed Decision Making Period (2000-Present)

Although the period of time beginning in 2000 can be considered the period of risk-informed decision making, several advances and publications prior to 2000 paved the way for the introduction of risk into SDF selection. The earliest reference to using risk-based analyses to determine the SDF appears to be in a 1964 manual prepared by the American Water Works Association (AWWA) titled: *Manual M13 – Spillway Design Practice*. The AWWA guidelines presented in this manual stress that for water supply dams, "the selection of a spillway capacity less than the maximum probable flood is a very serious decision for the designer and for management," and recommends the use of a "thorough cost study to evaluate the variable costs of (1) repairs to the dam and spillway, (2) lost water during periods of repairs, (3) damages caused by insufficient spillway, and (4) construction of spillways of specific capacity" [AWWA, 1964]. Although the concepts of risk, flood probability, and consequences are discussed in the manual, procedures for performing a formal risk analysis and establishing decision criteria are not addressed in Manual M13. The AWWA guidelines indicate that this type of cost analysis is largely subjective and almost entirely a matter of judgment.

In 1973, an ASCE Task Committee on the Reevaluation of the Adequacy of Spillways of Existing Dams published a report in the Journal of the Hydraulics Division [ASCE, 1973]. In the report, the Task Committee advocated "risk taking" in spillway capacity design and recommended that spillway capacities for new and existing dams of all sizes be based on a thorough economic analysis of the "social cost of risks and the cost of modification" computed on an average annual basis. An evaluated level of risk at which the total of all social costs will be at a minimum was proposed. The Task Committee recommended use of a monetary value for human life and injury in the analysis based on practices of courts in awarding damages in cases involving accidental deaths and injury. The ASCE Task Committee's report generated much controversy and their recommended approach was viewed as a "radical departure" from accepted standards [Williams, 1973]. The recommendation to place a monetary value on human life and suffering in the economic analysis was ultimately not accepted by the engineering profession or by regulatory agencies. Other factors contributing to the lack of interest for the recommended approach included the need to select an interest rate for the analysis of equivalent present-day costs, and the problem of assigning probabilities for extreme flood events.

From the time the ASCE Task Committee on the Reevaluation of the Adequacy of Spillways of Existing Dams published their report in 1973 through the present, there has been much discussion, debate and controversy on the use of risk-based analyses for dams. Between 1979 and 2000, several studies and guidelines on selecting acceptable flood capacity for dams were published by various individuals and agencies including the following:

- 1979 – *Federal Guidelines for Dam Safety*, FEMA ad hoc ICODS (Reprinted 2004)
- 1985 – *Flood and Earthquake Criteria,* NRC Committee on Safety Criteria for Dams
- 1986 – *Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams,* FEMA (ICODS)
- 1988 – *Evaluation Procedures for Hydrologic Safety of Dams,* ASCE Task Committee on Spillway Design Flood Selection
- 1996 – *Dam Safety Policy for Spillway Design Floods,* Dubler, James & Neil S. Grigg
- 1998 – *Selecting and Accommodating Inflow Design Floods for Dams,* FEMA Federal Guidelines for Dam Safety (Reprinted 2004)

Summaries of each of these documents as well as the aforementioned AWWA manual and the ASCE Task Committee report as they relate to spillway flood design criteria are presented in Chapter 4. Each of the documents listed above make reference to the use of risk-based analyses for selection of SDFs for dams. Most of these documents provide general guidelines and discussions on the issues involved in the decision analysis procedures. None of the documents provide risk tolerance criteria for making a final safety design decision.

The U.S. Bureau of Reclamation (Reclamation) appears to be the first agency to seriously apply risk-based decision making to dam safety and have emerged as world leaders in this approach. Beginning around 1995, Reclamation adopted the use of risk analysis as the primary support for their dam safety decision-making and have developed several important publications related to risk analysis including the following:

- 1998 – *Implementation of Risk Analysis Principles into the Bureau of Reclamation's Dam Safety Program Actions*
- 1999 – *A Framework for Characterizing Extreme Floods for Dam Safety Risk Assessment*
- 2000 – *Risk Based Profiling System*
- 2003 – *Guidelines for Achieving Public Protection in Dam Safety Decision-making*
- 2006 – *Guidelines for Evaluating Hydrologic Hazards*
- 2010 – *Dam Safety Risk Analysis Best Practices Training Manual*

Reclamation has devoted significant resources to the development of risk-based hydrologic hazard methods and guidelines related to extreme rainfall probabilities. A framework for the characterization of extreme flood events has also been developed which considers various types of flood estimation procedures ranging from paleoflood hydrology to regional precipitation frequency with L-Moments. The resultant reports and guidelines created by Reclamation facilitate the incorporation of hydrologic data in risk analysis.

In 2003, because of the growing interest in the use of risk assessment methods for dam safety, the USSD published a white paper titled *"Dam Safety Risk Assessment: What Is It?, Who Is Using It and Why?, Where Should We Be Going With It?"* [USSD, 2003]. The paper represented a consensus position of a diverse group of USSD members and other dam safety professionals at that time. The overall purpose of the paper was to assess the state-of-the-practice in dam safety risk assessment, and to provide commentary on appropriate types of applications and ways to facilitate and strengthen its use [USSD, 2003].

The USSD paper identified and described four risk assessment application categories: (1) Failure Modes Identification; (2) Index Prioritization; (3) Portfolio Risk Assessment; and (4) Quantitative Risk Assessment. Of the four risk assessment application categories, only the Quantitative Risk Assessment approach has been used as an analytical method to help select acceptable spillway design capacity for dams. The other three methods have been used primarily as a means of identifying dam deficiencies and prioritizing their repair or resolution. The USSD white paper emphasizes that limitations must be fully considered and that risk assessment approaches should be used only as a supplement and not as a replacement for the traditional approach. The USSD white paper concluded that this "risk-enhanced" approach provides a way for the benefits of improved understanding and management of dam safety risks to be realized, while maintaining a reference to established practice [Bowles et al, 2003].

Another leader in the forefront of risk-based methods is the U.S. Army Corps of Engineers (USACE). In the 1990s, USACE held workshops and invested research to evaluate risk analysis frameworks and began publishing regulations and documents supporting the use of risk analysis including the following:

1996 – *Risk Analysis for Dam Safety Evaluation: Hydrologic Risk*
1996 – *Risk-Based Analysis for Flood Damage Reduction Studies, EM 1110-2-1619*
1997 – *Dam Safety Assurance Program, Regulation No. 1110-2-1155*
2001 – *Hydrologic Research Needs for Dam Safety*
2003 – *Application of Paleohydrology to Corps Flood Frequency Analysis*
2007 – *Updated Principles for Risk Analysis*
2007 – *Draft Inflow Hydrographs Toolbox*
2007 – *Interim Risk Reduction Measures for Dam Safety*
2009 – *Interim Tolerable Risk Guidelines for US Army Corps of Engineers Dams*
2010 – *Safety of Dams – Policy and Procedures, ER 1110-2-1156 (DRAFT)*

In 1997, USACE replaced the PMF standard with an incremental procedure to provide a framework for evaluating the benefits of mitigating hazards presented by hydrologic deficiencies in high hazard situations, as described in their *Dam Safety Assurance Program, Regulation No. 1110-2-1155* [USACE, 1997]. The PMF standard was replaced because it did not provide analysis of the benefits versus costs of design as compared to a lesser flood and recognition of the fact that the PMF design does not result in zero risk [Eiker et al, 1998]. The new USACE policy was a compromise between the desire to provide a risk-based analysis of the benefits gained from mitigating the hazard and the traditional approach of requiring a design that is capable of safely passing the PMF.

The incremental procedure required by the 1997 USACE policy included two phases. Phase I was used to determine the Base Safety Conditions (BSC) as follows:

> *"…. 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 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 should never be more than 100% of the PMF"* [USACE, 1997].

Phase II was the risk-cost analysis required if modifications for a flood greater than the BSC were recommended. An important aspect of the new USACE policy was the focus on loss of life as the criteria for determining the BSC in the incremental analysis. Economic damage was not considered.

Although the USACE's incremental analysis represented a significant advance in developing an IDF for dam design, it was recognized by the USACE that it did not provide a means for comparing the benefits and costs to mitigate spillway capacity deficiencies within their portfolio of dams. Given the limitations on annual funding available for mitigating dam deficiencies, the USACE subsequently adopted the use of Risk Assessment to provide decision variables that relate the hazard and remediate measures for a particular dam deficiency to other dams. This approach was pursued as it allowed decision makers to develop a ranking system for prioritizing the implementation of the remediation measures. The remediation of the hazard would then depend on the ranking and funding available for implementing the remediation measure [Eiker et al, 1998].

The USACE later began working closely with Reclamation, the Federal Energy Regulatory Commission (FERC), and the Tennessee Valley Authority (TVA) to develop a common dam safety risk management framework and policies for its portfolio of dams that includes tolerable risk guidelines. In 2010, the USACE published a draft form of *ER 1110-2-1156; Safety of Dams – Policy and Procedures*. This document prescribes the guiding principles, policy, organization, responsibilities, and procedures for implementation of risk-informed dam safety program activities and a dam safety portfolio risk management process within the USACE and represents a significant paradigm shift. As explained in the *Guidelines on Risk Assessment* prepared by the Australian National Committee on Large Dams (ANCOLD) in 2003,

> "*The USACE is moving from a solely standards-based approach for its dam safety program to a dam safety portfolio risk management approach. The standards-based or essential guidelines approach is included in the risk-informed approach to the dam safety program and dam safety program decisions will now be risk-informed. One of the bases for a risk-informed decision, and prioritization of the work, is a consideration of the achievement of tolerable risk guidelines following implementation of risk reduction measures. In addition, it should be recognized that other non-quantitative factors will influence practical decision making for the dam safety program.*
>
> *"There was previously a view in some quarters that risk assessment was a means to justify less costly safety upgrades of dams than those required by the traditional approach. It is now recognized that such a view seriously misunderstands the true aim of risk assessment, which is more informed decision-making than would be possible from reliance on the traditional approach alone. It may be that the additional understanding that comes from the risk assessment process, will reveal that a less costly solution to a dam safety problem could be justified, though a decision that way should be made with great care and having regard to all of the community risk and business risk considerations. But it could as easily be the case that risk assessment shows that a more stringent safety level, and thus a more costly solution, ought to be implemented."*

The USACE's tolerable risk guidelines are based on an adaptation of the 2003 Reclamation guidelines, the risk evaluation guidelines published by the Australian National Committee on Large Dams [ANCOLD, 2003], and adaptations of the ANCOLD guidance implemented by the New South Wales Government Dam Safety Committee (NSW DSC) Risk Management Policy Framework for Dam Safety [NSW DSC, 2006]. According to the Tolerable Risk Guidelines, a dam is considered to be "Adequately Safe" (DSAC Class V) when residual risk is considered tolerable and meets all essential USACE guidelines with no dam safety issues. A summary of these guidelines is included in Chapter 8.

For determining the probability associated with the PMF and lesser events, the current interim USACE procedure is to perform statistical smoothing as described in EM 1110-2-1415 Hydrologic Frequency Analysis and the Draft Inflow Hydrographs Toolbox [USACE, 2007]. The PMF is assigned a probability of 1 in 10,000 (0.0001) per year.

Today, many professionals consider risk assessment to be a useful way to provide dam safety as it requires dam owners to investigate failure modes in detail and understand where the greatest risks lie. However, the main drawback of this approach is that it is technically challenging, time-consuming, and difficult to administer. Because of this, the traditional standards based approach is generally still adopted by the states. Note that the federal agencies who have led the way in developing risk analysis procedures and tolerances are owners of a significant number of dams. The administrative processes and reviews of regulatory agencies, such as FERC and most of the states, differ significant from that of dam owners like USACE and Reclamation. The application of quantitative risk analysis for dam design by regulatory agencies may be burdensome or even unnecessary. The state dam regulatory agencies of California, Washington and Montana have recently developed risk-based indices to determine acceptable flood capacity; however, none of the states use quantitative risk assessment.

4. Origins of Dam Safety Design Guidelines

4.1. Overview

Chapter 3 presented a history of SDF selection for dams in the United States without regard for the actual regulatory framework. That chapter described the state of the practice as far as methodology used to evaluate SDFs. Chapter 4 focuses on the application of the methodology in formal guidelines within the United States.

4.2. General Standard of Practice Prior to 1950

Prior to approximately 1950, hydrologic design standards for dams were based mainly on judgment and experience. In general, the probable maximum flood, as best determined at that time, was generally accepted as the standard for dams where the consequences of failure required the greatest conservatism. Pennsylvania enacted the first known dam safety legislation in the United States in 1913, and California's Division of Safety of Dams was created in 1929. Both states were prompted to action by catastrophic dam failures that occurred in their respective states. A U.S. Committee on Large Dams (USCOLD) survey on practices and regulations within the United States found that as of 1964, a fourth of the states exercised no supervision over dams at all, and a third exercised no responsibility over operation and maintenance of a dam once it was constructed. USCOLD then organized a committee to draft a model law to be considered by states for enactment. In 1968, the committee completed a proposed law that was modeled after the 1929 California law [Golze, 1973].

4.3. ASCE Task Force on Spillway Design Floods (1955)

The first organized effort to document SDF policy and criteria in the United States appears to have occurred in June 1955 when the first ASCE Task Force on Spillway Design Floods was organized. This committee attempted to formulate a questionnaire for submission to government agencies, utilities, private engineering firms, and technical groups with an interest in dam design in order to review and summarize existing spillway design policy and criteria. The task force was unsuccessful in developing a questionnaire and collecting the data; however, they developed the following three classifications of spillway requirements for dams [ASCE, 1988]:

- Class 1: Dams where failure cannot be tolerated
- Class 2: Dams where failure would result in serious economic loss
- Class 3: Dams where structural failure would result in minor damage

The task force's final report was presented in four papers in a symposium on the Hydrology of Spillway Design on May 16, 1962 as part of the first ASCE Water Resources Engineering Conference. The papers were published in the Journal of the Hydraulics Division in May 1964 and summarized the existing practice for designing new dams. With respect to Class 1 dams, Mr. Franklin Snyder, a member of the task force, made the following statement:

"For large major structures that would be subject to possible failure if the selected capacity were exceeded, there would be few instances, if any, where anything less than the provision for the probable maximum flood can be justified" [Snyder, 1964].

Snyder also published a dam classification and suggested the matrix as presented in Table 4-1 be used to select the minimum SDF. It is interesting to note that Snyder's suggested classification matrix closely resembles the current classification criteria used by many states (See Chapter 9).

Table 4-1 Snyder's Classification of Dams [Snyder, 1964]

Failure Category	Danger Potential		Damage Potential		SDF
	Storage (Acre-Feet)	Height (Feet)	Loss of Life	Damage	
Minor	<1,000	<50	None	Cost of Dam	50-100 Year
Intermediate	1,000 – 50,000	40 to 100	Possible/small	Within Capacity of Owner	SPF(1)
Intolerable	>50,000	>60	Considerable	Excessive	PMF

(1) The SPF is the Standard Project Flood which is the most severe storm "reasonably characteristic" of the region.

4.4. AWWA Spillway Design Practice - Manual M13 (1964)

In 1964, the AWWA published *Manual M13 – Spillway Design Practice*. The manual was intended to be a general reference for engineers in the water utility practice, and provides procedures for selecting SDFs for dams constructed on drainage areas less than 1,000 square miles. The guidelines stress that for water supply dams, "the selection of a spillway capacity less than the maximum probable flood is a very serious decision for the designer and for management" and recommends the use of a "thorough cost study to evaluate the variable costs of (1) repairs to the dam and spillway, (2) lost water during periods of repairs, (3) damages caused by insufficient spillway, and (4) construction of spillways of specific capacity" [AWWA, 1964]. The manual goes on to state that this type of cost analysis is largely subjective and almost entirely a matter of judgment.

As shown in Table 4-2, the AWWA manual presents three classifications of dams based on possible damages from overtopping to select the SDF. It is interesting to note that the AWWA criteria include an assessment of the anticipated damage to the dam following overtopping. The guidelines note that for smaller watersheds, the peak discharge computed from PMP may be ten or more times the maximum observed peak streamflow. In addition to the SDF requirements shown in Table 4-2, the AWWA indicated that "even under the most advantageous circumstances, the total freeboard above the maximum water level in the reservoir should not be less than 3-5 feet" [AWWA, 1964].

Table 4-2 Summary of 1964 AWWA Spillway Design Flood Guidelines [AWWA, 1964]

Possible Damages from Overtopping	Spillway Design Flood
Destruction of dam and catastrophic losses at downstream urban areas	Probable maximum precipitation (PMP) on very wet ground
Moderate damage to dam and little loss at downstream urban areas	Greatest known storm on another watershed that can be transposed to the study watershed
Minor damage to dam or other structures and no losses possible downstream	Storm obtained by applying a reduction factor to the probable maximum precipitation, or frequency studies to past floods

4.5. USCOLD Workgroup on Criteria and Practices Utilized in Determining the Required Capacity of Spillways (1970)

In 1967, a USCOLD workgroup was formed to compile information and to prepare a report regarding criteria and practices used in the United States for determining the required capacity of spillways. The national survey titled *"Criteria and Practices Utilized in Determining the Required Capacity of Spillways"* was published in 1970. The workgroup surveyed the USACE, Reclamation, TVA, Soil Conservation Service, state agencies, investor-owned utility companies and private engineering firms using a questionnaire. Only two state agencies (Pennsylvania and California) were surveyed. The final report summarized spillway requirements or "standards" for new dams for four hazard categories.

The workgroup indicated that all respondents stated that their current policies were consistent with the following statements:

> *"… The policy of deliberately accepting a recognizable major risk in the design of a high dam simply to reduce the cost of the structure has been generally discredited from the ethical and public welfare standpoint, if the results of a failure would imperil the lives and lifesavings of the populace of the downstream floodplain. Legal and financial capability to compensate for economic losses associated with major dam failures are generally considered as inadequate justifications for accepting such risks, particularly when severe hazards to life are involved. Accordingly, it is the policy of this agency that high dams impounding large volumes of water be designed to conform with Security Standard 1"* (design the dam and spillway large enough to assure that the dam will not be overtopped by floods up to the probable maximum) [USCOLD, 1970].

The workgroup also compared current (1970) criteria with past criteria and policies and concluded:

> *"The policies which are now generally accepted are not radically different from those followed 20 or more years ago by the responding organizations, even though procedures and techniques have been changed and improved and have been adopted rather uniformly as they have been developed. Accordingly, differences that do exist result largely from variations in interpretation of the policies, some differences in analytical technique, and designer's judgment"* [USCOLD, 1970].

The USCOLD report also provided a general summary of freeboard criteria and starting reservoir levels assumed in the SDF analyses, and identified erosion of spillway channels that could lead to breaching the spillway or eroding the toe of embankment dams as a common design concern.

4.6. National Dam Inspection Act, PL 92-367 and USACE Guidelines for Existing Dams (1972)

In the early 1970s a series of dam safety incidents occurred resulting in significant loss of life including the failure of Buffalo Creek Dam (West Virginia) in February 1972 and Canyon Lake Dam (South Dakota) in June 1972. In June of 1972, severe flooding caused by Hurricane Agnes endangered many dams. Large areas in Pennsylvania and New York experienced rainfall rates that were within 90 percent of PMP values [Riedel, 1973]. The Black Hills, South Dakota storm of June 1972 resulted in rainfalls that were 75 percent of the PMP [Riedel, 1973]. Following these events, the Congress enacted the National Dam Inspection Act (PL 92-367) and it became law on August 8, 1972. At that time many states did not have laws regarding dam safety and often did not require a review of the dam design prior to construction or require construction inspection or post-construction inspection. It was also found that dam safety in most states was inadequate with a wide variation of practices, regulations and capabilities of all agencies supervising dam safety. There was also little or no overall coordination of dam safety efforts.

Dams subject to PL 92-367 were those having a height 25 feet or greater, or a maximum impounding capacity greater than 50-acre-feet. Dams less than six feet high or storing less than 15 acre-feet were excluded. Congress charged the USACE with implementing the provisions of the Act. In addition to carrying out a national program of inspection of dams for the purpose of protecting human life and property, the act also required: (1) an inventory of all dams located in the United States; (2) a review of each inspection made; and (3) recommendations for a comprehensive national program for the inspection and regulation of dams, and the respective responsibilities which should be assumed by Federal, State, and local governments and by public and private interests.

Because of the scale of the program, the USACE developed a classification system to screen the adequacy of spillway capacity. The selected classification system used the dam size based on dam height and impoundment volume as shown in Table 4-3, and the hazard potential based on loss of life and economic loss as presented in Table 4-4. Table 4-5 presents the USACE's recommended SDF based on the Hazard and Size classification. A comparison of the criteria in the Tables 4-3 through 4-5 with that proposed by Snyder in 1964 in Table 4-1 shows remarkable similarities.

Where a range of SDF is indicated, the USACE guidelines specify that the magnitude that most closely relates to the involved risk should be selected. The use of partial PMF values are not discussed. For "Significant Hazard" dams, no more than six single-family type inhabitable structures were permitted in the downstream and upstream inundation zones, and consideration was to be given to probable future development in order to select a conservative but realistic category [Hagen, 1973]. The original USACE guidelines also contained freeboard criteria, but these were deleted from the final guidance documents. The decision on freeboard allowance for each project was left to the inspection team [Hagen, 1973]. The USACE guidelines were reported to be based on a professional consensus [Dubler, 1995].

Table 4-3 USACE Dam Classification [USACE, 1979]

Category	Impoundment	
	Storage (Acre-Feet)	Height (Feet)
Small	<1,000 and 50	<40 and 25
Intermediate	1,000 and < 50,000	40 and <100
Large	50,000	100

Table 4-4 USACE Hazard Potential [USACE, 1979]

Category	Loss of Life (Extent of Development)	Economic Loss (Extent of Development)
Low	None expected	Minimal
Significant	Few	Appreciable
High	More than a few	Excessive

Table 4-5 USACE Hydrologic Evaluation Guidelines Recommended Spillway Design Floods [USACE, 1979]

Hazard Potential	Size	Spillway Design Flood (SDF)
Low	Small	50 to 100-Year Flood
	Intermediate	100-Year to ½ PMF
	Large	PMF
Significant	Small	100-year to PMF
	Intermediate	½ PMF to PMF
	Large	PMF
High	Small	½ PMF to PMF
	Intermediate	PMF
	Large	PMF

In developing the spillway capacity guidelines, the USACE made a distinction between new and existing dams and emphasized that the proposed guidelines were intended for existing dams. As stated in a discussion paper presented by the USACE, the "analysis of hydrologic and hydraulic competency of existing structures should not be as rigorous as the design requirements for new dams. Costs associated with extra conservatism in a new project are almost always a small fraction of the cost required to modify an existing structure" [Hagen, 1973].

4.7. ASCE Task Committee on the Reevaluation of the Adequacy of Spillways of Existing Dams (1973)

In 1973, following four years of study, the ASCE Task Committee on the Reevaluation of the Adequacy of Spillways of Existing Dams published their report in the Journal of the Hydraulics Division [ASCE, 1973]. In the report, the Task Committee advocated "risk taking" in spillway capacity design and recommended that spillway capacities for new and existing dams of all sizes be based on a thorough economic analysis of the "social cost of risks and the cost of modification" computed on an average annual basis. An evaluated level of risk at which the total of all social costs will be at a minimum was proposed. The Task Committee recommended use of a monetary value for human life and injury in the analysis. Mr. Bob Buehler, Chief of the Flood Control Branch of the TVA and member of the committee, subsequently published a paper on "The Monetary Value of Life and Health" [Buehler, 1973]. Values assigned by Mr. Buehler in an example economic analysis presented in a paper titled *Reevaluation Spillway Adequacy of Existing Dams* showed values of $150,000, $200,000, and $10,000 for deaths, disabling injuries, and non-disabling injuries, respectively [Buehler, 1973].

Assigning a probability to extreme floods was a concern expressed by engineers reviewing the report. For expediency, the ASCE Task Committee's solution to the problem of assigning probability to extreme events was to arbitrarily assign an average return interval of 10,000 years to the PMF. This was considered by the committee to be a conservatively low return period, yet high enough to accomplish the purposes of the analysis process. Assigning a 10,000-year probability to the PMF at that time was suggested and supported by others as well [Beard, 1973]. With the upper extreme fixed arbitrarily at 10,000 years and the lower extreme defined by observed data, a curve on probability paper provided probabilities for all in-between floods.

An interesting and intriguing argument presented by the committee, and demonstrated with analysis examples, was that risk costs can increase as additional dam safety is provided, since improved safety is often provided by raising the dam and/or increasing spillway capacity with a resulting increase in downstream flood flow. The economic analysis approach was recommended to avoid mistakes where circumstances exist in which modification to reduce failure probability would increase rather than decrease potential average annual losses, and that "modification with good intent to increase safety would be an incorrect move" [Buehler, 1973].

The ASCE Task Committee's report generated much controversy and 13 published discussions which was said to be a record number. The discussions were equally divided in favor and against the proposed approach [Buehler, 1973]. The recommendation to place a monetary value on human life and suffering in the economic analysis was ultimately not accepted by the engineering profession or by regulatory agencies. The approach was viewed as a "radical departure" from accepted standards [Williams, 1973]. For dams where loss of life was not expected, the risk-based economic analysis proposed by the ASCE Task Committee was supported by the Bureau of Reclamation with the provision that the public be kept aware of the possibility of failure, that a land use plan be enforced that ensured the minimum hazard to life, and that a periodic re-examination must be scheduled and made to verify that the downstream hazard and damage assumptions continue to be valid [Bertle, 1973]. The economic analysis proposed by the ASCE Task Committee was also viewed as impractical for smaller dam projects as the cost to perform the analysis could approach the cost of the structural modifications [Williams, 1973].

4.8. FEMA ad hoc ICODS – Federal Guidelines for Dam Safety (1979, Reprinted 2004)

In 1979, the *ad hoc* Interagency Committee on Dam Safety (ICODS) issued "Federal Guidelines for Dam Safety." This document provided the first guidelines for federal agency dam owners and dam owners regulated by federal agencies. As stated in the preface:

> *"These guidelines apply to Federal practices for dams with a direct Federal interest and are not intended to supplant or otherwise conflict with State or local government responsibilities for safety of dams under their jurisdiction."*

For flood selection for design or evaluation, the federal guidelines supported the use of risk analysis, and stated:

> *"The selection of the design flood should be based on an evaluation of the relative risks and consequences of flooding, under both present and future conditions. Higher risks may have to be accepted for some existing structures because of irreconcilable conditions"* [FEMA, 1979].

The guidelines were clear, however, that the spillway design standard to be adopted for dams where loss of life or major property damage could be significant was the PMF. The following statement concerning selection of the flood for design for spillways is in the 1979 guidelines:

> *"When flooding could cause significant hazards to life or major property damage, the flood selected for design should have virtually no chance of being exceeded. If lesser hazards are involved, a smaller flood may be selected for design. However, all dams should be designed to withstand a relatively large flood without failure even when there is apparently no downstream hazard involved under present conditions of development"* [FEMA, 1979].

For existing dams, "risk-based analyses should be considered in establishing priorities for examining and rehabilitating the dams, or for improving their safety" [FEMA, 1979]. The guidelines did not provide a specific framework for classifying dams or for assigning SDFs using risk-based analyses.

4.9. National Research Council Committee on Safety Criteria for Dams, Safety of Dams – Flood and Earthquake Criteria (1985)

In response to a request by the Assistant Secretary of the Interior for Water and Science and the Assistant Secretary of the Army for Civil Works, the National Research Council (NRC) established an *ad hoc* Committee on Safety Criteria for Dams to prepare an inventory of currently used criteria for dams relating to safety from hazards of extreme floods and earthquakes, and to identify and evaluate alternative criteria for safety of federal dams. The committee was made up of experts in risk assessment, regulation of dams, law, science, and engineering. A comprehensive survey of design criteria in use for dams relative to hazards of extreme floods was performed for 35 states, 10 federal agencies, four technical societies (ASCE, ICOLD, and USCOLD), nine firms, and one foreign country (England).

The following key findings were made by the Committee as they relate to selecting spillway inflows for dams:

- Current dam practices reflect a great variety of standards used to classify dams relative to hazards and in the criteria for evaluation of safety from extreme floods.
- While simple hazard rating categories based on downstream development may be useful for identifying dams for high-priority safety evaluation and study, they do not reflect the potential for incremental loss of life and damage caused by failure of a dam due to an inadequate spillway when a river is already in flood.
- More uniformity is needed among the several federal and state agencies establishing size and hazard definitions and correlative design standards.
- New concepts and improved methods for estimating floods have resulted in generally larger flood estimates and future estimates of magnitude for extreme floods can be expected to increase. However, unless the runoff characteristics of the watershed were to change, increments in future flood estimates should be less than those noted in the past. There have been instances where more intensive hydrometeorological studies have resulted in reductions in estimates of PMP by earlier investigations.
- A dam designed for the PMF using the PMP does not provide absolute assurance that the dam is safe for every possible flood.
- The federal government has become increasingly involved in risk management issues and a number of federal agencies have developed various risk management standards, but these are not applicable to risk management for dams. Adaptation of these concepts to dam safety requires research.
- Court decisions relating to dam failures in general have held the owner liable for the damages resulting from a failure.

The Committee made the following recommendations:

- To the extent practicable, reservoir safety evaluations should strike a balance among project benefits, construction costs, social costs, and public safety. Currently available technology does not permit this balancing with full confidence in the results.
- Safety evaluation standards for existing dams and new dams do not need to be the same.
- The use of PMFs based on estimated PMP as the general design standard for new high-hazard dams should be continued. Instances may be encountered where a lower standard may be justified if failure of a dam during floods of PMF magnitude would cause no significant increase in potential loss of life or property damage.
- For existing high-hazard dams, the adopted SDF should take into account estimated flood probabilities, expected project performance, and incremental damages that would result from dam failure for a range of floods up to and including the PMF.
- In the design of new dams and spillways when design alternatives of approximately equal cost are available, a selection among these alternatives should give consideration to potential future needs for increased safety against floods.
- Periodic reviews of hazard determinations and safety decisions for all dams should be required, especially when safety evaluations are based on criteria less conservative than the PMF.
- As advances occur in hydrology, meteorology, and the relevant databases, and as changes are noted in public attitudes toward risk, federal agencies should periodically undertake a review of dam safety practices and standards by an independent body representing the professions involved in engineering for dams and experts from other relevant disciplines.

For new high-hazard dams, the Committee recommended the PMF be adopted for the SDF unless risk analyses that examine the incremental impact of overtopping and dam failure during an extraordinary flood demonstrate that little or nothing is gained by such a high standard. The SDF would be the smallest value that ensures that a dam breach results in no significant increase in potential for loss of life or major property damage.

For existing high-hazard dams, the Committee concluded that there was no universally satisfactory approach to establishing spillway capacity criteria. The Committee therefore recommended that risk-based analysis be considered for existing high-hazard dams "for which the PMF is not required." A section describing risk-based analyses was included in the report.

No specific recommendations were made by the Committee for spillway design requirements for intermediate hazard and low hazard dams.

4.10. FEMA (ICODS) – Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams (1986)

This publication was prepared by an ICODS working group on inflow design floods to supplement the *FEMA Federal Guidelines for Dam Safety* which was published in 1979. The primary purpose of the document was to provide general guidelines on procedures for selecting and accommodating inflow design floods for use by federal agencies in developing agency criteria and to ensure more nationwide uniformity in application. The guidelines apply to both proposed and existing dams.

For existing and proposed dams where failure is expected to result in loss of life or extensive property damage, the guidelines specified using the PMF as the IDF. The evaluation dam failure impacts are based on both existing and future conditions. Key statements made in the guidelines with respect to evaluating dam failure impacts and selection of the IDF follow:

> *"The PMF should be adopted as the IDF in those situations where consequences attributable to dam failure from overtopping are unacceptable. The determination of unacceptability exists when the area affected is evaluated and factors indicate loss of human life, extensive property and environmental damage, or serious social impact may be expected as a result of dam failure"* [FEMA, 1986].
>
> "*Dams and their appurtenant structures should be designed to give satisfactory performance and to practically eliminate the probability of failure"* [FEMA 1986].
>
> *"The presence of public facilities within the potential area inundated by dam failure that would attract people on a temporary basis (e.g., campgrounds, State or National parks, etc.) requires special consideration"* [FEMA, 1986].
>
> *"The presence of an emergency action plan and/or a warning system should not be substituted for safe design practice or for use in reducing the potential for loss of life in the analysis for selecting the IDF"* [FEMA, 1986].
>
> *"Re-evaluation of an existing dam with respect to selecting and accommodating the IDF should normally be based on the same basic guidelines as for proposed dams"* [FEMA, 1986].

The guidelines make a specific distinction between service, auxiliary, and emergency spillways. For the design of auxiliary and emergency spillways, infrequent limited damage during passage of the IDF is acceptable provided the damage does not endanger the dam or usefulness of the service spillway and the control section of the spillway is not degraded to the extent it results in an unacceptable loss of storage or uncontrolled discharges which exceed the peak inflow. According to the guidelines, emergency spillways may be permitted to sustain significant damage when used and may be designed to a lower structural standard than auxiliary spillways.

Consideration for floods less than the PMF were permitted only when there were no existing permanent human habitations, commercial or industrial development, or such developments that were projected to occur within the foreseeable future, and transient population was not expected to be affected within the hazard area. An exception was made for a few permanent human habitations located within the flood hazard area provided there was no significant increase in the hazard resulting from the occurrence of floods larger than the proposed IDF up to the PMF (for example, where failure would not add appreciable volume to the outflow hydrograph and the downstream inundation would be essentially the same with or without failure). For selection of the IDF less than the PMF, "the spillway capacity should be not less than some minimum standard to reduce the risk of loss of benefits during the life of the project; to hold O&M costs to a reasonable level; to maintain public confidence in agencies responsible for dam design, construction, and operation; and to be in compliance with local, State, or other regulations applicable to the facility" [FEMA, 1986].

The guidelines also made provisions for Federal agencies to develop agency-specific criteria and allowed the use of risk analyses as an approach to evaluating spillway inflow requirements less than the PMF on a case-by-case basis for existing dams.

> "*It is recognized that for some existing dams which do not meet current hydrologic design criteria but have been soundly designed and well constructed, it may be prudent to select an IDF smaller than the PMF. … However, any relaxation of design criteria should be undertaken on a case-by-case basis after the consequences of dam failure have been thoroughly evaluated and quantified. … Local interests should be made aware of the possibility of larger floods occurring when a flood smaller than the PMF is selected as the IDF*" [FEMA, 1986].

A section describing risk-based analyses was included in the guidelines.

4.11. ASCE Task Committee on Spillway Design Flood Selection (1988)

This ASCE Task Committee was formed in 1984 in response to the growing national concern for dam safety and the lack of uniformity in the hydrologic procedures used in dam safety evaluation. The charge of the Task Committee was to develop standards for selecting SDFs which could be readily implemented and applied nationwide. Their objective was to identify an acceptable procedure for selecting the SDF which, in addition to the traditional economic analysis, would permit the inclusion of loss of life, owner liability, social disruption, and the magnitude of destruction. The committee consisted of 14 persons. The final report was submitted to nearly 60 outside peer reviewers and was revised six times.

The ASCE Committee developed a quantitative risk assessment approach for selecting the SDF that applies to both new and existing dams. The Committee's design selection process was based on dividing dams into three categories depending on their failure consequences as summarized in Table 4-6.

The quantitative risk assessment proposed by the Committee for Category 2 dams does not provide specific risk guidelines or thresholds for the potential for loss of life and economic damage but assumes them to be "a matter of judgment." The Committee provides a tabulation of population at risk (PAR) from dam failure versus warning time for use in the initial screening of Category 1 dams. The values range from a PAR of 50 for a flood wave arrival time less than 2 hours to a PAR of 1,000 or more for a time of flood wave arrival of less than 12 hours.

Table 4-6 Summary of ASCE Committee's Spillway Design Flood Selection Process [ASCE, 1988]

Category	Description	Spillway Design Flood
1	Dams where failure consequences include loss of life or other social and economic losses that warrant the use of the PMF as the spillway design flood.	PMF
2	Dams where the social and economic consequences of failure are not large enough to require use of the PMF as the spillway design flood.	PMF unless quantitative risk assessment shows smaller flood is justified
3	Small dams where the cost of construction is small and the failure damage is low and confined to the owner.	10- to 100-year flood[1]

1 *The committee suggests that the owner may benefit from a quantitative risk assessment to determine the spillway design flood. However, it may not warrant the cost of the analysis. Guidelines adapted from the SCS were offered with the provision that the owner should consider the chances the investment will be lost during the planned project life.*

It is unclear how loss of life is to be addressed for a Category 2 dam since there is no explicit accounting for loss of life in the proposed quantitative risk assessment or in the examples provided; only economic losses that can be quantified in dollars are explicitly considered, although loss of life estimates are shown in the summary of consequences. The committee does state that "the relative weighing of nonmonetary consequences and their comparison to dollar savings is a matter of judgment which will vary among decision makers for each site examined."

A requirement attached to adopting a SDF less than the PMF for Category 2 dams is that the dam owner must consider the cost of indemnifying possible victims of dam failure against financial losses. The cost of indemnification, rather than the flood damage, is taken as the proper measure of damage sustained by parties other than the dam owner. In addition to the loss of project benefits and physical damages created by the dam failure, the indemnification costs include income losses, emergency response, flood fighting, disaster assistance, reoccupation, cleanup, personal trauma, and post-disaster studies. The ASCE Committee concluded that the procedure requires a regulatory mechanism to make sure that the dam owner maintains the capability throughout the project life to fully compensate all victims should the dam fail.

A criticism of the ASCE Task Committee's proposed procedure is that the relative weighing of non-monetary consequences and their comparison to dollar savings were assumed to be a matter of judgment, and no criteria were provided for making a final design decision [Graham, 2000].

4.12. FEMA Federal Guidelines for Dam Safety – Selecting and Accommodating Inflow Design Floods for Dams (1998 – Reprinted 2004)

In 1994, an ICODS subcommittee was formed to review and update the existing Federal Guidelines for Dam Safety to meet current dam safety challenges and to ensure consistency across agencies and users. With the passage of the National Dam Safety Program Act in 1996 (Public Law 104-303), ICODS and its Subcommittees were reorganized to reflect the objectives and requirements of

Public Law 104-303. In 1998, the newly convened ICODS Subcommittees completed work on the update of the *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams*. The ICODS Subcommittees were also made responsible for maintaining the guidelines to help achieve the objectives of the National Dam Safety Program.

The current (1998 – reprinted 2004) *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams* places an emphasis on basing the selection of the SDF on an accurate hazard potential determination that evaluates the consequences of dam failure based on the dam being in place, and comparing the impacts of with-failure and without-failure conditions on existing development and prospective future development. The guidelines stipulate that the flood wave created by a dam failure should be routed downstream to the point where the incremental effect of a failure no longer results in unacceptable consequences. The IDF is then selected based on the results of the incremental hazard evaluation. This evaluation involves simulating a flood event during existing and dam failure conditions. The additional downstream consequences due to the incremental increase in flood flows downstream are assessed for each dam failure scenario. The above procedure is to be repeated until the flood inflow condition is identified such that a failure at that flow or larger flows (up to the PMF) will no longer result in unacceptable additional consequences. The resultant flow is the IDF for the dam. The maximum IDF is always the PMF. The guidelines provide specific guidance and procedures, including a comprehensive flowchart, for conducting an incremental hazard evaluation to select the appropriate IDF.

The guidelines stipulate that the PMF should be adopted as the IDF in those situations where consequences of a dam failure for floods less than the PMF are unacceptable. A flood less than the PMF may be adopted as the IDF in situations where the consequences of dam failure at flood flows larger than the selected IDF are acceptable as determined by the incremental hazard evaluation. When an IDF less than the PMF is selected, the consequences of a dam failure resulting from floods in excess of the IDF must be limited to the dam owner’s facilities. The guidelines stipulate that acceptable consequences exist when evaluation of the area affected indicates either of the following two conditions:

1. There are no permanent human habitations, known national security installations, or commercial or individual developments, nor are such habitations or commercial or industrial developments projected to occur within the potential hazard area in the foreseeable future.
2. There are permanent human habitations within the potential hazard area that would be affected by failure of the dam, but there would be no significant incremental increase in the threat to life or property resulting from the occurrence of a failure during floods larger than the proposed IDF.

The guidelines indicate that when a dam break analysis shows downstream incremental effects of approximately two feet or more, engineering judgment and further analysis are necessary to finally evaluate the need for modification of the dam. In general, the consequences of failure are considered acceptable when the incremental effects (depth) of failure on downstream structures are less than two feet. The consequence analysis should also include consideration of impacts to vital community services such a municipal water or energy supply and may require increasing the spillway capacity to ensure those services are continued during and following extreme flood conditions. The guidelines suggest that it would not be appropriate to set the IDF for a spillway with an exceedance flood frequency less than the 100-year flood, including low-hazard dams.

The guidelines note that "there are times when selection (of the IDF) becomes difficult and it may be necessary to conduct further analyses with a risk-based approach," but follows by stating that "incremental hazard evaluation is, in essence, a risk-based approach." No guidelines were provided for performing an alternate type of risk-based analysis.

The guidelines indicate that it may be appropriate to perform site-specific PMP studies or regional PMP studies to better define existing NWS HMR estimates, provided the additional analysis costs are warranted.

The guidelines address minimum freeboard requirements (the difference between the top of dam and the maximum pool elevation during the IDF) and note that it is generally not necessary to prevent splashing or occasional overtopping of a dam by waves under extreme conditions, however, the number and duration of such occurrences should not threaten the structural integrity of the dam. The guidelines for minimum freeboard allowance do, however, recommend consideration of combinations of components that have a reasonable probability of simultaneous occurrence including: wind-generated wave run-up, effects of possible malfunction of the spillway and outlet works, settlement of the embankment, and landslide-generated waves.

4.13. FEMA Federal Guidelines for Dam Safety – Hazard Potential Classification System for Dams (1998 – Reprinted 2004)

The ICODS Subcommittee on Federal/Non-Federal Dam Safety Coordination was also tasked to develop a new guideline, *Hazard Potential Classification System for Dams*, which was subsequently published in 1998 and reprinted in 2004. Three classification levels were adopted: Low, Significant, and High. The hazard potential classification system categorizes dams based on the probable loss of human life and the impacts on economic, environmental, and lifeline interests and is summarized in Table 4-7. The assigned classification of a dam is based on failure consequences that will result in the assignment of the highest hazard potential classification of all probable failure and misoperation scenarios. The guidelines state that the probable scenarios considered are to be reasonable, justifiable, and consistent with the FEMA *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams*.

Table 4-7 Summary of Proposed ICODS
Hazard Potential Classification System for Dams [FEMA, 1998]

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None expected	Low and generally limited to owner
Significant	None expected	Yes
High	Probable. One or more expected.	Yes (but not necessary for this classification)

The ICODS Subcommittee recommended that the proposed Hazard Potential Classification System be adopted in lieu of existing numerical and alphabetical systems to eliminate confusion in the dam safety community and to educate the public on the importance of dam safety. The guidelines do not establish how the system should be used, such as prescribing specific spillway design criteria.

4.14. FEMA Model State Dam Safety Program (2007)

This document was prepared by ASDSO to outline key components of an effective dam safety program. The first edition of this document was published in 1987 with amendments in 1998 to reflect the experience of state programs. Spillway design criteria for dams are not provided in this document.

5. Relevant International Guidelines

5.1. Introduction to Summaries of International Guidelines

While the scope of this study specifically addresses guidelines for hydrologic safety of dams within the United States, there are several developments in the international arena that are particularly relevant to the study. Recently updated guidelines in Australia and Canada were reviewed and are summarized in the following sections to provide a glimpse of how other countries' guidelines are changing. This literature review is by no means intended to be a comprehensive overview of international guidelines.

5.2. ANCOLD Guidelines on Selection of Acceptable Flood Capacity for Dams

In Australia, there is no federal legislation on dam safety. Therefore, Australian jurisdictions that have dam safety regulations in place including Victoria, New South Wales, Queensland, and the Australian Capital Territory (ACT) are responsible for developing their own dam safety guidelines. In order to provide a basis for consistency throughout Australia in the assessment of hydrologic safety of dams, the Australian National Committee on Large Dams (ANCOLD) established a Working Party in 1994 to revise the existing standards based guidelines in light of moves to integrate risk assessment into dam safety procedures.

The prior *1986 ANCOLD Guidelines on Design Floods for Dams* introduced the concept of incremental flood hazard categories for ranking the recommended design flood against consequences of a dam failure. At that time risk analysis was being considered; however, the methodology was not well developed. As a result, the 1986 guidelines did not propose the use of risk analyses for dams where lives were at risk. In 1987, the guidelines were revised to include *Australian Rainfall and Runoff*, which included a chapter on estimation of extreme floods.

ANCOLD then led the way internationally in the development of acceptable risk criteria in dam safety and published *Guidelines on Risk Assessment* in 1994. These guidelines provided a basis for integrating risk assessment into dam safety. At that time it became apparent that procedures for risk-based dam safety evaluation were still in the development phase worldwide, and the 1994 risk guidelines needed review. In addition flood estimation procedures for risk-based dam safety evaluation were required to provide flood probabilities for application in risk assessment.

In 2000, *ANCOLD Guidelines on Selection of Acceptable Flood Capacity for Dams* was published to provide more appropriate and consistent guidance within a risk process for dam safety evaluation under floods. The 2000 guidelines superseded the 1986 guidelines in accordance with the ANCOLD aim for integration of risk assessment into the guidelines. The estimation of extreme floods and associated assigned probabilities are based on the procedures developed for Australia in 1999. A point reiterated in the 2000 ANCOLD guidelines is that spillway capacity should be assessed within the total load context and not as a separate case so that all safety issues can be identified and an optimum solution can be developed.

The guidelines include a deterministic “fall-back option” that the owner can adopt instead of the quantitative risk assessment approach. The fall-back option is intended to be more conservative and result in a higher design requirement and cost to bring the dam up to the required standard than the alternative risk assessment procedure. The fall-back option involves first determining the Hazard Category based on consequences and then assigning the acceptable flood capacity based on the assigned return period for the selected Hazard Category rating. The hazard category rating system adopted by Queensland in 2007 based on the ANCOLD Guidelines as well as the corresponding range of acceptable flood capacities for the different hazard categories are presented in Table 5-1. The guidelines also specify flood surcharge “wet” and “dry” freeboard requirements.

Table 5-1 Queensland Hazard Category Rating System [State of Queensland, 2007]

Incremental Population at Risk (PAR)	Severity of Damage and Loss: Negligible		Minor		Medium		Major	
$2 \leq PAR \leq 10$	Low	$5.0x10^{-4}$ $5.0x10^{-4}$	Significant	$5.0x10^{-4}$ $1.0x10^{-4}$	Significant	$1.0x10^{-4}$ $1.0x10^{-4}$	High C	$1.0x10^{-5}$ C
$10 < PAR \leq 100$	If in this region, go to the next highest severity of Damage and Loss category for the same PAR	$5.0x10^{-4}$ $1.0x10^{-4}$	Significant	$1.0x10^{-4}$ $1.0x10^{-4}$ C	High C	$1.0x10^{-4}$ C B	High B	$1.0x10^{-5}$ B
$100 < PAR \leq 1000$				A A	High A	A A	High A	A A
$PAR > 1000$						PMF PMF	Extreme	PMF PMF

Where
- A = PMP Design Flood
- B = PMP Design Flood or 10^{-6}, whichever is the smaller flood event
- C = PMP Design Flood or 10^{-5} whichever is the smaller flood event

Note that the probability of the PMP Design Flood is a function of the catchment area.

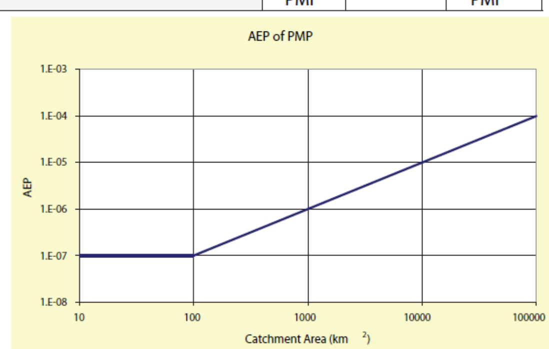


Table 2: Required range of Acceptable Flood Capacities for different hazard categories

Supplied courtesy of the Department of Environment and Resource Management, Queensland, Australia.

The ANCOLD *Guidelines on Risk Assessment* was revised in 2003. Victoria, New South Wales, Queensland subsequently adopted the ANCOLD guidelines with minor differences in the limits for tolerability of risk and other provisions. The Victorian regulations require risk assessments for high hazard dams. Risk assessments are optional for the Queensland and New South Wales regulations [Sih et al, 2010]. Reclamation and USACE have recently revised and adopted elements of the ANCOLD guidelines in the formulation of their new risk-based guidelines.

5.3. Canadian Dam Association Guidelines (2007)

Regulation of dams in Canada is primarily a provincial responsibility. Federal agencies have limited jurisdiction related to international boundary waters with the United States and some responsibility for security of critical infrastructure. In 1995, after three years of effort by working groups, the Canadian Dam Safety Association (CDA) published *Dam Safety Guidelines*. In 1999, the CDA issued a revision, and in 2007, the CDA published its most recent guidelines that include a companion series of technical bulletins on dam safety. The technical bulletins suggest methodologies and procedures for use by qualified professionals as they perform dam analyses and safety assessments.

The CDA guidelines include a dam classification system based on failure consequences and discuss both the traditional standards-based approach and the risk-based approach to dam safety decision making. However, IDF requirements are only specified using a deterministic assessment. *Technical Bulletin 6 – Hydrotechnical Considerations for Dam Safety* presents details of the CDA guidelines for selecting the inflow design flood (IDF) and freeboard. The suggested CDA IDF for use in deterministic assessments is presented in Table 5-2. The suggested CDA dam classification scheme is shown in Table 5-3. The IDFs presented in Table 5-2 make reference to the 1 in 1,000-year flood, and ratios of 1/3 and 2/3 between the 1 in 1,000-year flood and the PMF. The CDA guidelines indicate that beyond the 1 in 1,000-year flood, floods cannot be obtained by flood statistics methods. The proposed method consists of interpolating the flood hydrographs rather than the flood peaks or volumes since experience has shown unacceptable distortions using these parameters.

Selecting the IDF using quantitative risk analyses is not discussed and appears to be discouraged because of the inability to accurately assign a probability to extreme floods. As noted in Table 5-2, "extrapolation of flood statistics beyond the 1 in 1,000 year flood is discouraged."

Provinces, like British Columbia, have adopted the CDA guidelines with only minor modifications. Table 5-4 shows the downstream consequence classification system presented in the 2009 *British Columbia Dam Safety Guidelines*. Minimum design standards for determining the IDF for dams constructed after 2008 are identical to those shown in Table 5-2. The British Columbia guidelines note that the 1999 CDA dam safety guidelines were updated in 2007 and that this update resulted in, among other things, a more stringent suggested annual exceedance probability (AEP) for determining the IDF. For dams constructed prior to 2008, the British Columbia Dam Safety

Program allows dam design engineers to use the 1999 CDA Dam Safety Guidelines. Since the 2007 CDA guidelines use a different dam classification table than the British Columbia Dam Safety Regulations, design engineers are instructed to contact their Dam Safety Officer for the policy on how to use the two classification tables together.

Table 5-2 Suggested CDA Inflow Design Flood for Use in Deterministic Assessments [CDA, 2007]

Consequence Class	IDF
Low	1/100-year
Significant	Between 1/100 and 1/1000-year (Note 1)
High	1/3 between 1/1000-year and PMF (Note 2)
Very High	2/3 between 1/1000-year and PMF Note 2)
Extreme	PMF

Note 1. Selected on basis of incremental flood analysis, exposure and consequence of failure.
Note 2. Extrapolation of flood statistics beyond 1/1000-year flood (10^{-3} AEP) is generally discouraged. The PMF has no asssociated AEP. The flood defined as "1/3 between 1/1000-year and PMF" or "2/3 between 1/1000 year and PMF" has no defined AEP.

Table 5-3 Suggested CDA Dam Classification System [CDA, 2007]

Dam class	Population at risk [note 1]	Incremental losses		
		Loss of life [note 2]	Environmental and cultural values	Infrastructure and economics
Low	None	0	Minimal short-term loss No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of *important* fish or wildlife habitat Restoration or compensation in kind highly possible	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very high	Permanent	100 or fewer	Significant loss or deterioration of *critical* fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of *critical* fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Note 1. Definitions for population at risk:

None—There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary—People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent—The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

Note 2. Implications for loss of life:

Unspecified—The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

Table 5-4 British Columbia Dam Safety Dam Classification System [British Columbia, 2009]

Rating	Loss of Life	Economic and Social Loss	Environmental and Cultural Losses
VERY HIGH	Large potential for multiple loss of life involving residents and working, travelling and/or recreating public. Development within inundation area (the area that could be flooded if the dam fails) typically includes communities, extensive commercial and work areas, main highways, railways, and locations of concentrated recreational activity. Estimated fatalities could exceed 100.	Very high economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to large residential areas, concentrated commercial land uses, highways, railways, power lines, pipelines and other utilities. Estimated direct and indirect (interruption of service) costs could exceed $100 million.	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and/or practicality of restoration and/or compensation is low.
HIGH	Some potential for multiple loss of life involving residents, and working, travelling and or recreating public. Development within inundation area typically includes highways and railways, commercial and work areas, locations of concentrated recreational activity and scattered residences. Estimated fatalities less than 100.	Substantial economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to concentrated commercial land uses (highways, railways, power lines, pipelines and other utilities). Scattered residences may be destroyed or severely damaged. Estimated direct and indirect (interruption of service) costs could exceed $1 million.	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high.
LOW	Low potential for multiple loss of life. Inundation area is typically undeveloped except for minor roads, temporarily inhabited or non- residential farms and rural activities. There must be a reliable element of natural warning if larger development exists.	Low economic losses to limited infrastructure, public and commercial activities. Estimated direct and indirect (interruption of service) costs could exceed $100,000.	Loss or significant deterioration of regional important fisheries habitat (including water quality), wildlife habitat, rare and endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high. Includes situations where recovery would occur with time without restoration.
VERY LOW	Minimal potential for any loss of life. The inundation area is typically undeveloped	Minimal economic losses typically limited to owners property and do not exceed $100,000. Virtually no potential for future development of other land uses within the foreseeable future.	No significant loss or deterioration of fisheries habitat, wildlife habitat, rare or endangered species, unique landscapes or sites of cultural significance.

6. Prior State and Federal Surveys Related to Design Flood Selection

6.1. Background

As design practices and regulatory guidelines relating to the selection of a design flood have developed over the past several decades, multiple organizations and individuals have striven to understand what the industry standard was at a particular point in time. The use of surveys has been a common tool in identifying current dam safety practices. Several past surveys regarding design flood selection are summarized in this chapter. Each survey provides a snapshot in time of dam safety practices and regulations as well as common opinions and ideologies of the dam safety community. A careful review of each of the surveys is helpful in identifying the trends and changes regarding the hydrologic safety of dams over the past 40 years.

6.2. USCOLD – 1970

In the late 1960s, the U.S. Committee on Large Dams performed a survey of dam design practices for sizing spillways in the United States. Surveys were solicited from both federal and state dam safety agencies, and results were published in a 1970 report "Criteria and Practices Utilized in Determining the Required Capacity of Spillways."

It was reported that all respondents to the survey followed policies discouraging the use of risk analysis when designing high hazard dams. Without exception, respondents agreed that the prevention of overtopping during extreme flood events is of such importance that the required cost is justified. It was also noted that the policies generally accepted at the time were not radically different from those from 20 or more years previous to the study, although procedures and techniques had improved.

6.3. National Research Council – 1985

As part of a study entitled "Safety of Dams: Flood and Earthquake Criteria" performed by the Committee on Safety Criteria for Dams of the Water Science and Technology Board of the NRC's Commission on Engineering and Technical Systems, inquiries regarding current dam safety provisions were made to federal agencies most concerned with dams, state dam safety units, several prominent dam engineering firms, and other organizations with interests in dam safety. The data from 10 federal agencies, 35 state and local agencies, 9 private firms, and 4 professional engineering societies were used to determine the state of the practice in 1985.

The survey found a broad range of classification criteria being used at the time. Most dam classification systems were based on dam height, volume of water impounded, the extent of development in the downstream dam failure hazard area, or a combination of the preceding characteristics. The summary notes that:

> *"While it appears that many of the differences in dam classification systems are the result of arbitrary choices of regulatory authorities, it also appears that most of the classification systems have been structured to meet the perceived needs of the issuing agency or state government"* [NRC, 1985].

In regards to spillway capacity, the survey found that the majority of design criteria were based on deterministic estimates of the PMP or PMF, some percentage of the PMP or PMF, and probabilistic flood events with a return period of 100 years or less frequent. The Soil Conservation District and the state of West Virginia reported using mixed criteria based upon both probabilistic and deterministic estimates. The only reports of probabilistic floods less frequent than the 100-year event occurred in California (1,000 year flood event) and Michigan (200-year flood event). A summary of spillway capacity criteria used by various U.S. states and agencies in 1985 is included in Table 6-1.

Table 6-1 Spillway Capacity Criteria Reported to Be in Use by Various U.S. Agencies in 1985 [NRC, 1985]

Deterministic Criteria	Mixed Criteria	Probabilistic Criteria
Criteria specifying rainfalls		
PMP	P100 + 0.40 (PMP – P100)	2.25 P100
0.90 PMP	P100 + 0.26 (PMP – P100)	1.50 P100
0.80 PMP	P100 + 0.12 (PMP – P100)	P100
0.75 PMP	P100 + 0.06 (PMP – P100)	P50
0.50 PMP		P10
0.45 PMP		
0.40 PMP		
0.33 PMP		
0.30 PMP		
0.25 PMP		
0.225 PMP		
0.20 PMP		
0.10 PMP		
Criteria specifying floods		
PMF		1,000-year flood
0.75 PMF		200-year flood
0.50 PMF		100-year flood
0.40 PMF		50-year flood
0.30 PMF		
0.25 PMF		
0.20 PMF		

Criteria specific to each agency included in this study are published within the report. The following key points regarding spillway capacity design were noted:

- There was a fair consensus on the spillway requirements for large, high-hazard dams. The use of PMP or PMF estimates for such dams predominated, although many state regulatory agencies indicated that their standards did not require the full PMP or PMF.
- There was a much greater diversity of hydrologic criteria for the safety of classes of dams other than large, high hazard dams.
- While simple hazard rating categories based on downstream development may be useful for identifying dams for high-priority safety evaluation and study, they do not reflect the potential for incremental loss of life and damage caused by failure of a dam due to an inadequate spillway when a river is already in flood.
- Though not included in most published criteria, the use of incremental damage assessments was growing in acceptance and used to establish the required spillway capacity.
- New concepts and improved methods for estimating floods have resulted in generally larger flood estimates and future estimates of magnitude for extreme floods can be expected to increase. However, unless the runoff characteristics of the watershed were to change, increments in future flood estimates should be less than those noted in the past. There have been instances where more intensive hydrometeorological studies have resulted in reductions in estimates of PMP by earlier investigations.
- A dam designed for the PMF using the PMP does not provide absolute assurance that the dam is safe for every possible flood.
- The study noted that the use of arbitrary criteria such as a percentage of the 100-year storm, fraction of the PMF, or combinations of the PMF and probability based floods was common, even though there is no documented scientific rationale for such approaches.

For new high-hazard dams, the Committee recommended the PMF be adopted for the SDF unless risk analyses that examine the incremental impact of overtopping and dam failure during an extraordinary flood demonstrate that little or nothing is gained by such a high standard. The SDF would be the smallest value that ensures that a dam breach results in no significant increase in potential for loss of life or major property damage.

For existing high-hazard dams, the Committee concluded that there was no universally satisfactory approach to establishing spillway capacity criteria. The Committee therefore recommended that risk-based analysis be considered for existing high-hazard dams “for which the PMF is not required.” A section describing risk-based analyses was included in the report.

No specific recommendations were made by the Committee for spillway design requirements for intermediate hazard and low hazard dams.

Additional recommendations made by the Committee are summarized in Section 4.9.

6.4. Dubler Thesis, Colorado State University – 1995

James R. Dubler published the thesis "Dam Safety Policy for Spillway Design Floods" as part of his Master of Science degree at Colorado State University in 1995. Representatives of 46 state dam safety agencies provided responses to a survey included in the thesis.

The study found that disagreement concerning the selection of the SDF among professionals still existed. At the time of the survey, risk analysis was not popular in the professional community, and most states' guidelines for the selection of the SDF were based on a prescriptive approach. The survey also explored a variety of topics related to the SDF and risk analysis including incremental damage analysis, early warning systems, the development of probable maximum flood estimates, downstream development controls, advantages and disadvantages concerning risk analysis, and opinions regarding the level of conservatism required for spillway design.

Dubler made the following conclusions in his thesis:

- The use of prescriptive standards for important structures usually implies adoption of the "no-risk" stance. This is inappropriate. That is not to say use of the PMP/PMF as a design criterion is necessarily inappropriate, but it is inappropriate to make that selection on the basis of "no-risk."
- It is not reasonable to have different probabilities of failure for different aspects of dam design.
- It is not reasonable to have different degrees of conservatism for different sorts of risks facing society.
- The risk analysis approach is not popular in the professional community. Perhaps this is partly because "risk" is a bad word. Perhaps we need a more appealing label, such as "balanced design."
- There are those who believe it is wrong for public policy to explicitly acknowledge that for some stated endeavor a certain degree of risk exists. The unfortunate fact is that risks do exist and accidental deaths do occur. We as a society must decide what portion of our resources we are willing to allocate to reduce such deaths. Clearly, certain expenditures involving construction or retrofitting of spillways are not justifiable. It is the moral duty of the engineer, and in fact of everyone, to make optimum use of resources.

6.5. Paxson and Harrison – 2003

In 2003, Greg Paxson and John Harrison of Schnabel Engineering, Inc. performed an independent survey of state dam safety officials as part of a technical paper entitled "Hydrology and Hydraulics for Dams: State of the Practice or Practice of States?" All 50 states were included in the study which placed an emphasis on the hydrologic and hydraulic methods and models used.

The survey revealed that a total of 76 percent of the states would allow the development of site specific PMP studies. Eighty-eight percent of the states would allow the use of incremental damage assessment to establish the SDF. Only 43 percent would allow the use of rigorous risk-based analysis. It was noted that the allowance of these practices did not necessarily equate to their common use.

The authors of the technical paper commented that standardization of certain practices not dependent upon regional conditions would likely be beneficial to the dam safety community. Standard criteria could include approved hydrologic models, freeboard requirements, reservoir inflow and initial water surface elevation criteria for dam failure inundation analyses, and criteria for incremental damage analysis.

6.6. ASDSO Surveys

The Association of State Dam Safety Officials has performed numerous surveys of the state dam safety agencies over the past decade. Recent material includes the “State Dam Safety Dam Size Classification Schemes” and “State Dam Safety Hazard Potential Classification” which were both published in 2010 and are included in Appendix F. On an annual basis, ASDSO collects information on states’ public awareness, education, staffing, training, budgets, legislation/regulations, program improvements, litigation, dam failures/incidents, dam removals, research, and other activities.

7. 2011 Hydrologic Safety of Dams Survey and Database

7.1. Questionnaire Distribution and Database Compilation

The purpose of this report is to document the present state of the practice for evaluating the hydrologic safety of dams, including inventorying current practices used by state and federal agencies. As a significant portion of this effort, a detailed questionnaire was prepared and distributed to all state dam safety agencies as well as any federal agencies which own, regulate, or assist in the design of dams. Members of the research team initially reviewed each agency's published policies and guidelines and completed applicable portions of the questionnaire. Respondents were requested to complete the survey and verify any responses initially completed by the research team. Electronic copies of the questionnaire were distributed to potential respondents in February 2011. Questionnaires were completed by respondents and returned to the research team by May 2011.

As questionnaires were returned, a member of the research team reviewed each response to ensure its accuracy and completeness. If needed, the respondent was contacted to clarify their responses. In a few cases, questionnaires were edited to create consistency between responses, thereby enabling comparison and analysis of the results. For example, when asked if the agency had hazard classification criteria, the survey allowed several responses including "Yes (High, Significant, and Low)." Several agencies responded "Yes (Other)" and commented that they utilized classification system consisting of high, moderate, and low hazards. In these cases, the terms "moderate" and "significant" were judged to be equivalent and interchangeable and the response was edited by the research team accordingly. All responses were incorporated into an electronic database which facilitated analysis of the survey results.

The questionnaire addressed many important issues related to the hydrologic safety of dams including dam classification criteria, determination of the SDF, allowable methodologies and software, consideration of future development, incremental damage assessment, use of early warning systems, current practices related to risk analysis, and agencies' ability and receptiveness to perform risk analysis. Thirteen questions were included in an "off-the-record" or anonymous portion of the survey due to their potentially sensitive nature. A copy of the survey questionnaire and corresponding answer choices is included in Appendix C.

7.2. Response

Of the 63 surveys distributed, a total of 58 were completed. Surveys were completed by the appropriate dam safety agency from all 50 states, as well as Puerto Rico, with exception of Alabama and Florida. The State of Alabama does not currently have a dam safety program and therefore did not provide a response. Florida's Dam Safety Program elected to not complete the questionnaire due to the fact that dams within the state are regulated separately by each water management district. Each of the five districts within the state has different spillway design standards.

Of the federal agencies, respondents included:

- Bureau of Indian Affairs
- Federal Energy Regulatory Commission
- Mine Safety and Health Administration
- Natural Resources Conservation Service
- Tennessee Valley Authority
- U.S. Army Corps of Engineers
- U.S. Bureau of Reclamation
- U.S. Forest Service
- U.S. Fish and Wildlife Service

The National Park Service declined to participate. The Bureau of Land Management and U.S. Nuclear Regulatory Commission did not respond to the survey request.

Chapters 8 and 9 of this report present the key findings of this survey effort in relation to current hydrologic design practices of both the federal and the state agencies, respectively. "On-the-record" portions of questionnaires completed by respondents and finalized by the Research Team are included in Appendix C.

8. Summary of Current Federal Hydrologic Design Guidelines

8.1. Background

Historically, a few key federal agencies have led the way in developing dam safety regulations and design standards. Agencies that have typically been at the forefront of dam safety include the Federal Emergency Management Agency, Bureau of Reclamation, Army Corps of Engineers, and the Natural Resources Conservation Service. Summaries of the hydrologic design practices of these agencies are provided in this chapter. A compilation of pertinent federal publications and guidance documents are included in Appendix D. Policies of other federal agencies who responded to the Hydrologic Safety of Dams Survey are also reviewed.

8.2. Overview of Dam Classification and Spillway Design Criteria

8.2.1. Definition of Regulatory Dam

In identifying non-jurisdictional or non-inventory dams, all federal agencies other than FERC and the Mine Safety and Health Administration (MSHA) follow the definition outlined in FEMA's Federal Guidelines for Dam Safety. FEMA's guidelines specify that a dam is:

> *"…any artificial barrier, including appurtenant works, which impounds or diverts water and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or water course, to the maximum water storage elevation or (2) has an impounding capacity at a maximum water storage elevation of fifty acre-feet or more. These guidelines do not apply to any such barrier which is not in excess of six feet in height regardless of storage capacity, or which has a storage capacity at maximum water storage elevation not in excess of fifteen acre-feet regardless of height. This lower size limitation should be waived if there is a potentially significant downstream hazard"* [FEMA, 2004].

The MSHA's non-coal program area also follows these guidelines; however, for the coal program, any impoundment less than 5 feet high or less than 20 feet high with a storage volume of less than 20 acre-feet is considered non-jurisdictional. FERC considers any dam included in a FERC license to be a jurisdictional dam.

8.2.2. Dam Classifications and Selection of the Spillway Design Flood

All of the federal agencies responding to the survey indicated the use of hazard classification criteria. All of these agencies use a three-class system consisting of high, significant, and low hazard. Most of the agencies defined "Significant Hazard" as having *no potential for loss of life,* though extensive economic losses would be expected. Under these agencies, any dam creating a hazard to human life would be classified as "High Hazard." The Bureau of Indian Affairs (BIA) definition of a significant hazard dam states that between 1 and 6 lives would be at risk or significant property damage could occur if the dam failed. USACE indicated that loss of life is "not probable" during the failure of a significant hazard dam.

The only federal agencies indicating the use of size classification criteria were the U.S. Fish and Wildlife Service (USFWS) and MSHA. Both of these agencies use a combination of hazard and size classification to determine the SDF. Most of the other federal agencies prescriptively assign the SDF based on hazard classification only. The only exceptions to this are USACE and Reclamation who are leading the way in developing spillway design criteria using risk analysis. Additionally, the BIA indicated that the use of risk analysis in connection with its prescriptive hazard classification system was acceptable.

With the exception of the Bureau of Reclamation, all federal agencies use the same criteria for both the design of new dams and the evaluation and rehabilitation of existing dams. Reclamation indicated that the application of updated design guidelines to an existing dam would vary by project after considering the amount of risk reduction, feasibility of the modification, and cost/benefit analysis results.

8.2.3. Design Criteria

By way of the 2011 Hydrologic Safety of Dams survey, several key points were identified concerning the practices of federal agencies. These are as follows:

- For PMP/PMF designs, most federal agencies determine the necessity for freeboard on a case-by-case basis. The Natural Resources Conservation Service (NRCS), TVA, and U.S. Forest Service (USFS) do not require freeboard for such designs.
- Most federal agencies either allow or encourage the use of early warning systems on Significant and High Hazard structures; however, they will not consider an early warning system as an alternative to designing a dam for the regulatory SDF. MSHA will allow storm runoff flood control dams to be designed to low hazard criteria if an early warning system is provided to prompt the evacuation of downstream personnel.
- All federal agencies permit the use of site specific PMP studies.
- The only federal agency that does not allow the use of an incremental damage assessment to establish the SDF is the TVA.
- While not all federal agencies have reviewed a risk-based design, there are no federal guidelines or regulations that forbid such designs. Federal agencies that have reviewed risk-based designs include the BIA, NRCS, USACE, Reclamation, and USFWS.

8.3. Summary of Guidelines from Select Federal Agencies

8.3.1. U.S. Bureau of Reclamation

As noted in Section 3.7, Reclamation appears to be the first federal agency worldwide to seriously apply risk-based decision making to dam safety. The Bureau began applying principles of risk analysis to dam safety as early as the 1980s. In 1985, the NRC Committee on Safety Criteria for Dams reported that while many Reclamation dams were held to the industry standard PMF, the concepts of incremental damage analysis and even the beginnings of full-fledged risk analysis (including consideration of social, environmental, and political effects of dam failure in additional to incremental damage and loss of life) were incorporated in Reclamation design criteria.

Since that time, Reclamation has moved away from deterministic design flood standards and has emerged as a major promoter of risk analysis. In utilizing risk analysis, each dam site and structure is considered individually with the SDF being determined on a case-by-case basis. Under current Reclamation practice, any modifications to spillway design capacity would follow a risk-based approach using Reclamation's Risk Analysis Best Practices Manual and would vary by project. Modifications to existing structures must consider the amount of risk reduction, feasibility of modification, and cost/benefit analysis when selecting the design criteria. Reclamation’s recommended guidelines for evaluating the need and urgency to implement risk reduction activities based on the estimated risk are shown in Table 8-1 and Figure 8.1. Incremental damage analysis is used when appropriate but not required.

In 2006, Robert E. Swain, John F. England, Jr., and Kenneth L. Bullard of Reclamation published Guidelines for Evaluating Hydrologic Hazards as a guidance document for generating hydrologic hazard information to be used in evaluating the hydrologic risk at dams. This document outlines a procedure for developing hydrologic hazard curves using a combination of seven hydrologic methods. These methods include the use of flood frequency analysis with historical and paleoflood data as well as the development of a PMF using published HMR and Reclamation guidelines. Other significant contributions and guidelines that Reclamation has published over the past two decades to facilitate application of risk analysis to dam safety are noted in Section 3.7.

Table 8-1 Bureau of Reclamation Risk Reduction Guidance [Adapted from Reclamation, 2003]

Guidance for Estimated Risk	
Estimated risk is portrayed to be greater than 0.01 lives per year	Reclamation considers that there is justification for taking expedited action to reduce risk. While there is a full range of possible risk reduction actions that can be taken, Reclamation should focus on those that can quickly reduce risk or improve understanding of the uncertainties associated with the risk. As confidence increases that the risk is in this range, actions considered should concentrate more on reducing the risk than reducing the uncertainties. Any reassessment of the risk should be done prior to increased storage if at all possible, and every effort should be made to complete the reassessment within 90 days of determining the need for expedited risk reduction action.
Estimated risk is portrayed between 0.01 and .001 lives per year	Reclamation considers that there is justification for taking action to reduce risk. When the range of risk estimates falls in this range, there are a wide variety of possible actions which may be appropriate. However, the actions can be scheduled into the dam safety program and coordinated with other needs at the facility or at other facilities. Actions to reduce risks should be implemented on a schedule that is consistent with budgeting and appropriations processes. Typically, risk reduction should be accomplished within 7 years of a decision that risks need to be reduced. When there is an indicated need for risk reduction, the time spent on additional loading definition, data collection, and risk assessment should be completed in a reasonable timeframe. While it is desirable for this timeframe to be within a year, other times may be considered reasonable by decision makers based on the severity of the identified risks. Decisions on adequate time frames should be documented in appropriate decision documents.
Estimated risk is portrayed to be less than 0.001 lives per year	The justification to implement risk reduction actions or conduct additional studies diminishes as estimated risks become smaller than .001. Risk reduction action costs, uncertainties in the risk estimates, scope of consequences, operational and other water resources management issues play an increased role in decision making. Actions considered reasonable and prudent should be considered for implementation when the risk is in this range.

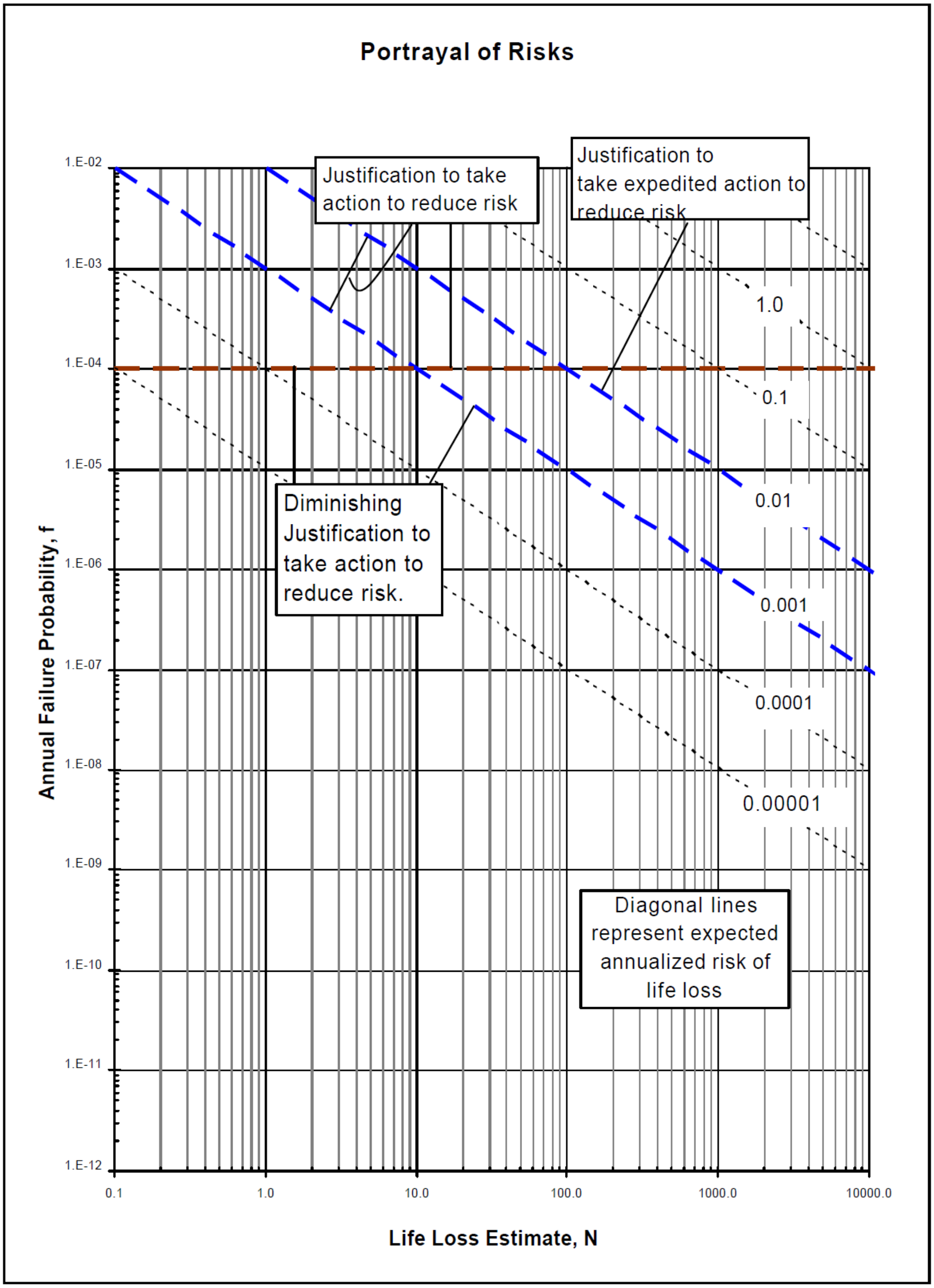


Figure 8.1 Reclamation f-N Chart for Displaying Probability of Failure, Life Loss, and Risk Estimates [Reclamation, 2003]

8.3.2. U.S. Army Corps of Engineers

The other major contributor to the development of risk-based dam safety standards in the United States has been the U.S. Army Corps of Engineers. USACE has published numerous guidance documents outlining policy and procedures related to dam safety. Under current guidelines, High hazard dams with potential life loss must pass 100% of the PMF per Standard 1 of ER 1110-8-2. Significant hazard dams with no probable life loss must pass major floods typical of the region without excessive damage or loss of operability per Standard 2 of ER 1110-8-2. Significant hazard dams with no incremental life loss due to dam failure must pass a minimum of 1/2 PMF per Standard 3 of ER 1110-8-2. Low hazard dams typically fall under Standard 4 of ER 1110-8-2 which requires rainfall-runoff probability analyses with no specific minimum requirement. These design standards are consistent with those that were utilized at the time of the 1985 NRC report.

One of the most recent USACE publications is ER 1110-2-1156 which is in draft form and is dated September 30, 2010. This publication provides an overview of the Dam Safety Program, provides guidelines and procedures for decisions, and discusses periodic assessments, inspections, and other items.

Some of the most relevant and state-of-the-art portions in ER 1110-2-1156 are the guidelines for assessing tolerable risk. The overall goal is to lower the residual risk to a tolerable level while also meeting project-specific requirements for what is practicable. The project-specific limits defined for what is practicable are termed “ALARP” which stands for “As Low As Reasonably Practicable.”

ER 1110-2-1156 presents the state-of-the-art guidelines for assessing tolerable risk including the application of the following concepts: “Tolerable Risk,” “Broadly Acceptable Risk,” “Tolerable Risk Range,” and “As-Low-As-Reasonably-Practicable” in a generalized and project specific tolerability of risk framework. A schematic illustrating these concepts is shown in Figure 8.2. Determining ALARP is ultimately a matter of judgment. General guidance is provided in ER 1110-2-1156 on how to satisfy the ALARP requirement.

The following four risk measures are evaluated under the USACE tolerable risk guidelines:

1. Annual Probability of Failure (APF)
2. Life Safety Risk
3. Economic Risk
4. Environmental and Other Non-Monetary Risk

Incremental consequences (consequences resulting from dam failure vs. consequences resulting without dam failure) are to be considered when performing quantitative risk analysis.

The USACE’s policy for the estimated annual probability of failure (APF) is that it is unacceptable to be greater than 1 in 10,000 (0.0001). An APF will be considered tolerable when it is less than 1 in 10,000 (0.0001) per year provided the other tolerable risk guidelines are met.

The USACE has identified three types of risk safety guidelines; (1) individual incremental life safety risk using probability of life loss, (2) societal incremental life safety risk expressed as a probability distribution of potential life loss (F-N chart), and (3) societal incremental life safety risk expressed as an Annualized Life Loss (ALL). For existing and new dams, the individual incremental life safety risk probability of life loss should be less than 1 in 10,000 and 1 in 100,000 per year, respectively. For existing dams the societal risk should be less than the tolerable risk limit line shown on Figure 8.3 and satisfy the ALARP requirements. Dams with failure risks that plot above a tolerable risk limit shown on Figure 8.3 are considered to have an unacceptable level of risk, except in exceptional circumstances. Annualized incremental societal life loss is evaluated based on the guidelines presented in Figure 8.4.

Risk informed hydrologic designs are permitted for flood damage reduction studies (e.g. levees, channel improvements, etc) per ER 1105-2-101. However, despite the significant efforts given to developing risk analysis for dam safety, risk-informed hydrologic designs are not permitted for dams under current USACE guidelines. Risk-informed hydrologic analyses for dams are used to prioritize risk reduction actions for dams in the USACE inventory and to inform decisions on incremental risk reduction actions for specific projects.

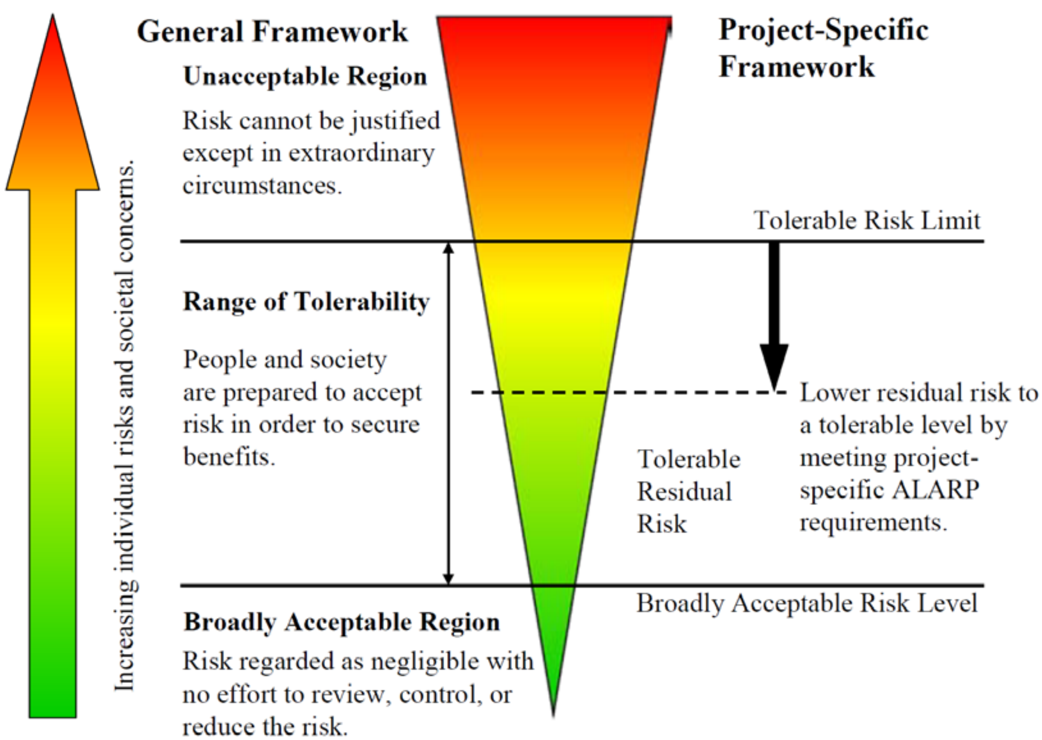


Figure 8.2 Generalized and Project Specific Tolerability of Risk Framework [USACE, 2010]

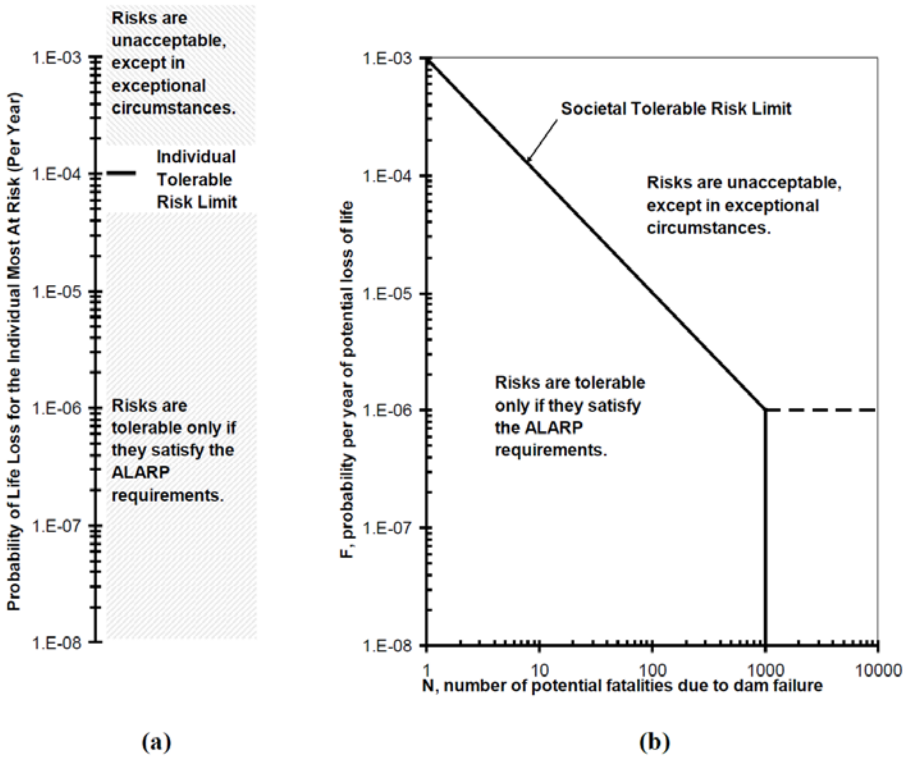


Figure 8.3 Individual Risk Guidelines (a) and Societal Risk Guidelines (b) for Existing Dams [USACE, 2010]

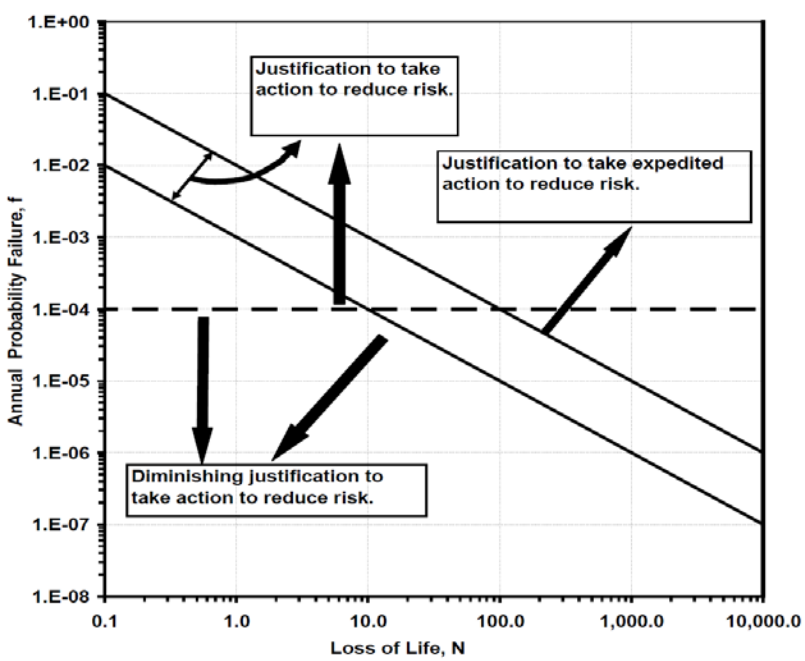


Figure 8.4 F-N Chart for Displaying Annual Probability of Failure and Annualized Life Loss [USACE, 2010]

8.3.3. Natural Resources Conservation Service

NRCS (previously known as the Soil Conservation Service or SCS) is not a regulatory agency, but rather an agency that provides financial and technical assistance to landowners and project sponsors in the evaluation, design, and installation of dams. SCS/NRCS guidelines were first developed in the 1930s. Since then the guidelines have evolved and are reviewed and updated on a continual basis. The NRCS has adopted a nationwide standard and allows state NRCS offices to revise the standards to make them more restrictive, but not less restrictive. Additionally, NRCS dams must meet all state and local regulations.

The NRCS has published numerous guidelines regarding the design and safety of dams. Technical Release 60 (TR-60) contains design requirements for earth dams and their associated spillways; National Engineering Handbook Part 630, Chapter 21 contains procedures for developing inflow hydrographs; and the National Conservation Practice Standard No. 378 contains design requirements for ponds and their associated spillways. NRCS design flood criteria from the TR-60 publication are listed in Table 8-2. These criteria are identical to those used by the NRCS in 1985 [NRC, 1985]. About 60 percent of NRCS dams are small, low hazard structures that provide water for livestock, fish and wildlife, recreation, fire control, or other related uses. Design criteria for these structures are listed in Table 8-3 as described in the National Conservation Practice Standard No. 378 for ponds.

NRCS encourages the use of a site-specific PMP where information is available. Where limiting physical site constraints exist, the NRCS does allow the use of incremental damage assessment in the rehabilitation of existing dams provided downstream land use controls are put in place to prevent voiding incremental risk assumptions [Hoeft et al, 2010]. NRCS will consider risk-based designs, but they are not a part of design guidelines.

Table 8-2 Minimum Auxiliary Spillway Capacity Criteria for Dams of the Natural Resources Conservation Service [NRCS, 2005]

Class of Dam	Product of storage X effective height	Existing or planned up-stream dams	Precipitation data for [1]	
			Auxiliary spillway hydrograph	Freeboard hydrograph
Low [2]	less than 30,000	none	P_{100}	$P_{100} + 0.12(PMP - P_{100})$
	greater than 30,000		$P_{100} + 0.06(PMP - P_{100})$	$P_{100} + 0.26(PMP - P_{100})$
	all	any [3]	$P_{100} + 0.12(PMP - P_{100})$	$P_{100} + 0.40(PMP - P_{100})$
Significant	all	none or any	$P_{100} + 0.12(PMP - P_{100})$	$P_{100} + 0.40(PMP - P_{100})$
High	all	none or any	$P_{100} + 0.26(PMP - P_{100})$	PMP

[1] P_{100} = Precipitation for 100-year return period. PMP = Probable maximum precipitation
[2] Dams involving industrial or municipal water are to use minimum criteria equivalent to that of Significant Hazard Class.
[3] Applies when the upstream dam is located so that its failure could endanger the lower dam

Table 8-3 Minimum Auxiliary Spillway Capacity Criteria for Ponds of the Natural Resources Conservation Service [NRCS, 2002]

Drainage area (Ac.)	Effective height of dam[1] (Ft.)	Storage (Ac-Ft)	Minimum design storm[2] Frequency (Years)	Minimum duration (Hours)
20 or less	20 or less	< than 50	10	24
20 or less	> than 20	< than 50	25	24
> than 20		< than 50	25	24
All others			50	24

1. As defined under "Conditions where Practice Applies".
2. Select rain distribution based on climatological region.

8.3.4. Federal Energy Regulatory Commission

FERC guidelines for the hydrologic safety of dams are consistent with FEMA's "Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams." These guidelines emphasize hazard evaluation as the primary means of determining the SDF. This emphasis includes the use of incremental damage analysis. FERC has also used information obtained from risk-based hydrologic analysis to aid in reviewing spillway designs. Although FERC has not utilized or developed risk analysis as fully as USACE or Reclamation, they have transitioned from a very deterministic and prescriptive approach to placing increasing emphasis on risk-related practices such as incremental damage analysis. A complete summary of FERC/FEMA's guidelines is included in Section 4.12.

8.3.5. Mine Safety and Health Administration

MSHA guidelines for the hydrologic safety of dams are based upon FEMA's "Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams." As noted previously, MSHA also utilizes a size classification system in conjunction with hazard classification to determine the appropriate SDF.

8.3.6. Tennessee Valley Authority

TVA guidelines are based upon FEMA's Federal Guidelines for Dam Safety as well as self-imposed criteria that TVA has developed over time. At present, TVA regulates 49 dams. They are in the process of creating a Dam Safety Governance organization which will implement guidelines for any impoundment within the TVA system which meets the definition of a dam within FEMA's Federal Guidelines for Dam Safety.

TVA typically selects the PMF as the appropriate SDF for dams with a high hazard classification. Significant and low hazard dams must pass the "TVA precipitation" as defined by a hydrometeorological design basis report developed for TVA by the National Weather Service. This precipitation is significantly less than the PMP. These SDF criteria are very similar to those used by the Authority in 1985 [NRC, 1985].

8.3.7. Bureau of Indian Affairs

BIA has custom developed dam safety guidelines based upon those published by Reclamation. In following with Reclamation guidelines, BIA determines the SDF using a combination of risk analysis and hazard classification. Under these guidelines, the SDF is typically defined as the largest flood which will cause incremental dam failure flooding. However, BIA reserves the right to select something smaller based on downstream conditions. Normally, the IDF will not be greater than a 10,000-year storm.

8.3.8. U.S. Forest Service

Both FEMA and USACE guidelines were consulted in the development of revised USFS dam safety guidelines. It is anticipated that the new guidelines will be completed in summer 2011. With the adoption of new guidelines, the Forest Service will discontinue the use of design flood criteria based upon a combination of size and hazard classification. SDF standards will be based entirely upon hazard classification. High Hazard dams will be required to pass the PMF, significant hazard dams will be required to pass 50% of the PMF, and low hazard dams will be required to pass the 100-year flood. Incremental damage analysis may allow spillway capacity to be reduced, but not any lower than the minimum thresholds which are as follows: 50% PMF (High Hazard), 100-year event (Significant Hazard), 50-year event (Low Hazard). Other than its use of incremental damage analysis, the revised USFS guidelines do not address risk analysis.

8.3.9. U.S. Fish and Wildlife Service

USFWS owns and self-regulates over 250 dams. SDF standards for these dams are based upon a combination of size and hazard classification. SDF criteria for varying size and hazard classes are as follows: all sizes of High Hazard dams (100% PMF); large, Significant Hazard dams (50-100% PMF); small or intermediate, Significant Hazard dams (50% PMF); large, Low Hazard dams (100-year to 500-year event); and small or intermediate, Low Hazard dams (100-year event). Incremental damage analysis may allow spillway capacity to be reduced, but not any lower than the 100-year flood. The Service indicated that risk-based hydrologic designs are permitted and have been used in the past.

9. Summary of Current State Hydrologic Design Guidelines

9.1. Introduction to State Guidelines

This chapter provides a summary of current state hydrologic design guidelines based on survey results, an examination of the actual guidelines, and review of prior state and federal surveys related to design flood selection. The information available from these sources was abundant, and only the most important and relevant findings are reviewed within this Chapter. Appendix C contains the completed surveys. A compilation of pertinent state regulations and guidance documents are included in Appendix E.

9.2. Origins and Status of State Guidelines

Most state dam safety officials who responded to the questionnaire indicated that their agency utilizes some sort of hydrologic design guidelines. Such guidelines are often published in the form of state administrative code, agency regulations and guidance documents, or a combination of both. Guidelines often hold the force of law. While guidelines are typically custom suited to each state and geographic region, the majority of state guidance documents draw heavily from federal dam safety regulations and design practices. The federal guidelines most commonly utilized by the states include those of FEMA, Reclamation, USACE, NRCS, and MSHA. A summary of when states adopted SDF criteria throughout the last century is shown in Figure 9.1 and shows that most states established SDF criteria prior to 1990.

In many states, dam safety guidelines are updated or revised on either a continual or recurring basis. However, of the 49 responding states, 31 indicated that they do not have any plans to update or revise their guidelines in the near future. At least 12 of the states had not updated spillway design guidelines in more than 15 years. It is noted that some states may consider altering requirements to be unfavorable due to potential cost consequences for dam owners in compliance with previous standards, potential for weakening of the overall standards due to lobbying, or the possible perception by the public that lives downstream are not worth the cost of protection.

In following with federal programs of the 1970s and 1980s, most states use a prescriptive approach to spillway design capacity. However, in the past few decades, a few states have adopted a more detailed, risk-based approach.

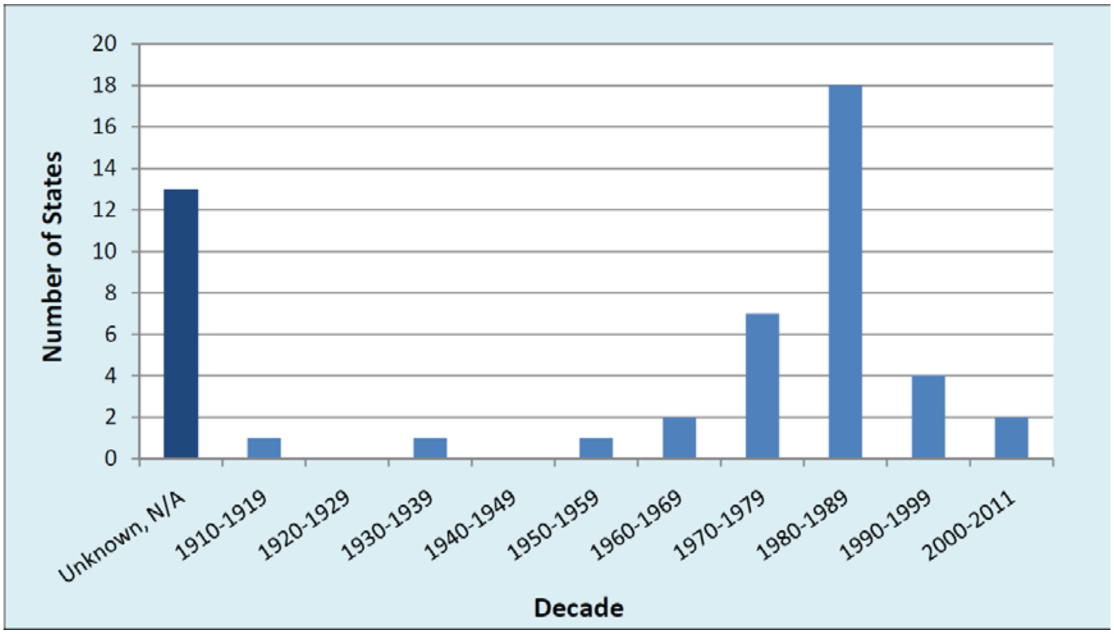


Figure 9.1 State Adoption of Spillway Design Flood Criteria by Decade

9.3. Dam Classification

States use many methods to identify and regulate dams within their jurisdiction. It appears that methods of dam classification have changed very little since the NRC's evaluation of flood design criteria in 1985. As noted in that report:

> *"There is considerable variety in the classification systems that have been adopted, and this variety often makes difficult any precise comparisons between criteria used by different agencies. Most systems for classifying dams specifically utilize dam height, volume of water impounded, and character of the development in the relevant downstream area as parameters in regard to probable effects of dam failure…*
>
> *"While it appears that many of the differences in dam classification systems are the result of arbitrary choices of regulatory authorities, it also appears that most of the classification systems have been structured to meet the perceived needs of the issuing agency or state government"* [NRC, 1985].

This broad variance of size, hazard, and other classification criteria is described in Sections 9.3.1 thru 9.3.4. Since these criteria are often used in prescribing the SDF, classification criteria is a very important aspect of the hydrologic safety of dams.

9.3.1. Regulatory Dam

The definition of a regulatory or jurisdictional dam varies greatly from one state to another. Most states determine the status of an impoundment based either loosely or entirely upon the similar definitions outlined in both the NID and FEMA's Federal Guidelines for Dam Safety (See Section 8.2.1). A total of 92% of the states define a jurisdictional dam by considering the storage volume of the impoundment. For 88% of the states, the height of the dam is also considered. Only 27% of the states mentioned the consideration of downstream hazard potential when determining if a dam is jurisdictional. Eight percent of states regulations included the drainage area in determining the regulatory status of an impoundment.

A few exceptions were also cited in determining the status of a dam. Under these exceptions, some states have defined farm ponds, road fills that do not normally impound water, dams associated with cranberry operations, dams used for manure storage, and dams not on watercourses as non-jurisdictional structures.

In the questionnaire, respondents were asked how their agency defines a "non-inventory or non-jurisdictional" dam. It is noted that in some states these two terms are distinctly defined. These states typically maintain an inventory of many small, limited hazard dams that do not necessarily fall under their regulatory jurisdiction.

9.3.2. Size Classification

In order to prescribe design standards or other regulations related to dams, several states utilize size classification criteria. Of the 49 surveys received, 29 states indicated that they utilize some sort of size classification system (See Figure 9.2). The names, number of size categories, and range limits vary extensively throughout the country. For example, depending on the state, a small-sized dam may be identified as a Class III, Class A, Class C, or small dam.

With respect to the number of size categories, the majority of size classification systems utilized by the states have only 3 classes (typically small, medium or intermediate, and large). Six states (Georgia, Kansas, Maryland, North Carolina, Ohio, and South Carolina) use size classification systems with 4 categories (either very large or very small in addition to the typical 3-class system). Four state/territories (Montana, New York, Puerto Rico, and Wisconsin) use size classification systems with only 2 categories (typically large and small). North Dakota is the only state that indicated a size classification system with 5 categories.

Size classification of a dam is typically based upon the height of the dam, the volume of storage, or some combination or product of the two values. The height and volume ranges vary dramatically. For example, the upper limit defining a small dam range anywhere from 10 feet high to 50 feet high and 12.5 acre-feet to 10,000 acre-feet. The most common definition of a small dam is less than 40 feet high storing less than 1,000 acre-feet. The lower limit defining a large dam is also extremely varied with the height ranging between 25 to 100 feet and the storage volume ranging between 50 acre-feet and 50,000 acre-feet. The most commonly used definition of a large dam is one having a height greater than 100 feet and storage greater than 50,000 acre-feet.

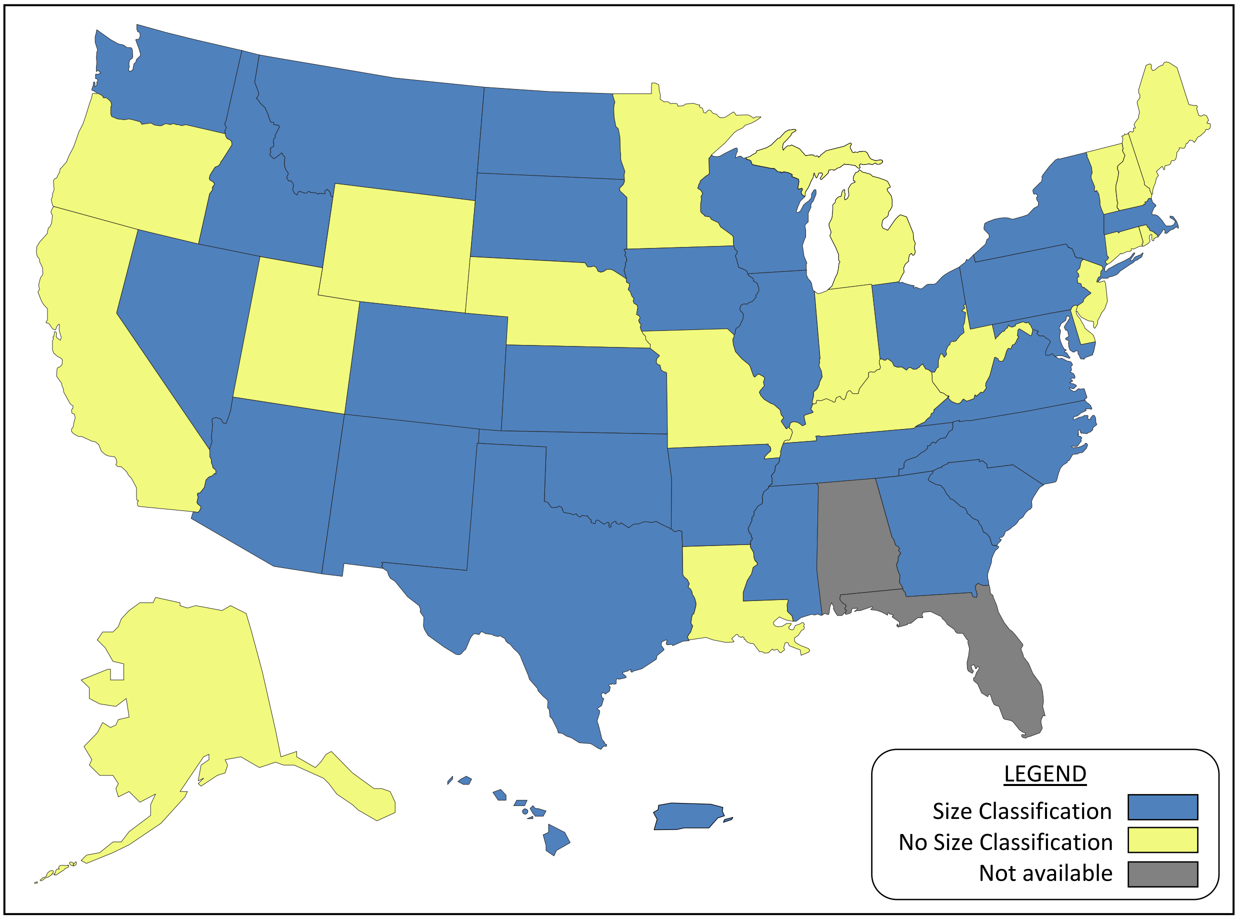


Figure 9.2 Size Classification Criteria within the United States and Puerto Rico

9.3.3. Hazard Classification

All of the states responding to the survey indicated the use of hazard classification criteria by their agency. A majority of 73% of respondents (36 states) use a three-class system consisting of high, significant, and low hazards. An additional 20% (10 states) have implemented a four-class system which typically includes a "Limited Hazard" classification below the "Low Hazard" class. Among the states using a three- or four-class system, there is a significant amount of disagreement concerning the definition of significant and high hazard dams. The key point of divergence is whether the probable loss of human life constitutes a high hazard rating. Sixty-five percent of the states have defined "Significant Hazard" as having *no potential* for loss of life, though extensive economic losses are expected. In these states, any dam creating a hazard to human life would be classified as "High Hazard." For the remaining 35% of the states, there are several ways that potential for loss of human life has been included in the definition of significant hazard. Some states define the loss of life potential as "few" or even designate a population at risk threshold for a significant hazard dam (such as 1 to 6 people or 1 or 2 habitable structures). Other states designate that the failure or misoperation of a significant hazard dam will cause “possible loss of human life” (as opposed to “probable loss of human life” for a high hazard dam). Others state that the failure of a significant hazard dam has a “low probability” of causing loss of human life.

Georgia and Montana utilize a similar hazard classification system that is entirely based upon the likelihood of loss of human life. Dams are divided into two categories: those that will cause probable loss of life and those that will not. Connecticut is the only state to use a 5-class hazard classification system (Negligible, Low, Moderate, Significant, and High). Figure 9.3 illustrates the number of hazard classes used by each state.

9.3.4. Additional Class Distinctions

Since new spillway requirements are often more conservative, upgrading an existing dam to meet current requirements each time the criteria are changed can be costly. For this reason, many states allow a reduction of SDF or even exemption from the updated criteria for dams existing prior to adoption of the criteria. Fifty-one percent of the responding states indicated that their guidelines for new and existing dams differ. The other 49% of the states hold all dams to the same standard, regardless of when they were constructed.

In addition to distinction between new and existing dams, several states require that mine tailings and coal ash dams be held to a different design standard. Fourteen percent of the respondents stated that their guidelines include additional design criteria for such dams.

In Alaska, the protection of anadromous fish habitat has been included in the hazard potential classification system. Missouri specifies varying hazard criteria based on dam type (conventional or industrial), stage of construction, and environmental class.

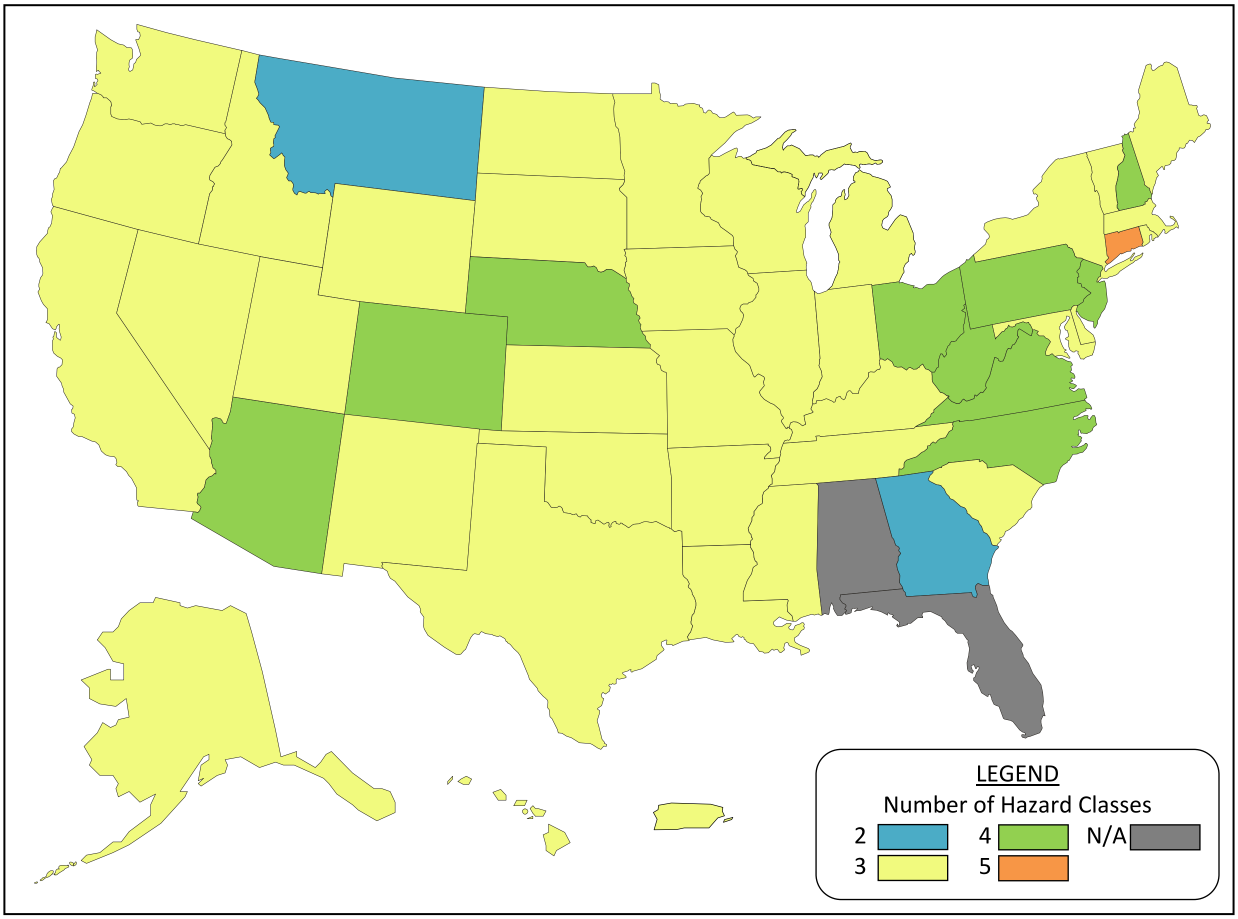


Figure 9.3 Hazard Classification Criteria within the United States and Puerto Rico

9.4. Determining the Spillway Design Flood

In determining the magnitude of the SDF, most states follow a prescriptive approach. Under a prescriptive approach, a design flood would be specified based upon the dam's classification (size, hazard, or both). Of the states using a prescriptive approach for SDF selection, most criteria are based upon either the hazard classification or a combination of size and hazard classifications. Georgia is the only state where the SDF is determined using only size classification criteria. Figure 9.4 shows a summary of each state's current approach to determining the SDF.

In the past few decades, a few states (including California, Washington, and Montana) have developed risked-based spillway design criteria. These methods are typically simpler than a rigorous risk analysis yet more complex than the typical hazard classification system. These criteria often determine the SDF using probabilistic loss of life estimates or consequence rating evaluation. The design flood in a risk-based system is often determined using a sliding scale between some lower threshold flood event and the maximum theoretical event. A few examples of such criteria are discussed in greater depth in Section 9.13 of this chapter.

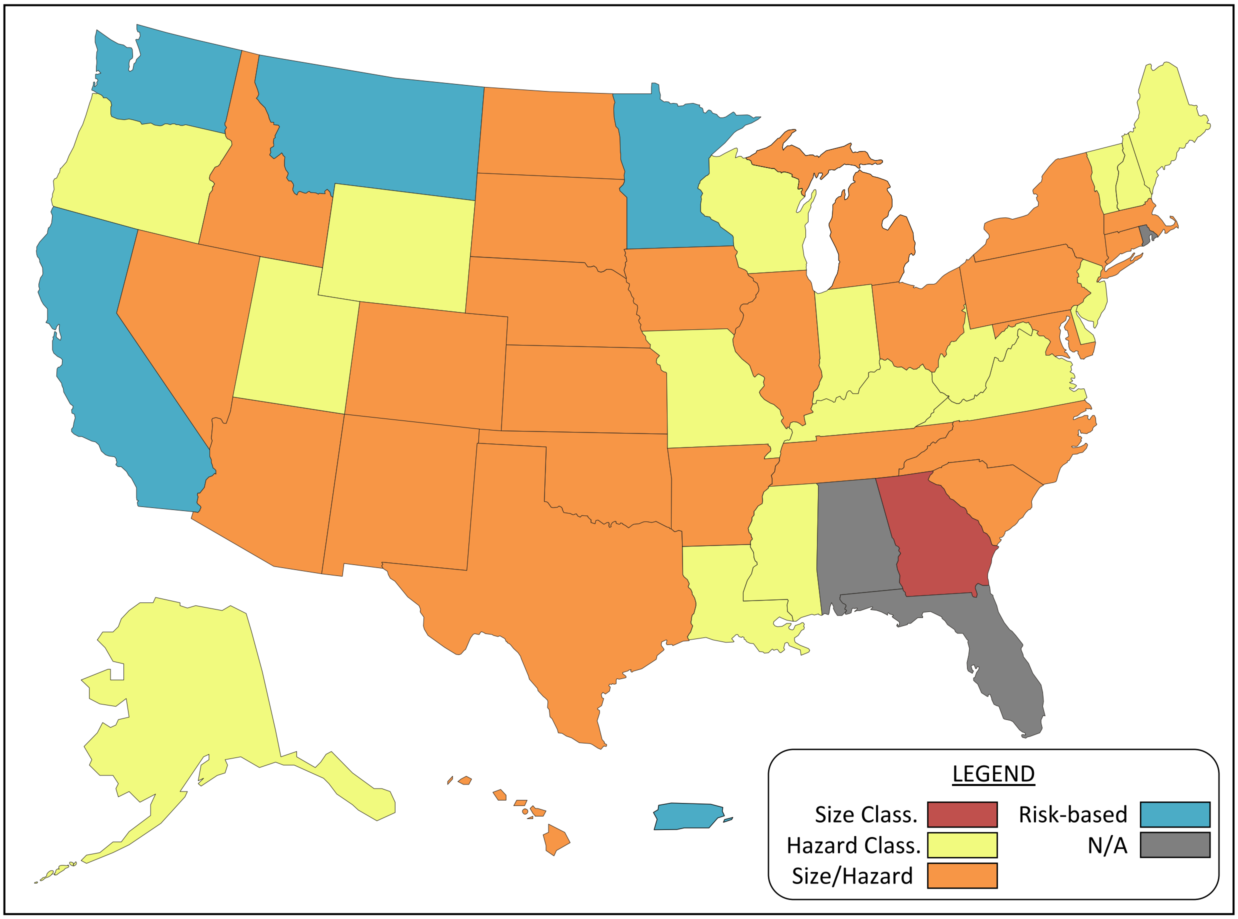


Figure 9.4 Approach to Selecting the SDF within the United States and Puerto Rico

Criteria for determining the SDF can be classified further as either probabilistic or deterministic. Probabilistic criteria are based on either floods or rainfall events which have specified probabilities or return periods. Deterministic criteria are based on PMP estimates or PMF estimates which are a derivative of the PMP. Of the states that utilize a deterministic approach, 33% define criteria with relation to the PMP while 67% are defined with relation to the PMF.

The variance in SDF criteria for new dams is significant as illustrated in Figures 9.5, 9.6, and 9.7. These figures represent the ranges of events specified by each state for low, significant, and high hazard dams. As described previously, there are many differences in the dam classification systems used by various states. In states where a High, Significant, and Low hazard rating system does not apply, classification systems were generalized to allow the comparison of SDF criteria. Also note that although probability events are shown on the figures, their plotted locations are not representative of their magnitude with relation to the probable maximum event. Tables 9-1 thru 9-3 provide additional analysis of spillway design criteria for both new and existing dams.

For new High Hazard dams, nearly half of the responding states indicated that the SDF should be no less than the probable maximum event. Eighty-two percent of the states use criteria extending up to the probable maximum event, usually dependent on size or hazard. A few states require only a fraction of the probable maximum event including Missouri (50 to 75% PMP depending on stage of construction), Colorado (45 to 90% PMP), Kansas (40% PMP), and Michigan (200-year event to 50% PMF). Wisconsin specifies that the SDF for a High Hazard dam is the 1000-year event. Idaho and Alaska specify that a SDF of 100-year magnitude is sufficient in some instances.

For new Significant Hazard dams, the range of SDF criteria is increasingly varied with acceptable design ranges stretching from the full probable maximum event down to the 100-year event. Thirteen states specify 50% of the probable maximum event as the SDF for a significant hazard dam. Several other states use the 50% mark as either an upper or lower limit.

For new Low Hazard dams, 15 states specify the 100-year event for spillway design. Eight additional states specify the 100-year event as a lower design limit. Low hazard spillway design in 11 states extends down to the 50-year flood. North Dakota is the only state allowing the 25-year event as a low hazard design event. For some large, low hazard dams, South Carolina and Tennessee require that the spillway pass the full probable maximum event. California's minimum design event is the 1000-year flood.

In Colorado, the spillway design ranges shown in Figures 9.5 thru 9.7 relate to a standard design using percentage of the PMP as developed using the appropriate HMR. Colorado has also specified SDF criteria for special cases such as high elevation dams and site specific PMP studies. For dams at elevations higher than 5,000 feet above MSL, PMP estimates can be decreased by an additional 5% or more depending on elevation [Colorado DNR, 2007].

In Virginia, the past few years have seen significant changes with regard to the hydrologic safety of dams. In response to revised regulations containing stricter hazard classification criteria, a dam owner recently led an effort to pass legislation that would provide relief to existing dam owners [Zamensky, 2010]. Multiple bills were subsequently passed. Under the new laws, the maximum design storm event to be required of existing dams is 90% of the PMP (formerly 100% of the PMP). Further reduction to 60% of the PMP was also permitted if certain conditions were met. These conditions include performing daily inspections, having an approved Emergency Action Plan, and obtaining insurance in an amount that would cover all losses due to dam failure. With regards to incremental damage analysis, the new laws also reduced the allowable lower limit of the SDF from 50% of the PMF to the 100-year flood [Commonwealth of Virginia, 2010].

Overall, it appears that current state SDF criteria for all dam hazard classes are similar to those reported in 1985 by the NRC. The following observations made in 1985 are equally applicable today:

- "Use of PMP estimates for evaluating spillway capacity requirements for large, high-hazard dams predominates, although a number of state agencies have indicated that their standards do not require that such dams pass the full estimated PMF based on the PMP.

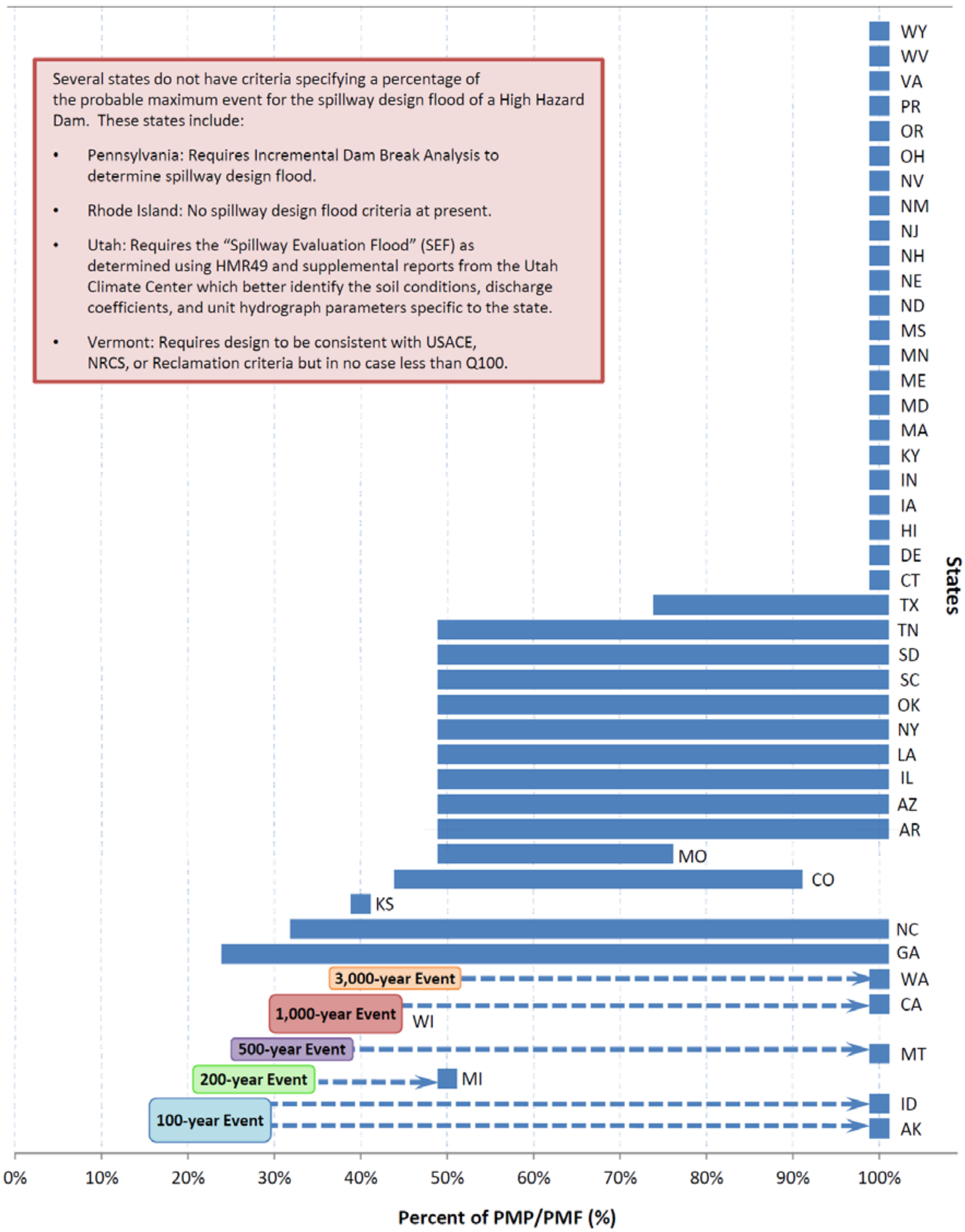
- "The influence of the practices of the principal federal dam-building agencies is evident in the majority of the standards for large, high-hazard dams, but the practices of those agencies have had less effect on current state standards for small dams in less hazardous situations.
- "Apparently as a result of the National Dam Inspection Program for nonfederal dams carried out by the Corps of Engineers in the 1977-1981 period, several state dam safety agencies have adopted the spillway capacity criteria used in those inspections.
- "Several states have adapted the standards used by the Soil Conservation Service (now NRCS) for the design of the tens of thousands of smaller dams constructed under that agency's programs.
- "Current practices include use of arbitrary criteria (such as 150 percent of the 100-year flood, fractions of the PMF, and combinations of the PMF with probability based floods) for which there is no apparent scientific rationale."

Note that the NRC's Committee on Safety Criteria for Dams questioned the use of composite criteria (combining flow frequency concepts with PMF concepts) as well as specifying percentages of the PMP, PMF, or various frequency events. "The problem with such a criterion, based on an arbitrary percentage of a derived flood or an arbitrary combination of floods developed from differing concepts, is that it permits no direct evaluation of the relative degree of safety provided." [NRC, 1985] The issue was further expounded upon in 1988 by the ASCE Task Committee on Spillway Design Flood Selection who stated:

> *"Studies by the National Weather Service indicate that the occurrence of a storm producing PMP is not equally probable nationwide. Thus, using a fraction of the PMF results in selecting a safety design flood which varies widely in exceedance probability… As long as the PMF is used to define a probable upper limit to flooding for use in a safety design, this is not a major concern. The exceedance probability of the PMF, assuming it is correctly defined, is essentially zero. When selecting a safety design flood less than the PMF, use of a fraction of the PMF produces a variation in exceedance probability that results in an inconsistent national safety standard"* [ASCE, 1988].

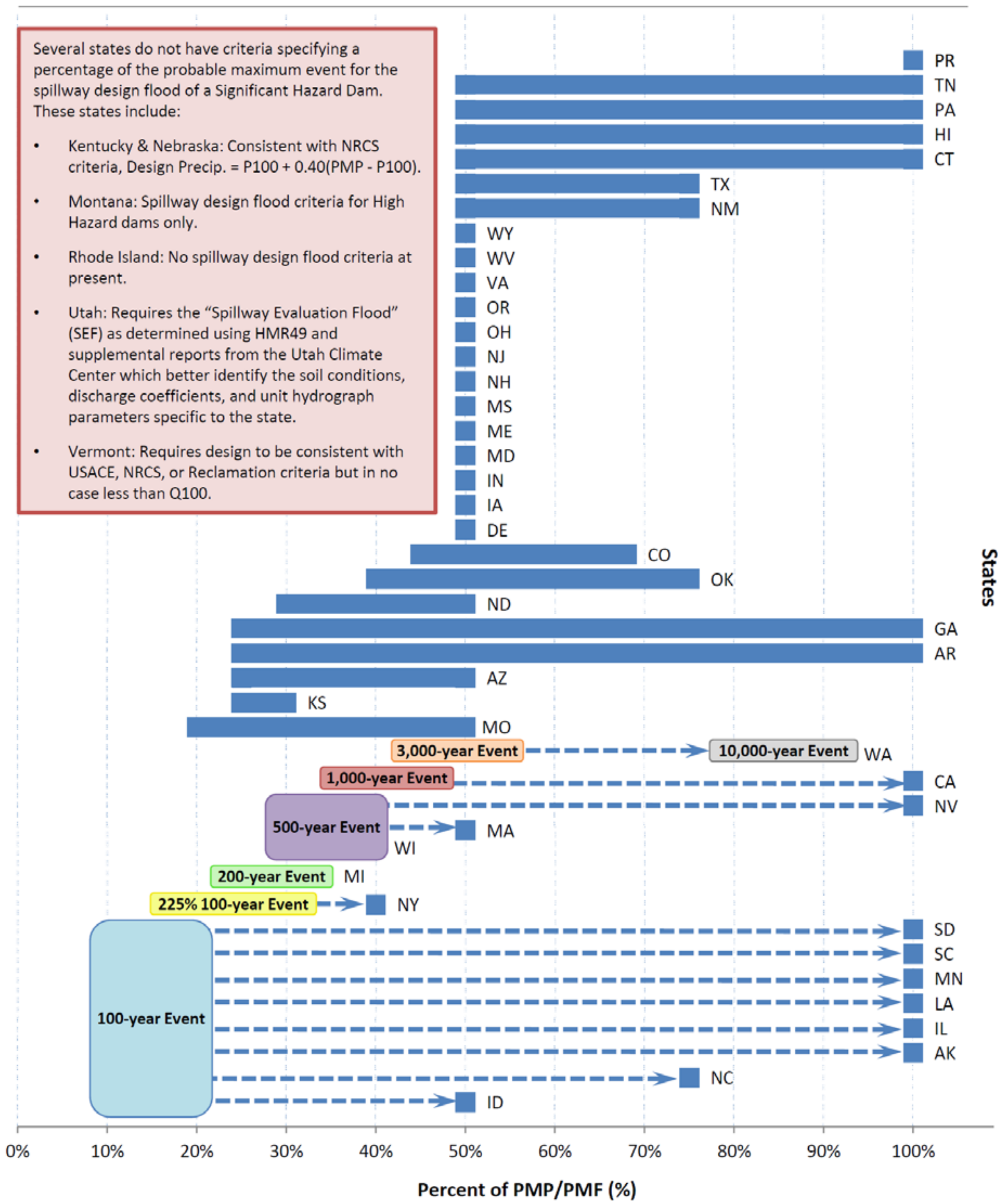
In light of technological advances which aid in calculating and assessing failure consequences, the ASCE Committee continued on to also question the practice of grouping dams based on size except for "projects too small and damages too low to warrant the expense of a specific failure analysis" [ASCE, 1988].

Although these concepts were disputed by experts in the mid- to late-1980s, the majority of state dam safety agencies continue to utilize such criteria multiple decades later. The NRC Committee did recognize that regional differences in climate, geography, and urbanization could justify differences in spillway design criteria. However, they also noted that not all criteria "could be efficient in limiting risks of dam failures to acceptable limits or in protecting the public interest" and recommended that more uniform approaches to specifying spillway capacity be considered.



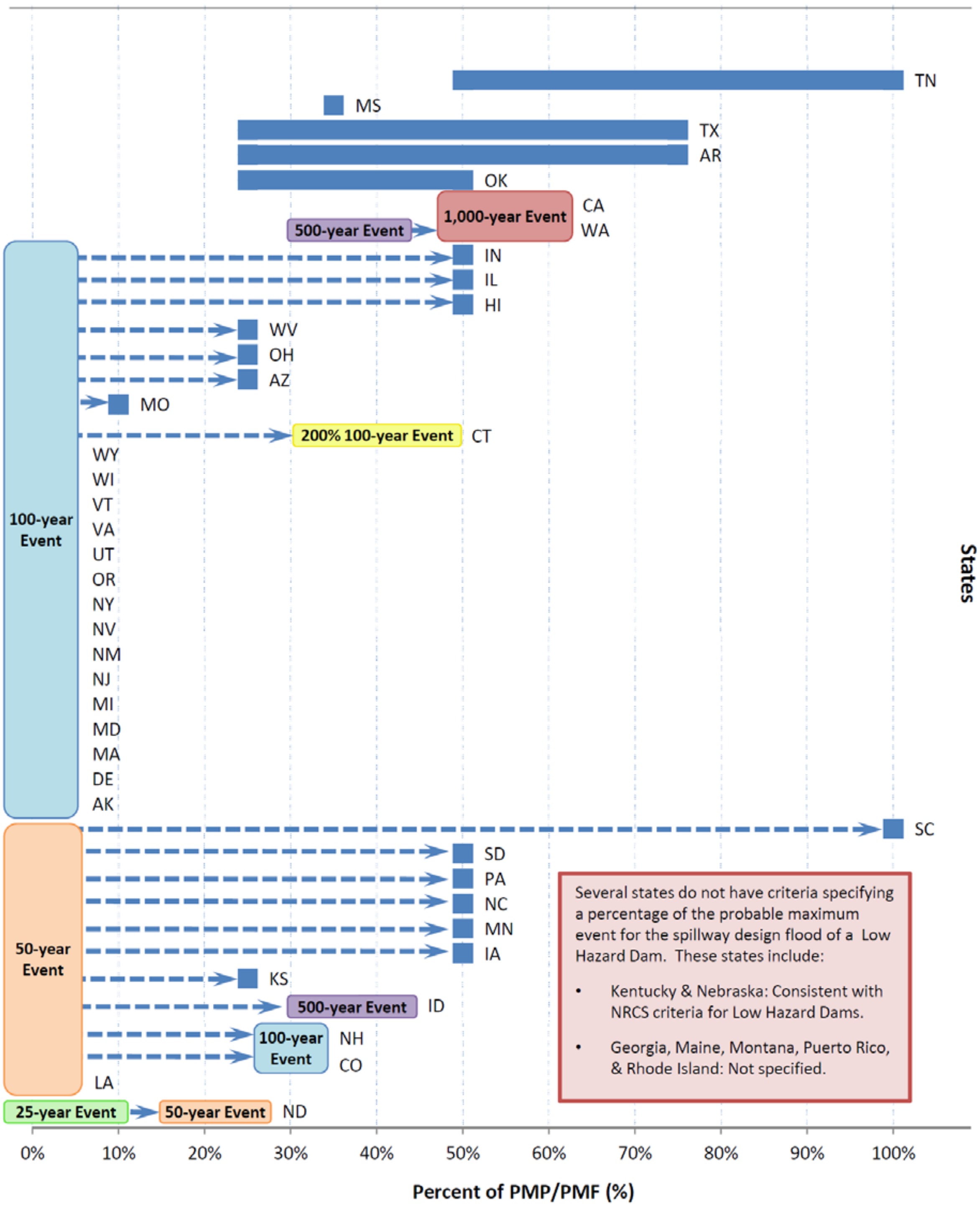
<u>Note</u>: For probability events (such as the 100-year flood), the corresponding percentage of the probable maximum event varies significantly in different areas of the country. The plotted location of probability events do not, therefore, represent the corresponding PMP/PMF percentage.

Figure 9.5 Range of Spillway Design Flood Criteria for New High Hazard Dams



Note: For probability events (such as the 100-year flood), the corresponding percentage of the probable maximum event varies significantly in different areas of the country. The plotted location of probability events do not, therefore, represent the corresponding PMP/PMF percentage.

Figure 9.6 Range of Spillway Design Flood Criteria for New Significant Hazard Dams



Note: For probability events (such as the 100-year flood), the corresponding percentage of the probable maximum event varies significantly in different areas of the country. The plotted location of probability events do not, therefore, represent the corresponding PMP/PMF percentage.

Figure 9.7 Range of Spillway Design Flood Criteria for New Low Hazard Dams

Table 9-1 Spillway Design Flood Criteria for New and Existing High Hazard Dams

Spillway Design Criteria	Number of States Specifying Criteria for New Dams	Number of States Specifying Criteria for Existing Dams
Requiring a Max Less Than 100% PMF	4	9
Requiring up to 100% PMF	17	15
Requiring Exactly 100% PMF	23	19
Requiring Incremental Damage Analysis	1	1
No Answer/Other*	4	5

**Includes 1,000-year event as well as recommendations to use various federal criteria.*

Table 9-2 Spillway Design Flood Criteria for New and Existing Significant Hazard Dams

Spillway Design Criteria	Number of States Specifying Criteria for New Dams	Number of States Specifying Criteria for Existing Dams
Requiring a Max up to 50% PMF	7	7
Requiring Exactly 50% PMF	13	13
Requiring Maximum between 50% PMF and 100% PMF	19	17
No Answer/Other*	10	12

**Includes 200-year event, 500-year event, 150% 100-year event, 25% PMP, 30% PMP, 40% PMP, and recommendations to use specific federal criteria.*

Table 9-3 Spillway Design Flood Criteria for New Low Hazard Dams

Spillway Design Criteria	Number of States Specifying Criteria for New Dams
Requiring Exactly 100-year Event	15
Requiring up to 100-year Event	2
Requiring up to 25% PMF	4
Requiring up to 50% PMF	9
Requiring up to 75% PMF	2
Requiring up to 100% PMF	2
Other*	9
Not Specified	6

**Includes 25-year event, 50-year event, 200% 100-year Event, 500-year event, 1000-year event, 10% PMP, 35% PMP, and NRCS criteria for low hazard dams.*

9.5. Storm Duration and Distribution

Thirty-seven percent of the states do not specify design storm duration within their hydrologic design guidelines. Of the 63% that do provide specific guidance regarding storm duration, it is typical to base the duration on the watershed's time of concentration or consider durations ranging from 6 hours to 72 hours. It should be noted that time of concentration is not the only determining factor in selecting the appropriate storm duration. For example, a reservoir with a large amount of available storage may not be significantly impacted by a short duration storm. A longer duration event yielding a larger volume of runoff could, therefore, govern the hydrologic design. Caution should be used when applying limiting or specific design criteria. Such criteria should allow for deference to a competent design engineer. The respondent in Alaska noted that hydrologic design criteria have specifically been excluded from their regulations to allow engineers to develop reasonable designs.

For the temporal distribution of the design storm, 57% of the states do not provide guidance. Of the 43% that do define the temporal distribution, about half indicate that the HMRs published by the National Weather Service should be used. Other commonly used temporal distributions include those developed by the NRCS as well as regional or custom distributions developed by the states.

One respondent noted that the duration and temporal distribution of a rainfall design event can have considerable impact on the required hydrologic design of a dam. Prior to 2005, the NRCS 6-hour design storm distribution was the basis for design of NRCS dams. The 6-hour rainfall amount and storm distribution has been used by the NRCS for over 50 years to set the top of dam and spillway requirements and is well established. Longer storm durations were considered only if the time of concentration exceeded six hours or the contributing drainage area exceeded 100 square miles. For dams with contributing drainage areas exceeding 100 square miles, the NRCS recommended that individual watershed PMP studies be performed by the NWS to take into account orographic features that are smoothed in the generalized precipitation studies.

In 2005, the NRCS revised TR-60 to require the analysis of both the 6-hour and 24-hour duration with the most critical results used for checking the discharge capacity and the integrity of the auxiliary spillway. It should be noted that although the 6- and 24-hour PMP rainfall amounts are obtained from NWS Hydrometeorological Reports, the rainfall distributions presented in TR-60 are used by the NRCS rather than the rainfall distributions presented in the hydrometeorological reports. For example, in the eastern United States, the rainfall distribution for the 24-hour duration PMP storm is not the same "critically stacked" rainfall distribution obtained using HMR-52, as it does not include critically stacking shorter duration rainfalls within the peak 6-hour rainfall. The NRCS approach to constructing the 24-hour storm is to critically stack incremental rainfall amounts of successive 6-, 12- and 24-hour durations, but distributing each 6-hour PMP depth uniformly over each six-hour period. This distribution is referred to by the NRCS as the 5-point storm distribution. The aforementioned 24-hour rainfall distribution was adopted primarily for checking the integrity of the auxiliary spillway since it produces a greater runoff volume and longer spillway flows as compared to the 6-hour PMP storm.

A comprehensive discussion of temporal rainfall distributions for near PMP storm events for design of NRCS dams is presented in a paper by James N. Moore et al. (2001). Based on an evaluation 72 NRCS dams, use of the 24-hour 5-point rainfall distribution would require 54 percent of the dam heights to increase with 61 percent within plus or minus one foot of the 6-hour design criteria. The HMR-52 rainfall distribution would require 97 percent of the dam heights to increase with 47 percent within plus or minus one foot of the 6-hour design criteria.

Montana and Washington have developed regional precipitation-frequency analyses to determine the return period of extreme events [Fischer & Lemieux, 2010; MGS Engineering Consultants, Inc., 2009]. Nebraska has had a site-specific PMP study performed for the entire state which resulted in PMP reductions ranging from 3 to 56 percent [Applied Weather Associates, 2008].

The majority of states do not provide guidance regarding the spatial distribution of a storm. The few states that do include it in their guidelines indicate that spatial distribution should only be used in cases where the drainage area is greater than 10 square miles.

9.6. Antecedent Moisture Conditions and Initial Reservoir Pool Levels

In developing the SDF and designing the dam, initial assumptions such as antecedent moisture conditions (AMC) and the initial reservoir pool level can have a significant impact on the results. Twenty-nine of the forty-nine states (59%) surveyed do not specify or provide direction regarding either of these variables in their guidelines. Of the states that do specify antecedent moisture conditions, most use either SCS AMC-II or AMC-III criteria. Several states also have specific directives regarding the consideration of snowmelt and frozen ground conditions.

For initial reservoir pool level criteria, most states specify that normal water surface elevation be used as an initial routing condition. Others specify similar criteria such as the “lowest uncontrolled spillway inlet” or “at the crest of the spillway for permanent water storage.”

9.7. Freeboard Requirements

For a PMP/PMF design, 37% of the surveyed states do not require freeboard above the peak PMP/PMF reservoir level. The remaining states use many varying criteria based on dam type, wave run-up calculations, dam size or hazard classification, and case-by-case evaluations. The following comments from survey respondents illustrate several of these varying criteria:

- Oklahoma – “Minimum freeboard varies from 1 to 3 feet based on both hazard and size classification.”

- Illinois – Freeboard is determined on a "case-by-case basis considering many factors including duration of high water levels during the design flood, the effective wind fetch and reservoir depth available to support wave generation, the probability of high wind speed occurring from a critical direction, the potential wave run up based on roughness and slope, and the ability of the dam to resist erosion from overtopping waves."
- Iowa – "For dams with emergency spillways, the top of dam elevation after settlement shall not be less than the highest peak pool elevation reached during the freeboard design flood. For dams without an emergency spillway, the top of dam elevation shall be 2 feet higher than the peak flood elevation expected to occur during passage of the freeboard design flood, unless it is specifically designed to withstand the overflow."
- Nevada – "'Rule of thumb' is 3 feet. Wave run up calculations are preferred and required if the owner is requesting a smaller freeboard. Exceptions are tailings facilities for deposition (beach) side embankments and Storm Water detention facilities."
- Colorado – "The minimum freeboard requirements for new or enlarged dams shall be based upon the dam height required to prevent overtopping by wave action, or the sum of the IDF maximum water surface level plus 1 foot of residual freeboard, but not less than 5 feet unless the State Engineer approves a lesser amount. Except for concrete dams where the design engineer has demonstrated that overtopping of the dam will not be detrimental to the safety of the dam, the IDF can be accommodated with zero residual freeboard or the overtopping depth at which the dam still meets the stability and stress requirements of Rule 5.9.5."
- Georgia – Based on wave run up computations with a "3-foot maximum."
- New York – "One foot minimum for small dam, 2 foot minimum for large dam."

This sampling of criteria as well as the large percentage of states that do not require freeboard demonstrates the variation that exists in current freeboard criteria. It is also apparent that there is a significant variation in the level of detail required for freeboard analysis among the states.

9.8. Applicable Methodologies and Software

The majority of state agencies will allow the use of any analysis methodologies, procedures, or computer software as long as results are verifiable and applied using good engineering practice. There are, however, several states which stipulate a specific methodology (i.e. using HMRs to develop the PMP) or approved computer software (i.e. HEC applications, NWS DAMBRK, SITES, etc.). The states of Mississippi, New York, and Pennsylvania specifically do not allow the use of the rational method in any case.

9.9. Provisions for Future Development

One common issue faced by regulatory agencies is development both upstream and downstream of existing dams. Development within a watershed can cause increased runoff and peak inflows higher than those used to design a dam. In some cases, development extends into the flood pool of a structure which poses a risk to those developments.

The development of an area downstream of a dam often causes a condition called "hazard creep." Low or significant hazard dams which are oftentimes built in rural areas are reclassified as high hazard dams due to development that occurs after construction of the dam. These reclassified dams are then subject to increasingly conservative design standards and usually need to be upgraded to pass flood events of a greater magnitude.

Figure 9.8 illustrates the percentage of states that specifically require consideration of future development when determining the SDF. Note that 22 states (45%) do not require the designer to consider upstream or downstream development when designing a dam, and only 6 states (12%) require the consideration of development upstream of the dam. Sixty-nine percent of states surveyed felt that hazard creep due to development was a problem, though only twelve percent considered it a major problem.

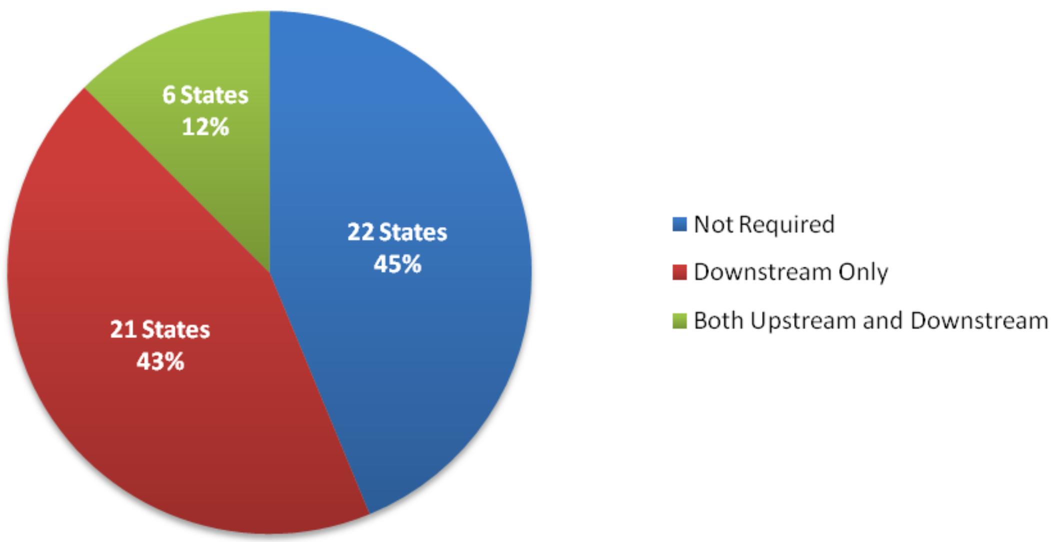


Figure 9.8 Consideration of Future Development for Spillway Design Flood Criteria

In Illinois, Delaware, and New Jersey, all Low and Significant Hazard dams must incorporate alternatives in the proposed design for increasing the total spillway capacity if the downstream hazard potential increases. Future downstream land use, land use controls, and growth projections are considered in the review of the spillway capacity design.

9.10. Early Warning Systems

When asked if an early warning system would be considered as an alternative to designing a high hazard dam for the regulatory SDF, the majority of states indicated that such an alternative would not be acceptable. Many noted that a safe design should be passive and not require significant maintenance or operation. Of the 10 states that would consider this as a viable alternative, most required significant justification and additional protective measures to be included with the early warning system. Most of these agencies would only consider this as an alternative for existing dams or as a temporary solution until structural modifications are made.

In 1995, Dubler asked state dam safety officials a similar question and found that about 15 states would allow the use of an early warning system on a case-by-case basis. This indicates a slight trend away from the use of these systems over the past 15 years.

9.11. Incremental Damage Analysis

As described in Chapter 3, incremental damage analysis is a comparative hazard approach that creates a compromise between the desire to provide a risk-based analysis of the benefits gained from mitigating the hazard and the traditional approach of requiring a design capable of safely passing the PMF. Of the responding states, 67% indicated that they allow the use of incremental damage analysis to establish the SDF (See Figure 9.9). A few allowed this type of analysis only in evaluating existing dams. Of those who allow incremental damage analysis, less than half require that future downstream conditions within the dam failure inundation zone be considered in the incremental damage analysis.

It is interesting to note that in the survey performed in 2003 by Paxson and Harrison, 88% of survey participants responded that their state would allow incremental damage analysis as opposed to 65% in 2011. The reason for this discrepancy is unknown; however, the 2011 response seems to correspond more closely to Dubler's 1995 survey in which 59% of respondents indicated that incremental damage analysis was utilized. In any case, it appears that the use of incremental damage analyses has become more common in the past decade.

Since incremental damage analysis is typically used to decrease the SDF, some states place a minimum limit on the SDF regardless of downstream consequences. Eighteen states indicated that they have restrictions or guidelines on the use of incremental damage assessments or risk analyses. Table 9-4 summarizes most of these criteria.

While most states perform incremental damage analysis in the downstream dam failure inundation zone to establish the magnitude of the SDF, some have also applied the concept to the mitigation of flooding due to spillway discharge. This would apply in situations where gate operators or fuse plugs provide the dam owner some control over spillway discharge. In Arizona, spillways are required to be constructed in a manner that avoids flooding in excess of that which would have occurred under the same conditions before construction. Other states have expressed similar interest in regulating flooding due to spillway discharge.

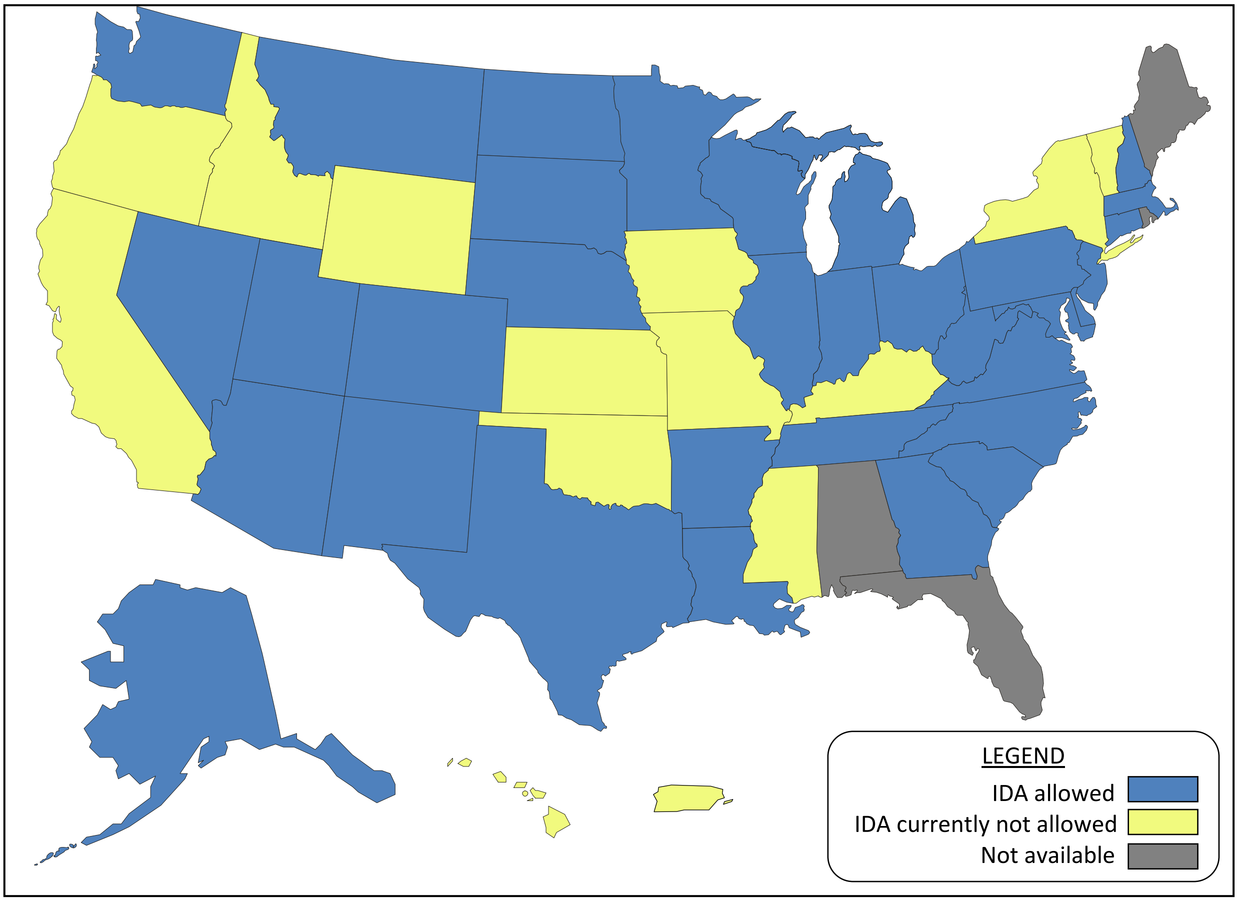


Figure 9.9 Use of Incremental Damage Analysis in the United States and Puerto Rico

Table 9-4 Minimum Design Event when Incremental Damage Analysis is Applied

Criteria	States Using this Criteria
Minimum SDF: 100-year flood (High and Significant Hazards); 50-year Flood (Low Hazard)	VA
Minimum SDF: 100-year frequency flood or storm event	AK, CO, DE, IL, NC, NJ, NM, NV, PA, SD, UT
Minimum SDF: 200-year flood or flood of record, whichever is greater	MI
Minimum SDF: 40% PMF (High Hazard); 20% PMF (Significant Hazard); 100-year flood (Low Hazard)	OH
Minimum SDF: 50% PMP (High Hazard); 100-year flood (Low Hazard)	IN
Minimum SDF: 70% PMP (High Hazard); 25% PMP (Significant Hazard); P100 (Low Hazard)	WV
SDF can only be reduced by up to 10%	GA

9.12. Provisions for Developing Site Specific PMP

The practice of developing a site specific PMP for a dam design is allowed in 32 states (65%). It is restricted in 6 states (12%). Permission to perform a site specific study in the remaining 11 states (22%) has never been requested (See Figure 9.10). It is important to note that of the 32 states allowing site specific PMP studies, more than half (17 states) have no guidelines, requirements, or restrictions regarding this practice.

Those that do have guidelines, requirements, or restrictions utilize a variety of criteria. Several states require a site specific design to pass through special levels of review or even be overseen by a board of consultants. Mississippi will only consider a site specific study if the drainage area is greater than 10 square miles. New Jersey only allows the use of site specific PMP's for existing structures. Colorado has a completely separate requirements matrix for site specific analyses. Using this guideline, a dam is required to pass a higher percentage of the site specific PMP/PMF than is required if the SDF has been developed following the HMR approach.

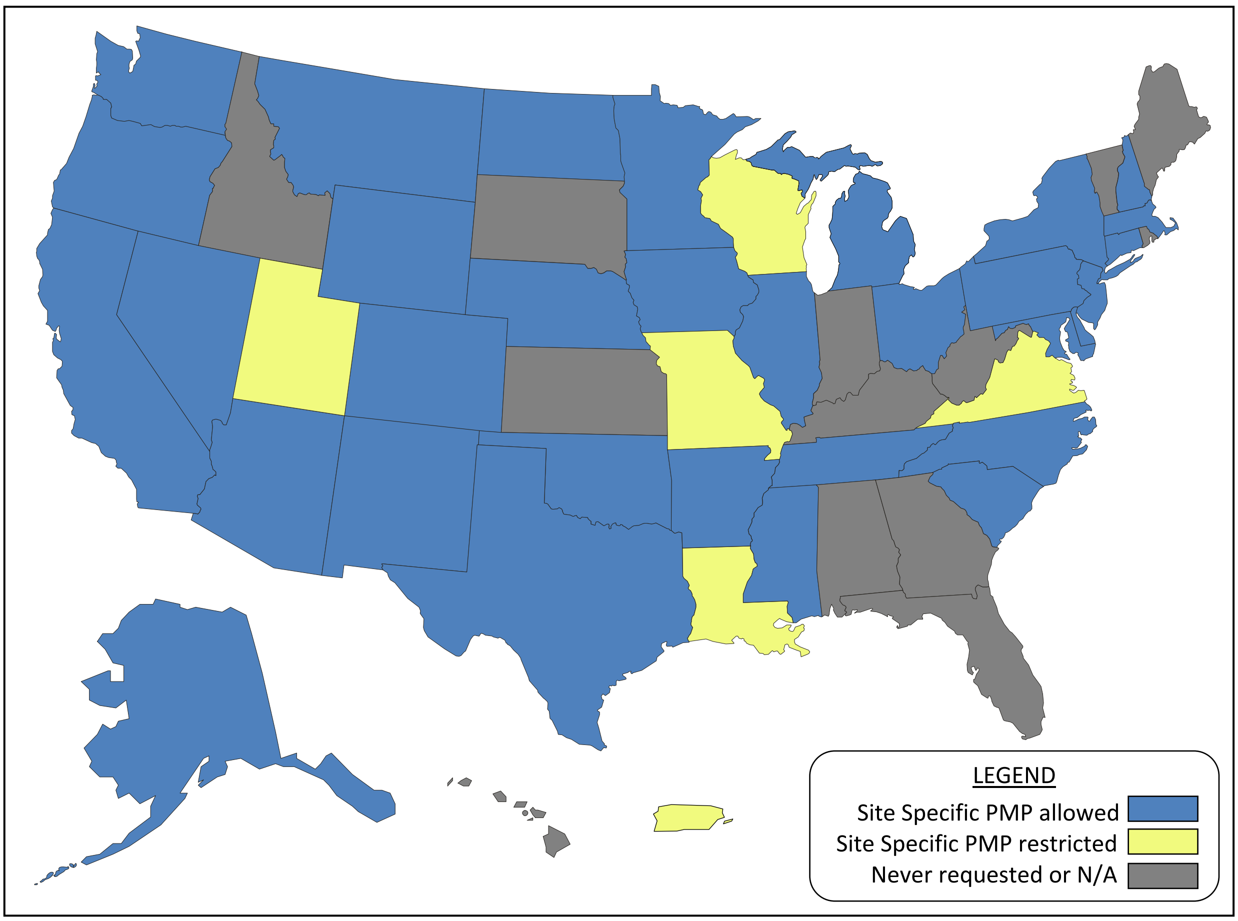


Figure 9.10 Use of Site Specific PMP Studies in the United States and Puerto Rico

9.13. Risk-based Criteria

Within the 1988 report published by ASCE, the Task Committee on Spillway Design Flood Selection concluded that the only standard which "could be applied consistently both today and in the future would be a selection based upon a site-specific evaluation of the likelihood of failure and the social, economic, and environmental consequences of failure – a quantitative risk assessment. A quantitative risk assessment provides the decision maker at each level of the decision making process – the engineer, the dam owner, and the regulator – with the information needed to select a safety design flood" [ASCE, 1988]. States tend to look toward the federal agencies to initiate changes in regulations, and the majority of federal agencies have made policy shifts toward the use of risk analysis (See Chapter 8). The level of acceptance continues to be greatly varied. It appears that the Bureau of Reclamation has fully embraced the use of quantitative risk analysis for the hydrologic design of dams. Several other state and federal agencies are taking a more gradual approach to adopting risk-based designs. In these agencies, the use of incremental damage analysis is a common way to introduce components of risk analysis into design criteria. It should be noted that the establishment of any guidelines introduces some sort of risk assessment. States that currently base dam design standards on size or hazard classification systems are effectively performing very generalized and informal risk analysis.

9.13.1. Current Use of Risk-based Criteria by the States

Of the 49 states surveyed, 15 (31%) indicated that they permit or review risk-based designs. Seven states (14%) indicated that risk-based designs are either forbidden by regulation or will not be considered due to administrative decision. The remaining 27 states (55%) indicated that their regulations do not specifically address the topic of risk analysis and it has never come up for consideration.

The same question regarding risk-based hydrologic designs was asked in Dubler's survey. In 1995, 43% indicated that they either permitted or reviewed risk-based designs on a case-by-case basis. The 2003 survey by Paxson and Harrison also indicated that 43% of states would allow the use of risk-based analysis. This decrease indicates that over the past decade, a number of states have stopped allowing the use of risk analysis. Chapter 10 provides a discussion of several trends which may have caused this reduction in the allowance of risk analysis.

In contrast to the current trend, a few states have dedicated significant resources over the past 30 years to develop risk-based design criteria for dams. Generally speaking, these risk-based guidelines do not comprise rigorous or quantitative risk analysis. Rather, they incorporate both principles of risk with some sort of hazard classification or consequence rating system. The design flood in a risk-based system is often determined using a sliding scale between a lower threshold flood event and the maximum theoretical event. California, Washington, and Montana each have unique risk-based criteria for the hydrologic design of dams.

9.13.2. California

In 1981, the State of California became the first state to adopt a risk-based methodology that could be applied to any spillway in the state [Calzascia & Fitzpatrick, 1987]. One challenge of devising such a method is that it must be able to be applied both rationally and consistently across a broad range of dam types and sizes. Under this methodology, a dam's hazard classification is determined by considering reservoir capacity, dam height, estimated number of people evacuated in anticipation of failure, and potential downstream damage.

> *"Each factor is categorized as low, moderate, high or extreme. The method produces a composite numerical rating termed the Total Class Weight (TCW)… With this system, small remote dams generally have a TCW of 2, while large urban dams might have a TCW of 36. The capacity of the reservoir and height of the dam are clearly defined. Estimated evacuation and potential downstream damage are uncertain and require an investigation of the potentially flooded area. This investigation includes estimating the population at risk, the possible loss of life, the physical property damage, the social consequences and the environmental impact. Through application to the many dams under its jurisdiction, [California's Division of Safety of Dams] has developed a coherent and uniform approach to conducting the damage investigations so that consistent total class weights are found"* [Calzascia & Fitzpatrick, 1987].

Figure 9.11 illustrates the weighting system used in California to determine the TCW. California considers the TCW criteria as an adequate assessment of risk; therefore, they do not allow the use of quantitative risk analysis. Once the TCW has been determined, the appropriate design storm is selected.

> *"The minimum allowable design event required is a 1000 year storm which corresponds with a TCW of 4. The maximum event is a storm derived from the Probable Maximum Precipitation and is equated with a TCW of 30. The design event is interpolated between these limits at the computed TCW"* [Calzascia & Fitzpatrick, 1987].

By applying these risk-based criteria, less than 8% of California's dams are required to pass the full PMF [Calzascia & Fitzpatrick, 1987].

DAMAGE POTENTIAL CLASSIFICATION FOR

FLOOD ESTIMATE AND SPILLWAY ANALYSIS

Name of Dam ____________________ Type of Dam _______________Dam No. ___________

County _________________________ Located on ____________________________________

Damage Potential Rating

	Extreme	High	Moderate	Low
Capacity ___________ AF	100,000 & Over	1,000-99,999	100-999	15-99
(circle weight)	6	4	2	0
Height _____________ Ft.	150 & Over	100-149	50-99	6-49
(circle weight)	6	4	2	0
Estimated Evacuation ______	1,000 & Over	100-999	1-99	None
(circle weight)	12	8	4	0
Potential D/S Damage	High	Moderate	Low	None
(circle weight)	12	8	4	0

Total Class Weight _________

Figure 9.11 Total Class Weight and Hazard Potential Classification in California [Calzascia & Fitzpatrick, 1987]

9.13.3. Washington

In 1990, Washington State adopted an approach to dam safety that "can be characterized as employing risk concepts in a standards-based framework" [Johnson, 2000]. The state's approach utilizes what it calls the "Design Step Format." Under this format, a range of failure consequences are divided into 8 steps. For Design Step 1, the annual exceedance probability of the design event is 1 in 500. This step would apply "when the downstream consequences of a dam failure would be minimal and there would be no potential for loss of life" [Washington State Department of Ecology, 1993]. In situations where the consequences of failure would be "catastrophic," the theoretical maximum design event (PMP/PMF) is applied under Design Step 8. This maximum theoretical event is assumed to have an annual exceedance probability of 10^{-6}. In order to utilize probability-based hydrologic events, Washington has performed regional precipitation-frequency analyses to determine the return period of extreme events.

Table 9-5 outlines the range of consequence rating points assigned to several hazard indicating parameters. Using a cumulative total of consequence rating points, the designer can determine both the design step and the required annual exceedance probability for design as shown in Figure 9.12. This annual exceedance probability will apply to all aspects of the dam design (hydrologic, seismic, etc.) in an effort to provide "balanced protection." Table 9-6 relates the Washington State's design step criteria to typical downstream hazard classifications.

By adopting this approach to dam safety, the state has been able to apply risk concepts in a format that is fairly simple and easy to use. A similar ranking system has been applied to evaluate existing dams, thus allowing a prioritization of compliance efforts. "Of the 46 dams inspected under the National Dam Inspection Program still listed as unsafe in 1990, 40 had been repaired by 1999 [under this standard]. In addition, 78 of the 101 additional dams identified by the state dam safety program since 1985 have been repaired" [Johnson, 2000].

Table 9-5 Numerical Rating Format for Additive Weighting Scheme for Assessing Consequences of Dam Failure [Adapted from Washington Department of Ecology, 1993]

Consequence Categories	Consequence Rating Points	Indicator Parameter	Considerations
CAPITAL VALUE OF PROJECT	0 – 150	DAM HEIGHT	Capital Value of Dam
	0 – 75	PROJECT BENEFITS	Revenue Generation or Value of Reservoir Contents
POTENTIAL FOR LOSS OF LIFE	0 – 75	CATASTROPHIC INDEX	Ratio of Dam Breach Peak Discharge to 100-Year Flood
	0 – 300	POPULATION AT RISK	Population at Risk Potential for Future Development
	0 – 100	ADEQUACY OF WARNING	Likely Adequacy of Warning in Event of Dam Failure
POTENTIAL FOR PROPERTY DAMAGE	0 – 250	ITEMS DAMAGED OR SERVICES DISRUPTED	Residential and Commercial Property Roads, Bridges, Transportation Facilities Lifeline Facilities Community Services Environmental Degradation from Reservoir Contents (Tailings/Wastes/etc.)

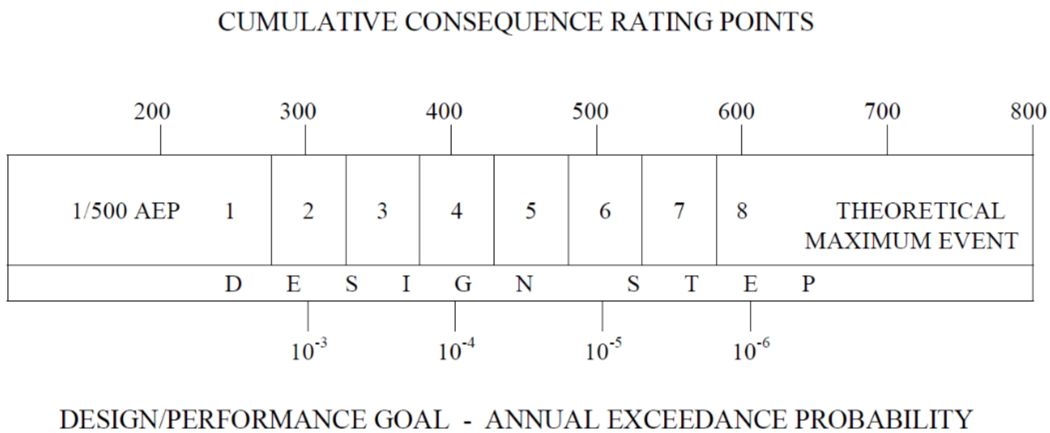


Figure 9.12 Design Step Format and Consequence Rating Points [Washington Department of Ecology, 1993]

Table 9-6 Relationship of Design Step to Downstream Hazard Classification [Adapted from Washington Department of Ecology, 1993]

Downstream Hazard Potential	Downstream Hazard Classification	Population at Risk	Economic Loss	Environmental Damages	Typical Design Step
LOW	3	0	Minimal: No inhabited structures; Limited agriculture development.	No deleterious materials in reservoir	1 – 2
SIGNIFICANT	2	1 to 6	Appreciable: 1 or 2 inhabited structures; Notable agriculture or work sites; Secondary highway and/or rail lines.	Limited water quality: Degradation from reservoir contents and only short term consequences	3 – 4
HIGH	1C	7 to 30	Major: 3 to 10 inhabited structures; Low density suburban area with some industry and work sites; Primary highways and rail lines.	Severe water quality: Degradation potential from reservoir contents and long term effects on aquatic and human life	3 – 6
HIGH	1B	31 to 300	Extreme: 11 to 100 inhabited structures; Medium density suburban or urban area with associated industry; property and transportation features.		4 – 8
HIGH	1A	More than 300	Extreme: More than 100 inhabited structures; Highly developed, densely populated suburban or urban area with associated industry, property, transportation, and community life line features.		8

9.13.4. Montana

Prior to 1999, Montana's Dam Safety Rules established spillway design criteria based on dam height and storage. After recognizing that the required spillway capacity was disproportionate to the level of downstream development, the state developed new hydrologic design criteria based upon estimated loss of life (LOL). Similar to Washington State, Montana has performed regional precipitation-frequency analyses to determine the return period of precipitation events having recurrence intervals up to 5,000 years [Fischer & Lemieux, 2010].

LOL estimates are obtained by considering three factors: 1) PAR or population occupying the area inundated by a dam failure flood, 2) the warning time given to PAR exposed to the resultant flood wave, and 3) the severity of the flood. In general, LOL is significantly less than PAR. The Montana DCNR publication titled "Technical Note 2, Loss of Life Determination for Spillway Capacity Analysis" describes in detail how to calculate LOL.

> *"If the estimated LOL is equal to or less than 0.5, the minimum IDF is the 500-year recurrence interval… If the LOL is greater than 0.5 and less than or equal to 5, the minimum IDF recurrence interval is determined by multiplying the LOL by 1,000* (i.e. a dam with estimated LOL of 2 would be required to pass the 2,000-year flood event)*… If the LOL is greater than 5 and less than 1,000, the precipitation depth for determining the IDF is calculated with equations that effectively interpolate between depths for the 5,000-year storm and the PMP... The IDF for an LOL greater than or equal to 1,000 is the probable maximum flood, or PMF. The PMF is runoff produced by the PMP"* [Hydrometrics, Inc., 2008].

Montana's SDF determination process is illustrated by a flowchart in Figure 9.13.

9.13.5. Inconsistencies with Current Risk-Based Criteria

Within the past few decades, the use of risk analysis and risk-based design criteria has increased. The methodologies developed by California, Washington, and Montana reflect a growing desire for site-specific, cost-effective, and risk-based designs. They also demonstrate how the complexities of risk analysis can be applied in a simplified, standard-based system. Due to a lack of resources and staff in many state dam safety offices, such simplification would likely be necessary if broad application were to be successful. There is also a general lack of region-specific precipitation-frequency analyses, thus making it difficult for states desiring to adopt risk-based criteria to assign annual exceedance probabilities to extreme events.

Perhaps the most apparent observation regarding these recently developed, risk-based approaches is the lack of both consistency between the states as well as defensible risk tolerance criteria. California's weighting criteria are based entirely on the storage volume and height of the dam, the estimated evacuation, and potential downstream damage. Washington's consequence rating points are determined based on similar criteria (capital value of project, potential for loss of life, potential for property damage); however, in Washington's system, loss of life accounts for 50% of the entire design weight while it accounts for only 33% of the total weight in California. Montana alternatively bases the design entirely (100%) on potential loss of life and completely disregards the value or size of the project as well as potential property damage due to dam failure.

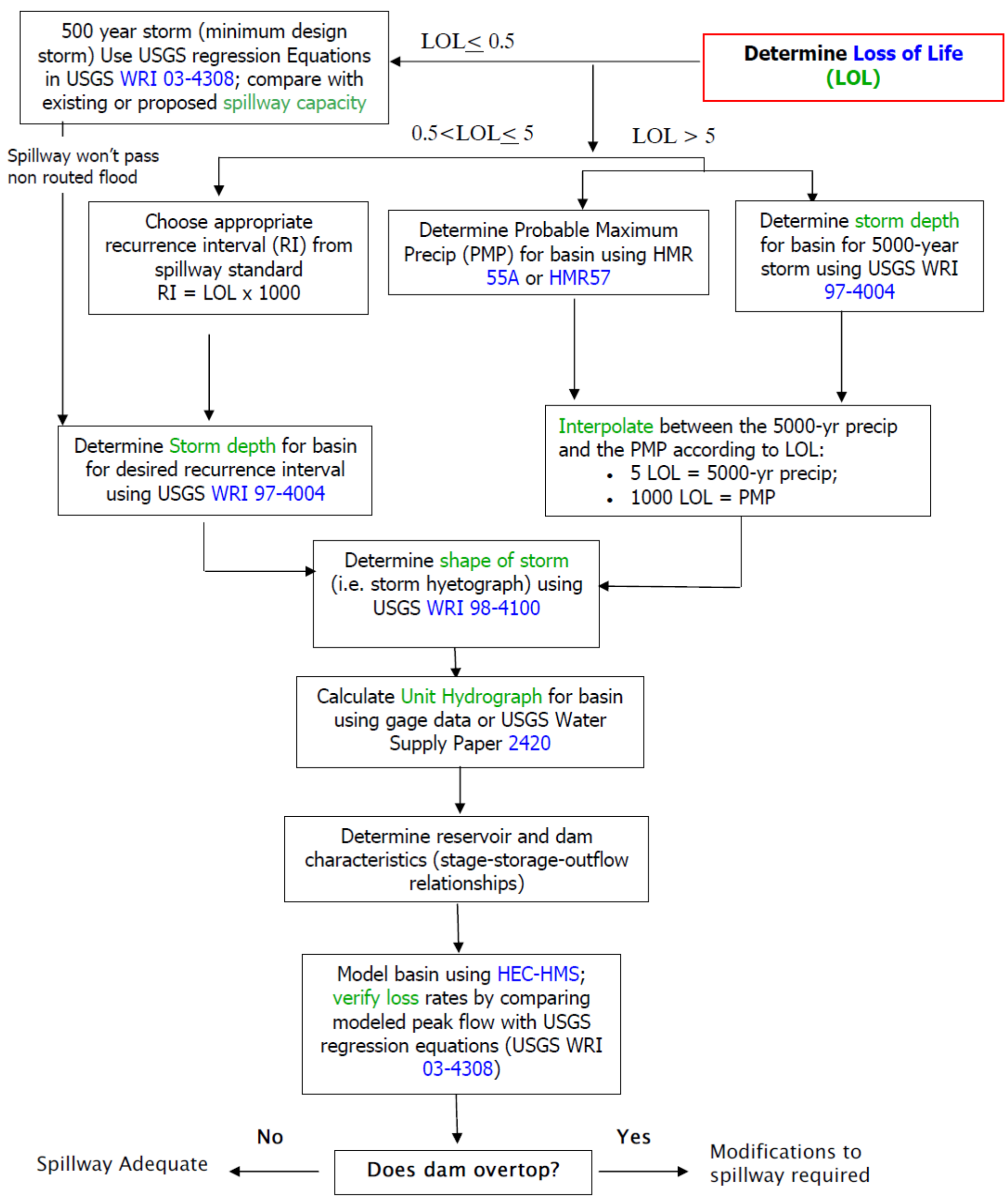


Figure 9.13 Procedure for Determining Spillway Adequacy [Montana DNRC, 2008]

Also inconsistent in the states' approaches are the probabilities of spillway design events required. In California, the minimum SDF is the 1,000-year event while Washington and Montana both allow a minimum of the 500-year event. Even though all three indicate that the PMP/PMF is the maximum event, the different weighting systems, loss of life determination, and other varying criteria could introduce significant deviation in spillway capacity requirements from one state to another.

It may be that risk-based criteria have been structured to meet the perceived needs or societal demands of the issuing agency or state. However, it is also possible that these differences are the result of somewhat subjective choices made by regulatory authorities. In either case, the considerable variety in risk-based criteria will complicate any precise comparisons between criteria used by different agencies. It will also result in a variation or imbalance of risk tolerances with regards to dam safety throughout the country.

9.14. Agency Review

The role of state dam safety agencies in determining the SDF varies from state to state. Only 8 of the 49 state agencies perform an independent verification of all submitted designs. An additional 15 agencies perform both limited detail reviews and in depth verifications as they deem fit (case-by-case basis). Most other agencies perform reviews of the hydrologic design, but do not verify the design independently. A few agencies also act as the designer/engineer for work done on state-owned dams.

10. Receptiveness of States to Changing Guidelines

10.1. The Need for Uniformity

There are many differing opinions regarding the need for uniformity of design criteria between states and federal agencies. It is generally recognized that the implementation of strictly uniform criteria is not a possibility. A flexible framework of criteria would be required to provide for the specific requirements, budget, and technical ability of each state. The NRC Committee's critique of the state-of-the-practice summarizes this issue in the following:

> *"The goal of dam safety is to limit the risks from dam failures to acceptable levels. Probability of failure is controlled partly by design standards and partly by quality of design, construction, inspection, operation, and maintenance. Ideally, hazard failure probability, and acceptable damage would be quantified for the site-specific conditions of each individual existing or proposed dam in order to establish site-specific standards for achieving this goal. With few exceptions, current practices do not involve quantification of these three critical elements for each dam.*
>
> *"Instead, the most widespread current practice is to classify dams in three broad, not well-defined, qualitative damage potential categories (i.e. high, intermediate, and low hazard) and to somewhat arbitrarily assign one of three or four grades or ranges of design standards to each dam depending on its height, storage capacity, and qualitative hazard rating. Current practice treats all of the elements needed for selecting design standards in a generalized way; thus, the appropriateness of the design standards as applied to individual dams is generally unknown.*
>
> *"In defense of this current general practice, it must be recognized that most of the scores of federal and state regulatory agencies each have hundreds to thousands of dams under their jurisdictions. Given their limited resources, as a practical matter, they must use a generalized system of assigning design standards according to generalized hazard and size classifications, at least as an interim step until more detailed site-specific studies can be made. However, the wide range of hazard versus size versus design standards among various agencies reflects a lack of uniformity even within the generalized current practice.*
>
> *"This lack of uniformity in dam classification and safety design standards appears to result from three main factors: (1) lack of interagency and intergovernmental communication, (2) variations in engineering judgment in selecting the generalized standards, and (3) variations in public policy attitudes at the times the standards were selected. In any case, a critique of present practices must point out that, though a generalized approach to selecting design standards is justified as a practical interim step, there is a need for more uniformity among the various federal and state agencies in establishing size and hazard definitions and correlative design standards"* [NRC, 1985].

10.2. Awareness of Existing Federal Guidelines

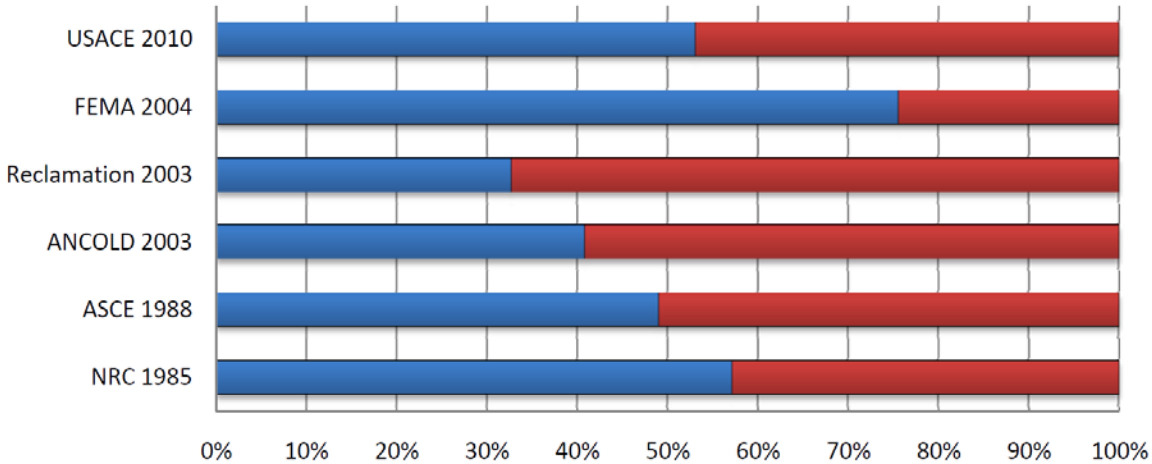
As noted in Section 9.1, the majority of states adopted guidelines or regulations regarding the SDF in the 1970s and 1980s. Since then, each state dam safety agency has had varying degrees of success in updating these guidelines. Some states have recently revised their guidelines or maintain a continuous process of revision and are very aware of current research and recommendations regarding dam safety. Other agencies which are under-staffed or under-funded have limited time to give to such activities. As part of the survey, all agency representatives were asked if they were aware of several documents published on the federal and international levels regarding spillway design criteria. These documents are as follows:

1. Safety of Dams: Policy and Procedures (ER 1110-2-1156), *Draft Version* – U.S. Army Corps of Engineers [USACE, 2010]
2. Federal Guidelines for Dam Safety – Selecting and Accommodating Inflow Design Floods for Dams – Federal Emergency Management Agency [FEMA, 2004]
3. Guidelines for Achieving Public Protection in Dam Safety Decision-making - U.S. Bureau of Reclamation [Reclamation, 2003]
4. Guidelines on Selection of Acceptable Flood Capacity for Dam & Guidelines on Risk Assessment – Australian National Committee on Large Dams [ANCOLD, 2000 & 2003]
5. Evaluation Procedures of Hydrologic Safety of Dams – Prepared by the Task Committee on Spillway Design Flood Selection of the Committee on Surface Water Hydrology of the Hydraulics Division of the American Society of Civil Engineers [ASCE, 1988]
6. Safety of Dams: Flood and Earthquake Criteria – Prepared by the Committee on Safety Criteria for Dams, National Research Council [NRC, 1985]

The results are shown in Figure 10.1 and indicate that a significant portion of the dam safety community is unaware of current and even long-standing publications regarding the hydrologic safety of dams. A quarter of respondents were unaware of FEMA’s federal guidelines for inflow design. It is apparent that any attempt to encourage the adoption of more uniform guidelines would require a significant outreach and educational effort on the part of FEMA.

10.3. Perception of PMP and PMF Criteria

When asked if they thought that designing for the PMP/PMF is unreasonably conservative, 31% of the respondents agreed. Fifty-one percent indicated that the PMP/PMF is a reasonable design criterion. The remaining 18% were either neutral or undecided (See Figure 10.2). This is interesting when considering that about half of the states require a full PMP/PMF design for high hazard structures, and in over 80% of the states, the SDF range extends up to the full PMP/PMF. It is also interesting to note that in Dubler’s 1995 survey, only 17% of the states agreed that the PMP/PMF was unreasonably conservative, and none of those respondents strongly agreed. Conversely, 76% of states indicated in the 1995 survey that the PMP/PMF was a reasonable design criterion (59% indicated strongly disagreeing that the PMP/PMF was unreasonable).



	NRC 1985	ASCE 1988	ANCOLD 2003	Reclamation 2003	FEMA 2004	USACE 2010
Aware	57%	49%	41%	33%	76%	53%
Unaware	43%	51%	59%	67%	24%	47%

Figure 10.1 Awareness of Previously Published Spillway Design Guidelines

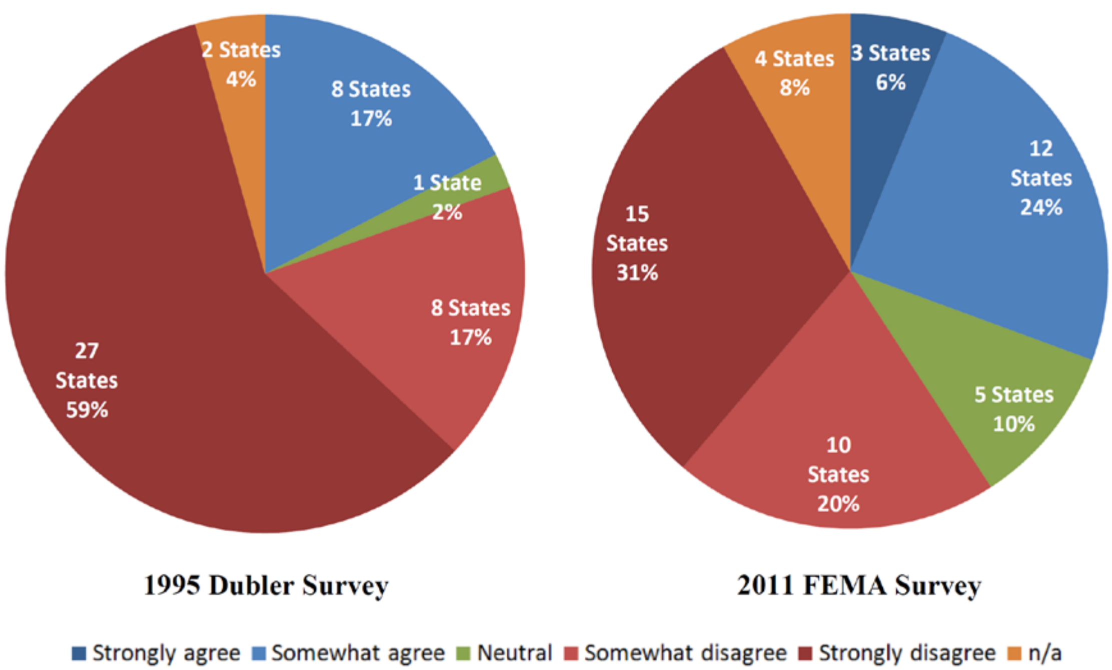


Figure 10.2 Do you agree that designing for the PMF is unreasonably conservative?

While these opinions indicate that a slight majority of the professional community supports design for the PMP/PMF, it also indicates that existing guidelines and spillway design criteria do not align with the current views of all dam safety professionals. Over the past 15 years, support for the PMP/PMF design in general appears to have diminished.

10.4. Concerns Regarding Consistency of Hydrologic Analyses

Many different design methods and models are currently used by dam designers. Twenty-six of the states indicated that they have concerns regarding the consistency of hydrologic and hydraulic analyses. Many of these concerns seem to stem from a general lack of training and experience of consultants as well as varying levels of detail given to the analyses. The variability of inputs into models, the various models used, and the inherent uncertainty in the computational methods and data are common sources of variability in analysis results.

10.5. Perception and Concerns Regarding Risk-Based Criteria

While leading federal agencies and a few states have transitioned from strictly prescriptive to risk-based criteria, it is evident that a large portion of the dam safety community doubts the validity and practicality of risk analysis. Fifty-one percent of respondents indicated that they have concerns regarding either the use of risk analyses or incremental damage analysis to determine spillway capacity requirements. Respondents indicated a number of concerns with these approaches to spillway design including the following:

- The complexity of risk analysis makes it expensive and time consuming to either perform or review.
- There is a general lack of minimum design criteria available. Current methodologies are still under development and are neither mature nor proven.
- Risk-based analyses lack consistency.
- Any argument can be justified using risk analysis if data are selectively analyzed and evaluated.
- There are currently no clear or acceptable guidelines for evaluating incremental damage.
- Many dam safety personnel lack training necessary to perform or review such designs.
- Risk analysis is too subjective and could be problematic over time with new development downstream of a dam.
- Risk analysis does not adequately address the worth of human life. “The potential adverse effects of a dam failure make ‘allowing’ a risk threshold somewhat unsettling both morally and politically.”
- Results of such a design may not be defensible during a lawsuit.

Figure 10.3 illustrates the current opinions of state dam safety officials regarding risk analysis, its usefulness, and constraints. This figure also shows the responses to the same survey questions as

Figure 10.3 Opinions regarding risk analysis: 1995 vs. 2011

collected by Dubler in 1995. While there are significant differences of opinions regarding the complexity of risk analysis as well as the litigious nature of society and its implications for dam design, the overall views of state dam safety officials appear to be very similar to those found in the 1995 survey. The past 15 years have seen little change in opinion regarding risk-based analysis for the hydrologic safety of dams.

10.6. Technical Ability and Availability of Staff to Implement and Enforce Guidelines

The training and resources available to state dam safety agencies oftentimes determines the level of enforcement of dam safety guidelines. This also impacts an agency's ability to implement state-of-the-art practices in their state. Survey respondents were asked if they felt their agency and personnel had the resources (availability and budget) and technical ability to review several more recent advances that relate to the hydrologic safety of dams (See Table 10-1). The majority of agencies felt that they lacked both the technical ability and resources to review rigorous risk analyses. With regard to site specific PMP studies, a majority believed they had the technical ability required but lacked the necessary resources. The majority of states have the necessary resources and training to review incremental damage analyses. There are significant percentages of state regulatory agencies which feel they lack both the training and the resources required to review these state-of-the-art practices.

Table 10-1 Resources and Technical Ability of State Dam Safety Agencies

		Site Specific PMP	Incremental Damage Analysis	Rigorous Risk Analysis
Technical Ability	*Yes*	59%	78%	31%
	No	41%	22%	69%
Availability and Budget	*Yes*	41%	57%	22%
	No	59%	43%	78%

10.7. Overall Receptiveness and Obstacles to Changing Existing Guidelines

Fifty-seven percent of the surveyed states believe that increased uniformity in state dam safety guidelines across the country would be beneficial; thirty-nine percent believed that increased uniformity would not be beneficial; and four percent did not respond to this question. Many indicated that it would be difficult to implement uniformity of the guidelines without eliminating many necessary regional distinctions that are currently in place. A solution would be to provide a uniform framework of guidelines that also provides for the specific requirements, budget, and technical ability of each state.

In general, dam safety officials were more receptive to adopting new recommended guidelines if they resulted in lower SDF criteria as opposed to higher SDF criteria. When asked how difficult it would be to change current regulations, the majority of states responded that it would be difficult. All others indicated a moderate level of difficulty. For many, such changes are expensive and time consuming, often extending over a period of years. Several respondents indicated that the current partisan political climate would also cause difficulty in changing regulations.

Many state representatives indicated that before the states attempt to standardize their guidelines, the major federal agencies who have traditionally led the effort to develop acceptable dam safety standards need to come to agreement. If these federal players could agree on basic items such as condition assessment, spillway standards, and risk determination, then the states would certainly be more receptive to adopting similar criteria.

11. The Current State of the Practice

11.1. Summary

This document, the “Summary of Existing Guidelines for the Hydrologic Safety of Dams,” is the first of two documents commissioned by FEMA related to the Hydrologic Safety of Dams. The purpose of this document is to compile available data and to summarize the state of the practice of evaluating the hydrologic safety of dams. The second document will be in the form of guidelines which will assist dam safety programs in evaluating the adequacy of their current hydrologic guidelines.

At the root of this study is the acknowledgement of the basic need for adequate guidelines for evaluating the hydrologic safety of dams. The inventory of United States dams is large, aging and increasing in hazard as the United States becomes more and more developed. This Summary of Existing Guidelines has traced the evolution and history of design flood practice for dams as well as the application of the methodology in formal dam safety guidelines. The existing hydrologic guidelines of many states and federal agencies were written in the 1970s or 1980s. Since that time, significant technological and analytical advances have been made along with better watershed and rainfall information that have improved the analysis of extreme floods and quantification of incremental dam failure consequences. Review of the published policy and guidelines for each state as well as the responses to the detailed survey completed as part of this study have revealed several important findings that can be used to define the current state of the practice regarding the hydrologic safety of dams.

In general, the guidelines for the hydrologic safety of dams are not consistent and vary widely from state-to-state and between federal agencies in many respects. Although some states and agencies have recently updated their guidelines, many states and agencies have not significantly changed their guidelines since their development. Some of those who have changed their guidelines have incorporated some form of risk-based analyses, but the requirements and methodology differ widely.

Some of the most notable inconsistencies in the existing guidelines relate to classification systems. From the most basic criteria for what defines a regulatory or a jurisdictional dam to whether the dam is classified by size, hazard, or not at all, there is no overwhelming majority of configurations for these classification systems. While size classification is used by many states and hazard classification is used by all states, the number of classifications and the distinctions between the classes vary. There is also no consensus on distinctions between new dams and existing dams.

In determining the magnitude of the SDF, most states follow a prescriptive approach in which the design flood is specified based upon the dam’s classification (size, hazard, or both). Both probabilistic and deterministic (based on PMP or PMF estimates) criteria are used for the prescriptive approach by the states and agencies. Many of the criteria in prescriptive approaches are arbitrary with no apparent scientific rationale [NRC, 1985], and the prescribed SDFs for identical dams in different states would have drastically varying magnitudes.

Historically, a few important federal agencies have led the way in the development of dam safety regulations and design standards, and the trend among these agencies is toward incorporating a risk-based approach rather than the prescriptive approach. In fact, USACE is currently partnering with Reclamation, FERC, and TVA to achieve a common risk management framework and guidelines. Internationally, the trend is also toward integrating risk assessment into dam safety procedures. Recent changes to guidelines in Australia and Canada have addressed risk-based approaches.

The transition to risk-based analyses in some states has also begun. The methodologies developed by California, Washington, and Montana reflect an initial movement to make site-specific, cost-effective, and risk-based designs. They also demonstrate how the complexities of risk analysis can be applied in a simplified, standard-based system. Comparison of these three recently developed, risk-based approaches indicates a lack of consistency regarding the criteria used among the systems, the weights assigned to the criteria, and the resultant risk tolerances.

Although the trend appears to be the incorporation of risk-based approaches into guidelines for the hydrologic safety of dams, there are many obstacles to widespread acceptance by state regulatory agencies. The budgets, staff availability, and technical ability of many state dam safety agencies are very limited. Many respondents indicated that they have concerns regarding risk-based analyses to determine spillway capacity requirements due to review requirements and the lack of widely acceptable and defensible guidelines.

It should also be noted that the federal agencies who have led the way in developing risk analysis procedures and tolerances are owners of a significant number of dams. These agencies have been able to utilize the prioritization and ranking aspects of risk analysis to manage their respective portfolios in addition to using quantitative risk analysis in design. The administrative processes and reviews of regulatory agencies, such as FERC, MSHA, and most of the states, differ significantly from that of dam owners like USACE and Reclamation. The application of quantitative risk analysis for dam design in regulatory agencies may be burdensome or even unnecessary. The state dam regulatory agencies of California, Washington and Montana have recently developed risk-based indices to determine acceptable flood capacity; however, none of the states use quantitative risk assessment.

There are many differing opinions regarding the need for uniformity of design criteria between states and federal agencies. It is generally recognized that the implementation of strictly uniform criteria is not a possibility. Instead, a flexible framework of criteria may be required to provide for the specific requirements, budget, and technical ability of each state. While leading federal agencies and a few states have recently transitioned from strictly prescriptive to risk-based criteria, it is evident that a large portion of the dam safety community has significant reservations concerning the validity and practicality of risk analysis. Having one set of federal dam safety standards for risk determination may help to promote the use of risk-based analysis by states and potentially encourage increased uniformity of state guidelines.

The survey responses also indicate that a significant portion of the dam safety community is unaware of current and even long-standing landmark publications regarding guidelines for the hydrologic safety of dams. A quarter of respondents were unaware of FEMA's 2004 federal guidelines for "Selecting and Accommodating Inflow Design Floods for Dams," and approximately half were not familiar with the most recently published USACE, Reclamation, and ASCE inflow design and dam safety guidelines. It is therefore apparent that any attempt to encourage the adoption of more uniform guidelines and consideration of adopting risk-based criteria will require a more effective outreach and educational effort.

Although the literature search identified several studies that provided information on state practices related to selecting inflow design floods for dams, none of the studies provided a comprehensive compilation of this data. In addition to providing background information for developing new federal guidelines for the hydrologic safety of dams, this report and the associated database provide a comprehensive compilation of current federal and state guidelines that can be used by individual states to evaluate and compare their current guidelines with those of other agencies. As individual states revise their guidelines, this information will provide them with important information that will help them to make informed decisions that should result in more uniformity.

Appendix A. Glossary and Acronyms

FEMA

A.1. Glossary

Below is a listing of terms used within this report. Many of these definitions were taken from FEMA's Federal Guidelines for Dam Safety, Glossary of Terms, April 2004.

Appurtenant structure. Ancillary features of a dam such as outlets, spillways, power plants, tunnels, etc.

Breach. An opening through a dam that allows the uncontrolled draining of a reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional opening caused by discharge from the reservoir. A breach is generally associated with the partial or total failure of the dam.

Consequences. Potential loss of life or property damage downstream of a dam caused by floodwaters released at the dam or by waters released by partial or complete failure of dam. Also effects of landslides upstream of the dam on property located around the reservoir.

Dam. An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water.

Dam failure. Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water or the likelihood of such an uncontrolled release It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters that adversely affect a dam's primary function of impounding water is properly considered a failure. These lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic 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 function 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.

Deterministic methodology. A method in which the chance of occurrence of the variable involved is ignored and the method or model used is considered to follow a definite law of certainty, and not probability.

Emergency Action Plan (EAP) Exercise. An activity designed to promote emergency preparedness; test or evaluate EAPs, procedures, or facilities; train personnel in emergency management duties; and demonstrate operational capability. Exercises consist of the performance of duties, tasks, or operations very similar to the way they would be performed in a real emergency. However, the exercise performance is in response to a simulated event.

Exceedance Probability. The likelihood that a random event will exceed a specified magnitude in a given time period, usually 1 year unless otherwise indicated.

Failure mode. A potential failure mode is a physically plausible process for dam failure resulting from an existing inadequacy or defect related to a natural foundation condition, the dam or appurtenant structures design, the construction, the materials incorporated, the operations and maintenance, or aging process, which can lead to an uncontrolled release of the reservoir.

Flood. A temporary rise in water surface elevation resulting in inundation of areas not normally covered by water. Hypothetical floods may be expressed in terms of average 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, Inflow Design (IDF).** The flood flow above which the incremental increase in downstream water surface elevation due to failure of a dam or other water impounding structure is no longer considered to present an unacceptable threat to downstream life or property. The flood hydrograph used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works and for determining maximum storage, height of dam, and freeboard requirements.
>
> **Flood, Probable Maximum (PMF).** The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the drainage basin under study.

Flood plain. An area adjoining a body of water or natural stream that may be covered by floodwater. Also, the downstream area that would be inundated or otherwise affected by the failure of a dam or by large flood flows. The area of the flood plain is generally delineated by a frequency (or size) of flood.

Hazard. A situation that creates the potential for adverse consequences such as loss of life, property damage, or other adverse impacts.

> **Hazard potential.** The possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or misoperation of the dam or appurtenances. Impacts may be for a defined area downstream of a dam from flood waters released through spillways and outlet works of the dam or waters released by partial or complete failure of the dam. There may also be impacts for an area upstream of the dam from effects of backwater flooding or landslides around the reservoir perimeter.
>
> **Hazard potential classification.** A system that categorizes dams according to the degree of adverse incremental consequences of a failure or misoperation of a dam. The hazard potential classification does not reflect in any way on the current condition of the dam (i.e., safety, structural integrity, flood routing capacity).

Hydrograph, breach or dam failure. A flood hydrograph resulting from a dam breach.

Hydrograph, flood. A graph showing, for a given point on a stream, the discharge, height, or other characteristic of a flood with respect to time.

Hydrograph, unit. A hydrograph with a volume of one inch of runoff resulting from a storm of a specified duration and areal distribution. Hydrographs from other storms of the same duration and distribution are assumed to have the same time base but with ordinates of flow in proportion to the runoff volumes.

Hydrology. One of the earth sciences that encompasses the natural occurrence, distribution, movement, and properties of the waters of the earth and their environmental relationships.

Indemnification Cost. The present cost to provide sufficient security against all claims of loss or damage in the event of a future dam failure.

Population at Risk. All those persons who could be in the flooded area below a dam attributable to the failure of the dam at the time of failure.

Probable Maximum Flood (PMF). See Flood. **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 during a certain time of the year.

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

Risk. A measure of the likelihood and severity of adverse consequences (National Research Council 1983). Risk is estimated by the mathematical expectation of the consequences of an adverse event occurring, i.e., the product of the probability of occurrence and the consequence, or alternatively, by the triplet of scenario, probability of occurrence, and the consequence.

Risk analysis. A procedure to identify and quantify risks by establishing potential failure modes, providing numerical estimates of the likelihood of an event in a specified time period, and estimating the magnitude of the consequences. The risk analysis should include all potential events that would cause unintentional release of stored water from the reservoir.

Risk assessment. The process of deciding whether existing risks are tolerable and present risk control measures are adequate and, if not, whether alternative risk control measures are justified. Risk assessment incorporates the risk analysis and risk evaluation phases.

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 that is designed to be operated infrequently, possibly in anticipation of some degree of structural damage or erosion to the spillway that would occur during operation.

Spillway, emergency. See Spillway, auxiliary.

Spillway, service. A spillway that is designed to provide continuous or frequent regulated or unregulated releases from a reservoir, without significant damage to either the dam or its appurtenant structures. This is also referred to as principal spillway.

Spillway capacity. The maximum spillway outflow that a dam can safely pass with the reservoir at its maximum level.

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 super-critical velocities.

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

Spillway Design Flood (SDF). The flood flow above which the incremental increase in downstream water surface elevation due to failure of a dam or other water impounding structure is no longer considered to present an unacceptable threat to downstream life or property. The flood hydrograph used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works and for determining maximum storage, height of dam, and freeboard requirements.

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.

Surcharge. The volume or space in a reservoir between the controlled retention water level and the maximum water level. Flood surcharge cannot be retained in the reservoir but will flow out of the reservoir until the controlled retention water level is reached.

Watershed. The area drained by a river or river system or portion thereof. The watershed for a dam is the drainage area upstream of the dam.

A.2. Acronyms

ACT. Australian Capital Territory

AEP. Annual Exceedance Probability

ALARP. As Low As Reasonably Practicable

ALL. Annualized Life Loss

AMC. Antecedent Moisture Condition

ANCOLD. Australian National Committee on Large Dams

APF. Annual Probability of Failure

ASCE. American Society of Civil Engineers

ASDSO. Association of State Dam Safety Officials

AWWA. American Waterworks Association

BC. British Columbia

BSC. Base Safety Conditions

CDA. Canadian Dam Safety Association

DOD. Department of Defense

DOI. Department of Interior

FEMA. Federal Emergency Management Agency

FERC. Federal Energy Regulatory Commission

FPC. Federal Power Commission

GIS. Geographic Information Systems

HMR. Hydrometeorological Report

ICODS. Interagency Committee on Dam Safety

ICOLD. International Commission on Large Dams

IDF. Inflow Design Flood

LOL. Loss of Life

MPF. Maximum Possible Flood.

MPP. Maximum Possible Precipitation

MRC. Mississippi River Commission

MCD. Miami Conservancy District

MSHA. Mine Safety and Health Administration

NOAA. National Oceanic and Atmospheric Administration

NWS. National Weather Service, formerly USWB

NID. National Inventory of Dams

NRC. National Research Council of the National Academy of Sciences

NRCS. Natural Resources Conservation Service, formerly SCS

NSW DSC. New South Wales Government Dam Safety Committee

O&M. Operation and Maintenance

PAR. Population at Risk

PMF. Probable Maximum Flood

PMP. Probable Maximum Precipitation

SCS. Soil Conservation Service, currently known as the NRCS

SDF. Spillway Design Flood

TCW. Total Class Weight

TF. Threshold Flood

TVA. Tennessee Valley Authority

USCOLD. United States Committee on Large Dams, currently known as USSD

USBR. United States Bureau of Reclamation

USFS. United States Forest Service

USFWS. United States Fish and Wildlife Service

USGS. United States Geological Survey

USSD. United States Society on Dams, formerly USCOLD

USACE. United States Army Corps of Engineers

USDA. United States Department of Agriculture

USWB. United States Weather Bureau, currently the National Weather Service

WES. U.S. Army Corps of Engineers Waterways Experiment Station

Appendix B. Bibliography

B.1 Bibliography

B.1. Bibliography

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Appendix C. Hydrologic Safety of Dams Surveys

C.1. Survey Content

FEMA

HYDROLOGIC SAFETY OF DAMS

QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

On the Record

1. Respondent information:
   - State/Federal Dam Safety Organization ______________________
   - Name of Representative ______________________
   - Title of Representative ______________________
   - Phone number(s) ______________________
   - Email address ______________________

2. Number of dams under Organization's jurisdiction by type:
   - Total Dams ______________________
   - Total Regulated Dams ______________________
   - High Hazard Dams ______________________
   - Significant Hazard Dams ______________________
   - Low Hazard Dams ______________________
   - Unregulated Dams ______________________
   - Other ______________________

3. What year did your Agency adopt minimum Inflow Design Flood criteria? ____________________

4. How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:
   - ☐ Less than 25 feet high (from streambed) and 15 acre-feet of storage (top of dam)
   - ☐ Less than 6 feet high (from streambed) and 50 acre-feet of storage (top of dam)
   - ☐ Both of the above
   - ☐ Less than 50 acre-feet of storage (top of dam)
   - ☐ Other (Please specify) ____

5. Are there types/categories of dams (other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)
   - ☐ Yes (Please explain)
   - ☐ No

6. Does the Organization have published size classification criteria?
   - ☐ Yes
   - ☐ No

   If "Yes", check and complete as appropriate:

Class A (Small)	=<_______	feet high and stores	=< _________	acre-feet
Class B (Medium)				
Class C (Large)	=>_______	feet high and stores	=> _________	acre-feet

   Other (Specify) ____

7. Does the Organization have published hazard classification criteria?
   - ☐ Yes (High, Significant, and Low)
   - ☐ Yes (High, Significant, Low, Limited Hazard)
   - ☐ Yes (Other)
   - ☐ No

   If "Yes" and Significant Hazard is defined, how is Significant Hazard defined?
   - ☐ Loss of life potential is "few" with "appreciable" economic loss
   - ☐ No potential for loss of life with significant but not excessive economic loss
   - ☐ Other (Please specify) ____

8. Does the Organization have guidelines for determining the spillway design flood?
   - ☐ Yes
   - ☐ No

   If "Yes", what is the status of the guidelines; do they have the force of law?
   - ☐ Published within State Laws
   - ☐ Published guidelines/regulations that are required
   - ☐ Published guidelines/regulations for consideration by the engineer/designer
   - ☐ Unpublished guidelines that are required
   - ☐ Unpublished guidelines for consideration by the engineer/designer
   - ☐ Other (Please specify) ____________________

9. What is the origin of the guidelines?
   - ☐ Custom developed by Organization
   - ☐ USBR guidelines
   - ☐ NRCS guidelines
   - ☐ FEMA/FERC federal guidelines
   - ☐ USACE guidelines (including Phase I Study guidelines)
   - ☐ Combination of the above (Please specify) ____________________
   - ☐ Other (Please specify) ____________________
   - ☐ Unknown

10. When were the guidelines last revised (MM/DD/YYYY)? ____________________

11. Are there any plans to update or revise the guidelines in the near future?
    - ☐ Yes (Please specify) ____________________
    - ☐ No

12. Are the guidelines different for new and existing dams?
    - ☐ Yes (Please elaborate) ____________________
    - ☐ No

13. Which of the following best describes your agency's role in determining the spillway design flood:
    - ☐ Agency does not review any technical information, but ensures that design is performed by qualified professionals
    - ☐ Agency reviews submitted designs
    - ☐ Agency performs independent verification of submitted designs
    - ☐ Agency acts as designer/engineer
    - ☐ Agency utilizes a combination of the above approaches, possibly on a case-by-case basis
    - ☐ Other (Please explain) ____________________

14. How are the guidelines applied?
    - ☐ Based on both size and hazard classification
    - ☐ Based on size classification only
    - ☐ Based on hazard classification
    - ☐ Based on risk analysis
    - ☐ Based on a combination of risk analysis and hazard/size classification
    - ☐ Based on other criteria (Please specify) ____________________

15. For PMP/PMF designs, is freeboard required?
    - ☐ No
    - ☐ Based on wave run up computations
    - ☐ 1.0'
    - ☐ 1.5'
    - ☐ 2.0'
    - ☐ 3.0' or more
    - ☐ Other (Please specify) ____________________

16. Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that must be used?
    - ☐ Yes
    - ☐ No

    If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?
    - ☐ Must use HMRs for developing PMP
    - ☐ Must use SCS unit hydrograph
    - ☐ Must use HEC-1
    - ☐ Must use HEC-HMS
    - ☐ Must use SITES
    - ☐ Other (Please specify) ______________________________

17. Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?
    - ☐ Yes (Please specify) ______________________________
    - ☐ No

18. Do the guidelines specify any criteria for storm duration?
    - ☐ Yes (6-hour)
    - ☐ Yes (24-hour)
    - ☐ Yes (48-hour)
    - ☐ Yes (72-hour)
    - ☐ Yes (Based on Tc)
    - ☐ No
    - ☐ Other (Please specify) ______________________________

19. Do the guidelines specify any criteria for temporal storm distribution?
    - ☐ Yes (HMR)
    - ☐ Yes (NRCS Standard)
    - ☐ Yes (Regional)
    - ☐ Yes (Other, Please specify) ______________________________
    - ☐ No

20. Do the guidelines specify any criteria for spatial storm distribution?
    - ☐ Yes (Please specify) ______________________________
    - ☐ No

21. Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?
    - ☐ Yes (Please specify) ______________________________
    - ☐ No

22. Does the organization allow development of a site specific PMP?
    - ☐ Yes
    - ☐ No
    - ☐ Unknown (never requested)

    If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?
    - ☐ Yes (Please specify) ______________________________
    - ☐ No

23. Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?
    - ☐ Yes, a major problem
    - ☐ Yes, a moderate problem
    - ☐ Yes, a minor problem
    - ☐ No
    - ☐ Unsure

24. Do guidelines require consideration or analysis of future development?
    - ☐ Yes (Impacts of development on watershed hydrology)
    - ☐ Yes (Impacts of development on hazard classification or failure consequences)
    - ☐ Yes (Both of the above)
    - ☐ Yes (Other; please specify) ____________________
    - ☐ No

25. Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?
    - ☐ Yes (Please specify) ____________________
    - ☐ No

26. Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?
    - ☐ Yes
    - ☐ No

    If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?
    - ☐ Yes
    - ☐ No

27. Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?
    - ☐ Yes (Please specify) ____________________
    - ☐ No

28. Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF? If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined. ____________________

New High Hazard Dams must pass	______ % of PMP, or	______ % of PMF
Existing High Hazard Dams must pass	______ % of PMP, or	______ % of PMF
New Significant Hazard Dams	______ % of PMP, or	______ % of PMF
Existing Significant Hazard Dams	______ % of PMP, or	______ % of PMF

29. For low hazard dams, the spillway design requirement is:
    - ☐ 25-year flood
    - ☐ 50-year flood
    - ☐ 100-year flood
    - ☐ 500-year flood
    - ☐ Not specified
    - ☐ Other (Please specify) ____________________

30. Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?
    - ☐ Yes
    - ☐ No

31. Does your organization permit risk based hydrologic designs?
    - ☐ Yes; our regulations permit them
    - ☐ Yes; although our regulations do not specifically address this topic, we review risk-based designs on a case-by-case basis
    - ☐ No; our regulations forbid them
    - ☐ No; our regulations address this topic and we have made an administrative decision not to consider risk-based designs
    - ☐ Our regulations do not specifically address this topic and it has never come up for consideration
    - ☐ Other (Please explain) ____________________

32. Has your agency ever reviewed a risk-based hydrologic analysis?
    - ☐ Yes (Reviewed and approved)
    - ☐ Yes (Reviewed and rejected)
    - ☐ Yes (Both approved and rejected)
    - ☐ No
    - ☐ Unsure
    - ☐ Other (Please explain)

33. How difficult would it be to change your regulations? Please explain. ___________________________________
    - ☐ Difficult
    - ☐ Moderate
    - ☐ Easy

34. Are they any unique provisions in your regulations?
    - ☐ Yes (Please explain) ____
    - ☐ No

<u>Off the Record</u>

35. Do you agree that designing for the PMF is unreasonably conservative?
    - ☐ Strongly agree
    - ☐ Somewhat agree
    - ☐ Neutral
    - ☐ Somewhat disagree
    - ☐ Strongly disagree
    - ☐ Undecided

36. In your opinion, does the general public believe that the PMF is unreasonably conservative?
    - ☐ Yes, the general public strongly opposes the PMF design
    - ☐ Yes, the general public somewhat opposes the PMF design
    - ☐ No, the general public strongly favors the PMF design
    - ☐ No, the general public somewhat favors the PMF design
    - ☐ Undecided
    - ☐ No opinion
    - ☐ Other (Please explain) ____

37. Do you have any concerns regarding the consistency of hydrologic and hydraulic analyses?
    - ☐ Yes (Please specify) ____
    - ☐ No

38. Are you aware of the guidelines in the following documents?

a.	Safety of Dams: Flood and Earthquake Criteria – Prepared by the Committee on Safety Criteria for Dams, National Research Council (1985)	☐ Yes	☐ No
b.	Evaluation Procedures of Hydrologic Safety of Dams – Prepared by the Task Committee on Spillway Design Flood Selection of the Committee on Surface Water Hydrology of the Hydraulics Division of the American Society of Civil Engineers (1988)	☐ Yes	☐ No
c.	Guidelines on Selection of Acceptable Flood Capacity for Dams, and Guidelines on Risk Assessment – ANCOLD (2000, 2003)	☐ Yes	☐ No
d.	Guidelines for Achieving Public Protection in Dam Safety Decisionmaking - US Bureau of Reclamation (2003)	☐ Yes	☐ No
e.	Federal Guidelines for Dam Safety – Selecting and Accommodating Inflow Design Floods for Dams – FEMA (2004)	☐ Yes	☐ No
f.	Safety of Dams: Policy and Procedures (ER 1110-2-1156) – US Army Corps of Engineers (2010)	☐ Yes	☐ No

39. Do you have any concerns regarding the use of risk analyses or incremental damage assessments to determine spillway capacity requirements?
    - ☐ Yes (Please specify) ____________________
    - ☐ No

40. Do you agree or disagree with the following statements:

a.	Risk analysis is the best and most logical approach to selection of the appropriate SDF.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree
b.	The complexity of risk analysis constitutes a severe constraint on its usefulness because virtually no one other than a skilled dam safety professional can understand it.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree
c.	One of the big problems in developing a risk analysis is assigning probabilities to extreme flood events.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree
d.	There are so many intangibles and judgment decisions in the development of a risk assessment that the result is little more than an academic exercise.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree
e.	The practicality of risk analysis is severely constrained by changing conditions in the downstream hazard zone.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree
f.	The litigious nature of our society forces the professional to choose the most conservative design option.	☐ Strongly agree ☐ Neutral ☐ Undecided	☐ Somewhat agree ☐ Somewhat disagree ☐ Strongly disagree

41. Do you believe your agency has the technical ability to review the following:

Site Specific PMP Studies	☐ Yes	☐ No
Incremental Damage Assessments	☐ Yes	☐ No
Rigorous Risk Analyses	☐ Yes	☐ No

42. Do you believe your agency has the resources (availability and budget) to review the following:

Site Specific PMP Studies	☐ Yes	☐ No
Incremental Damage Assessments	☐ Yes	☐ No
Rigorous Risk Analyses	☐ Yes	☐ No

43. Would you like to see any changes in your current guidelines?
    - ☐ Yes (Please specify) ____________________
    - ☐ No

44. Do you believe that increased uniformity in state dam safety guidelines across the country would be beneficial?
    - ☐ Yes
    - ☐ No

45. Would you be receptive to adopting new recommended guidelines if they resulted in lower spillway design flood criteria for existing and new dams?
    - ☐ Yes
    - ☐ No

46. Would you be receptive to adopting new recommended guidelines if they resulted in higher spillway design flood criteria for existing and new dams?
    - ☐ Yes
    - ☐ No

47. Do you have any other comments? ____________________

C.2. Completed Federal Surveys

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Bureau of Indian Affairs
Name of Representative	John Anevski
Title of Representative	Chief, Division of Water and Power
Phone number(s)	(202) 208-5480
Email address	john.anevski@bia.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	900
Total Regulated Dams	900
High Hazard Dams	91
Significant Hazard Dams	45
Low Hazard Dams	764
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 2006

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Based on Indian Dam Safety Act of 1994 (P.L. 103-302)--Between 1 and 6 lives would be at risk or significant property damage could occur if the dam failed.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

Comments: The current BIA Handbook calls for the Base Safety Condition to be determined and this is the largest flood which will cause incremental dam failure flooding. However, BIA reserves the right to select something smaller based on downstream conditions. Normally, the IDF will not be greater than a 10,000 year storm.

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Custom based on Bureau and USBR Guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 07/08/2007

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Plan to include revised current guidelines in BIA Safety of Dams Handbook in FY 2012

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: The current BIA Handbook calls for the Base Safety Condition to be determined and this is the largest flood which will cause incremental dam failure flooding. However, BIA

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: EWS instrumentation will be installed, operated, and maintained at High or Significant Hazard dams and in the upstream basin when early detection of hydrologic events would provide additional time needed for emergency management activities.

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Easy

Comments: Most of our criteria for IDF development is in the form of guidelines/standards and is not found in regulations. However, we would normally consult with Tribal organizations if and when revisions occur.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Federal Energy Regulatory Commission
Name of Representative	Daniel J. Mahoney
Title of Representative	Director, Dam Safety and Inspection
Phone number(s)	(202) 502-6743
Email address	daniel.mahoney@ferc.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	2530
Total Regulated Dams	2530
High Hazard Dams	780
Significant Hazard Dams	192
Low Hazard Dams	1558
Unregulated Dams	0
Other	0

3 When did your Organization adopt minimum Inflow Design Flood criteria? 1981

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Every dam included in a FERC license

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: They have the force of law.

9 What is the origin of the guidelines?

FEMA/FERC federal guidelines

10 When were the guidelines last revised (MM/DD/YYYY)?

Comments: FERC Engineering Guidelines are constantly updated and revised

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Continually revised as necessary.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

Comments: We review all of them, but when necessary we perform an independent verification

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: On a case by case basis, anticipated wave run-up and engineering judgement

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Outlet works and service spillways should be designed for frequent use and should by highly reliable. Auxiliary spillways are usually designed for infrequent use and it is acceptable to sustain limited damage during passage of the IDF. Emergency spillway may be used to obtain a high degree of hydrologic safety with minimal additional cost. Because of their infrequent use, it is acceptable for them to sustain significant damage when use and they may be designed with lower structural standards than those used for auxiliary spillways.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: A BOC is normally required to oversee the development of the PMP/PMF

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments:

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: In general, if there is no allocated or planned flood control storage (i.e., run-of-river), the flood routing usually begins with the reservoir at the normal maximum pool elevation. If regulation studies show that pool levels would be lower than the normal maximum pool elevation during the critical inflow design flood (IDF) season, then the results of those specific regulation studies should be analyzed to determine the appropriate initial pool level for routing the IDF.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: Follow FEMA's "Federal Guidelines for Dam Safety: Selecting and Accomodating Inflow Design Floods for Dams" (April 2004)

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Other (Please explain)

Comments: We have considered risk based hydrologic analysis as another bit of information when reviewing IDFs

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	DOL - Mine Safety and Health Administration
Name of Representative	Stanley Michalek
Title of Representative	Acting Dam Safety Officer
Phone number(s)	412-386-6974 (202-693-9476 until 4/4/11)
Email address	michalek.stanley@dol.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	2089
Total Regulated Dams	2089
High Hazard Dams	429
Significant Hazard Dams	266
Low Hazard Dams	1394
Unregulated Dams	unknown
Other	n/a

3 What year did your Agency adopt minimum Inflow Design Flood criteria? approx. 1975

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: < 5 feet high; or < 20 feet high and < 20 ac-ft. This is criteria used by Agency's coal program area. For the non-coal program area, the size criteria specified by NID is used.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: In some cases, flood control dams that would be classified as high hazard potential are allowed to be designed to low hazard storm event with warning system.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	<40	feet high and stores =<	<1000	acre-feet
Class B (Medium)					
Class C (Large)	=>	40	feet high and stores =>	1,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Facilties where failure would likely not result in loss of human life, but can cause economic loss, environmental damage, or disruption of lifeline facilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: MSHA guidelines use the inflow design flood in the design (freeboard design flood).

9 What is the origin of the guidelines?

FEMA/FERC federal guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 10/01/2007

Comments: "Coal Mine Impoundment Inspection and Plan Review Handbook"

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

MSHA uses inflow design flood.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

3.0' or more

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Designer must consider most severe storm duration up to 72 hours.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

Comments: Storm must be temporally and spatially distributed to produce the most severe conditions with respect to freeboard and spillway discharge.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: Storm must be temporally and spatially distributed to produce the most severe conditions with respect to freeboard and spillway discharge.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: While we allow it, we've never seen it done.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

Comments: Question poorly worded. We do not require consideration of future development in the design plan, but do require consideration/analysis after the development takes place.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC III for PMF; pool at elevation of lowest ungated outlet.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: inflow design flood or freeboard design flood.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Once hazard potential rating would be determined using incremental damage assessment, design storm is defined by guidelines.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50-100	% of the	PMF
Existing Significant Hazard Dam must pass	50-100	% of the	PMF

Comments: For significant hazard potential, storm depends on size classification of dam.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: For small reservoir - 100 year, 24 hour
For large reservoir - 1/2 PMF

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: Dams constructed to control floods due to storm runoff may be designed to low hazard storm criteria and use an early warning system to evacuate downstream personnel.

31 Does your organization permit risk-based hydrologic designs?

Other (Please explain)

Comments: We do not forbid risk-based designs. We have not seen one submitted. There is some question whether our regulations would allow them.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Not with regard to hydrologic issues. We do allow low hazard impoundments to be "abandoned" as live dams if specific criteria are met.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	USDA - Natural Resources Conservation Service
Name of Representative	Noller P. Herbert
Title of Representative	Director, Conservation Engineering Division
Phone number(s)	(202) 720-2520
Email address	noller.herbert@wdc.usda.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	27254
High Hazard Dams	2233
Significant Hazard Dams	2299
Low Hazard Dams	22722
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1930's

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Defined in "USDA - NRCS National Engineering Manual (NEM) Part 520, Subpart C Section F." http://directives.sc.egov.usda.gov/viewDirective.aspx?hid=27493

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: Regardless of structure purpose or type of dam, it is subject to either TR-60 or Conservation Practice Standard 378 design standards.

6 Does the Organization have published size classification criteria?

No

Comments: Design standards are based on hazard classification criteria, not size classification.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Significant Hazard - Dams in predeominately rural or agriclutural areas where failure may damage isolated homes, main highways, or minor railroads, or interrupt service of relatively important utilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: TR-60 contains policy on storm size; National Engineering Handbook Part 630, Chapter 21 contains procedure for developing inflow hydrograph.

9 What is the origin of the guidelines?

NRCS guidelines

Comments: SCS/NRCS guidelines were first developed in the 1930s when the first floodwater retarding dams were installed under the pilot watershed program. Since then the guidelines have evolved and are reviewed and updated on a continual basis.

10 When were the guidelines last revised (MM/DD/YYYY)? 07/01/2005

Comments: They are continually under revision and we are trying to get to the point again that they are reviewed every 5 years.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: We are currently in the process of updating a number of standards and guidelines used in dam design and dam safety activities

12 Are the guidelines different for new and existing dams?

No

Comments: The guidelines are the same for new and existing dams except in the case of rehabilitation of structures where site constraints prohibit the use of the existing guidelines. For those situations, FEMA 94 guidelines on Inflow Design Flood is allowed.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

Approach dependent upon time and resources available as determined by NRCS State Conservationists.

14 How are the guidelines applied?

Based on hazard classification only

Comments: Based upon size, various types of materials may be allowed for certain appurtenances (for example principal spillway pipes may be either corrugated metal, pvc, steel or concrete depending upon structure size).

15 For PMP/PMF designs, is freeboard required?

No

Comments: PMP/PMF is used to set the top of dam elevation. NRCS does not include additional freeboard.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use SITES

Comments: SITES must be used for TR-60 structures. Conservation Practice Standards 378 designs may use other analyses/methodologies/procedures/computer software dependent upon NRCS state conservation engineer guidance.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: This is based on the professional judgment of the designer, reviewer and approver.

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Both a short duration (6 hour or longer) and a long duration (24 hour or longer) storm shall be analyzed and the most critical results used to check the capacity and the integrity of the auxiliary spillway.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: Principal spillway design hydrographs use NRCS standard distributions. Spillway design hydrographs (used for auxiliary spillway design) use type B or standard distributions. PMP/PMF uses PMP distribution as defined in HMR 52 or 5-point distribution (developed based on HMR 52 methodologies).

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: Uniform rainfall depth assumed over the entire watershed. Rainfall depth may be adjusted based on watershed drainage area.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Spillway frequency of use criteria are provided. Also, earth and vegetated auxiliary spillways are designed on the basis that some erosion or scour will occur during passage of infrequent storms, but the spillway will not breach during passage of the freeboard storm.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: NRCS encourages the use of a site-specific PMP where information is available. Site specific PMP studies must be performed by a qualified professional.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

Comments: NRCS does not regulate any of the dams for which it provides technical or financial assistance. Changing dam classifications is a problem for our customers and sponsors.

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

Comments: TR-60 requires that consideration must be given to the damage that might occur to existing and future developments.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Use average antecedent runoff conditions (ARC II) or greater unless a special study shows that a different condition is justified. The initial reservoir stage for principal spillway hydrograph routing shall be at the crest of the lowest ungated inlet or (if not subtracted from the stage-storage curve) the anticipated elevation of the sediment storage, whichever is higher, except as provided below. For dams with significant base flow, principal spillway hydrograph routings must start not lower than the elevation of the water surface associated with the base flow. Significant base flow is average annual or seasonal flow that would produce at least 0.5 feet of head over the lowest principal spillway inlet immediately prior to a flood or occupy more than 10 percent of the floodwater storage capacity. For dams with joint use storage capacity, when one of the uses is floodwater detention, routing of the principal spillway hydrograph may begin at the lowest anticipated elevation of the joint use pool in accordance with the operation plan. Single purpose, low hazard class irrigation dams with gated outlets and earth or vegetated auxiliary spillways, which are located on ephemeral streams in areas where the average annual precipitation is less than 25 inches, may be considered to have discharged up to 70 percent of the storage, exclusive of sediment storage in determining the elevation to start routing. For auxiliary spillway and freeboard hydrographs, routings start at the 10-day draw-down elevation or the principal spillway hydrograph.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

Comments: Methods in the Federal Guidelines for Dam Safety - Inflow Design Floods, FEMA 94, may alternately be used to proportion the embankment and auxiliary spillway, provided downstream land use controls exist to prevent voiding incremental risk assumptions after the dam is completed. Only for rehabiliation projects. Not allowable for new projects.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Only allowed for rehabilitation projects - not allowed for new projects. For high hazard dams, when using an IDF (FEMA 94) analysis, the minimum storm that can be used can be no less than the freeboard design storm for a significant hazard dam. (P100+0.4(PMP-P100))

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: Significant Freeboard Design Hydrograph: P100 + 0.40(PMP - P100)

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: If product of storage and effective height is less than 30,000 and there are no upstream dams: P100 + 0.12(PMP - P100); if product of storage and effective height is greater than 30,000 and there are no upstream dams: P100 + 0.26(PMP - P100); if there is an existing or planned upstream dam: P100 + 0.40(PMP - P100)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: NRCS might consider an early warning system as alternative, but it is not a part of design guidelines.

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

Comments: NRCS will consider risk based designs, but they are not a part of design guidelines.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

Comments: NRCS has both approved and rejected designs based on FEMA 94 guidelines.

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: It takes time for review and coordination but we do not have to get any legislative approval for a change

34 Are there any unique provisions in your regulations?

No

Comments: NRCS tries to apply standards nationwide. States are allowed to revise the standards to make them more restrictive, but not less restrictive. Additionally, NRCS must meet all state and local regulations.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Tennessee Valley Authority
Name of Representative	Michael T. Scott
Title of Representative	Dam Safety Officer
Phone number(s)	423.751.6995
Email address	mtscott2@tva.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	49
High Hazard Dams	36
Significant Hazard Dams	10
Low Hazard Dams	3
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? circa 1978

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: This survey has been completed for TVA's 49 regulated dams. TVA is currently creating a Dam Safety Governance organization which will implement guidelines for any impoundment within the TVA system which meets the definition of dam given in FEMA 93.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: TVA is currently creating a Dam Safety Governance organization which will implement dam safety guidelines for any impoundment (tailings, coal combustion products, etc.) which meet the definition of a dam as given in FEMA 93.

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: TVA follows FEMA 333 for assigning hazard classifications.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: Our historic practice has been to select the PMF as the appropriate spillway design flood for TVA dams with a high hazard classification.

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: FEMA (Federal Guidelines) and self imposed criteria that TVA has historically adopted

10 When were the guidelines last revised (MM/DD/YYYY)? 1/1/2008

Comments: Note that the date is approximate. TVA's self imposed criteria changed based on new information including: operating guides, orifice flow coefficients, etc.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: TVA Dam Safety Governance organization will issue guidelines and each business unit will create implementing procedures.

12 Are the guidelines different for new and existing dams?

No

Comments: It is not expected that the hydrologic safety of dams guidelines will be different for new and existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency acts as designer/engineer

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

Comments: TVA has followed specific methodologies which were not stipulated. TVA uses rainfall design basis developed by NWS under contract with TVA, estimated watershed response (inflows) using TVA developed tools used to schedule the reservoir system, and routed those inflows through the system using hydrologic models developed by TVA.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: TVA uses a 9-day sequence specified by a hydrometeorological design basis report developed by NWS (contracted work).

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: TVA uses a distribution specified by a hydrometeorological design basis report developed by NWS (contracted work).

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: TVA uses a distribution specified by a hydrometeorological design basis report developed by NWS (contracted work).

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: TVA uses the hydrometeorological design basis report developed by NWS (contracted work).

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: Historically, this has not been a problem for TVA.

24 Do guidelines require consideration or analysis of future development?

No

Comments: Most communities downstream of TVA dams participate in the FEMA flood insurance program, and so they are somewhat self-regulating.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Historic practice includes median moisture conditions and conservatively high initial reservoir pool levels.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: 100-year frequency event minimum

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass		% of the	
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: Our historic practice has been to select the PMF as the appropriate spillway design flood for TVA dams with a high hazard classification. Significant hazard dams must pass the "TVA precipitation" as defined by the NWS study. This precipitation is significantly less than the PMP.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: TVA practice is that Low hazard dams must pass the "TVA precipitation" as defined by the NWS study. This precipitation is significantly less than the PMP.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: This practice has been adopted by TVA in the past, but was not used as the permanent solution (used as an interim measure).

31 Does your organization permit risk-based hydrologic designs?

Other (Please explain)

Comments: TVA has not practiced risk-basd hydrologic designs. However, the topic has been considered with no firm conclusions.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Changes to Dam Safety Guidelines would have to be approved by the Dam Safety Officer, Chief Operating Officer, and possibly the TVA Board of Directors/Chief Executive Officer.

34 Are there any unique provisions in your regulations?

No

FEMA

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Army Corps of Engineers
Name of Representative	Eric C. Halpin
Title of Representative	Special Assistant for Dam and Levee Safety
Phone number(s)	202-761-7662
Email address	Eric.C.Halpin@usace.army.mil

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	697
High Hazard Dams	525
Significant Hazard Dams	138
Low Hazard Dams	34
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? rocedures Pertaining to Deter

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Criteria is per the National Dam Safety Program Act.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

Comments: ER 1110-2-106, "Recommended Guidelines for Safety Inspection of Dams", 26 September 1979. This regulation is no longer valid. Current USACE guidance classifies dams by hazard potential and not size.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Loss of life not probable.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: ER 1110-8-2(FR), "Inflow Design Floods for Dams and Reservoirs", 1 March 1991.

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

10 When were the guidelines last revised (MM/DD/YYYY)? 03/01/1991

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: USACE has a program for updating guidance but there are no specific dates established for this regulation.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency acts as designer/engineer

14 How are the guidelines applied?

Based on other criteria (Please specify)

Comments: Standard 1: Risk to life and property; Standard 2: Run of river projects; Standard 3: Base safety condition, negligible incremental impacts due to failure; Standard 4: Small Dams

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Three feet minimum for concrete dams. Three feet minimum for embankment dams unless pool is within three feet of the maximum pool for more than 36 hours in which case the minimum is five feet. Required freeboard may be greater than the minimum based on wind setup, wave action, uncertainty in analysis procedures, or uncertainty in project function.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

Comments: Development of site specific PMPs is allowed. EM 1110-2-1417, "Flood Runoff Analysis", 31 August 1994.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: USACE maintains software lists that classify software as follows: Required, Recommended, Ok to use, Retired, Not Allowed for Use.

18 Do the guidelines specify any criteria for storm duration?

Yes (Based on Tc)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: HMR spatial distribution with orientation adjusted to maximize peak discharge.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Site specific PMPs require approval by HQUSACE.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: Although downstream development can change hazard potential classification and inflow design flood requirements, this has not been an issue for USACE dams. A more common issue relates to changes in routine operation due to downstream development. Hazard potential classification affects frequency of dam safety exercises.

24 Do guidelines require consideration or analysis of future development?

Yes (Other; please specify)

Comments: Analysis of new projects requires consideration of most likely future conditions. Existing projects based on existing conditions. Design of spillways requires consideration of potential for hazardous flow regardless of current or future development (ER 1110-2-1451).

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: ER 1110-8-2(FR) provides requirements for antecedent reservoir pool conditions. EM 1110-2-1417 provides guidelines for antecedent moisture conditions. Criteria can be modified at the regional (MSC) level based on regional conditions.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: Applies to Standard 3 dams per ER 1110-8-2(FR).

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum 1/2 PMF for Standard 3 dams per ER 1110-8-2(FR).

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: High hazard dams with potential life loss must pass 100% of the PMF per Standard 1 of ER 1110-8-2(FR). Significant hazard dams with no probable life loss must pass major floods typical of the region without excessive damage or loss of operability per Standard 2 of ER 1110-8-2(FR). Significant hazard dams with no incremental life loss due to dam failure must pass a minimum of 1/2 PMF per Standard 3 of ER 1110-8-2(FR).

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Low hazard dams typically fall under Standard 4 of ER 1110-8-2(FR) which requires rainfall-runoff probability analyses with no specific minimum requirement.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Early warning can be considered as a risk reduction measure but would not be accepted in lieu of meeting minimum essential guidelines for the inflow design flood.

31 Does your organization permit risk-based hydrologic designs?

Other (Please explain)

Comments: Risk informed hydrologic designs are permitted for flood damage reduction studies (e.g. levees, channel improvements, etc) per ER 1105-2-101. Risk informed hydrologic designs are not permitted for dams. Risk informed hydrologic analyses for dams are used to prioritize risk reduction actions for dams in the USACE inventory and to inform decisions on incremental risk reduction actions for specific projects.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: A significant challenge would be establishing appropriate new/revised essential guidelines. Updating USACE regulations is a well defined process but usually takes 2-5 years to complete.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: There are numerous guidelines that address/allow consideration of site-specific circumstances, regional considerations, and portfolio prioritization.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	US Bureau of Reclamation
Name of Representative	Brian Becker
Title of Representative	Chief, Dam Safety Office
Phone number(s)	303-445-2776
Email address	bbecker@usbr.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	587
Total Regulated Dams	468
High Hazard Dams	332
Significant Hazard Dams	38
Low Hazard Dams	98
Unregulated Dams	
Other	119

3 What year did your Agency adopt minimum Inflow Design Flood criteria? Around 1951.

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Reclamation follows definition in the Federal Guidelines for Dam Safety (FGDS). (Your pull downs use the word "and" between the 2 dimensions, when the FGDS uses "or" and your pull-downs incorrectly mixing the 2 dimensions. The way the FGDS reads is 25ft and 50 ac-ft for one jurisdiction test and 6' and 15ac-ft for the other test.)\

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Prior to adopting FEMA 333, Reclamation Dam Safety Program used the following definition for Significant: "Few Loss of Life is defined as 1 to 6 lives in jeopardy. Appreciable economics is defined as rural area with notable agriculture, industry, or worksites, or outstanding natural resources." While we now follow FEMA 333 definitions, dams that were assigned a hazard class of significant by following our 1988 guidelines and have potential life loss, these facilities have not been changed to high-hazard. It is the Reclamation's Dam Safety view that since these significant-hazard dams are treated as high-hazard.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

Comments: Reclamation uses the Reclamation Flood Hydrology Manual and the Reclamation Public Protection Guidelines (PPG) and uses a risk based approach.

9 What is the origin of the guidelines?

USBR guidelines

Comments: The risk assessment methodology of 1999 is superceded by the current Best Practices and used in coordination with the PPG. Reclamation has moved away from deterministic design flood standards and now uses risk-based approach. (Reclamation prefers the acronym of "Reclamation" instead of USBR or BOR.)

10 When were the guidelines last revised (MM/DD/YYYY)? 04/04/2011

Comments: Dam Safety Risk Analysis Best Practices Manual is updated as needed; approximately once or twice a year. PPG was last updated in 2010.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Dam Safety Risk Analysis Best Practices Manual is updated as needed; approximately once or twice a year. PPG was last updated in 2010.

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: The application of updated design guidelines, or state-of-the-art, will vary by project. Modifications to existing structures must consider the amount of risk reduction, feasibility of the modification, and the cost/benefit when trying to apply state-of-the art.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency acts as designer/engineer

In determining the spillway design flood, we set spillway design as case by case. It's very structure/site specific.

14 How are the guidelines applied?

Based on risk analysis

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Following the Federal Guidelines for Dam Safety, freeboard conditions include consideration factors that can reasonably occur at the given project site but include, wave height based on fetch and wind velocity assumptions, settlement, allowance for improper gate operation, landslide-generated wave potential, and perphaps an arbitrary allowance for contingencies to provide an increased factor of safety.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

Comments: The Dam Safety Risk Analysis Best Practice was written to guide the engineer but also allows for deviation if justifiable.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: Duration of flood overtopping is a critical element in determining the failure probability; however, it is difficult to accurately estimate.

18 Do the guidelines specify any criteria for storm duration?

No

Comments: Basis for storm duration is the PMP hydromet reports and is dependant upon site conditions. Type of spillway is a critical factor as well size of reservoir.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: The Reclamation Flood Hydrology Manual specifies a 2/3 PMP distribution.   We vary this based on site conditions and individual extreme storms according to Reclamations's

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: The Flood Hydrology Manual specifies a successive subtraction for PMP over watershed subbasins. We vary this based on site conditions and individual extreme storms according to Reclamations's guidelines for estimating hydrologic hazard curves.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Reclamation uses risk analysis but most likely freeboard would be integrated with other analysis, such as gate operations.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: PMPs are obtained for moderate level of effort studies such as Issue Evaluations, Corrective Action Studies, and Final Design. Reclamation uses generalized PMPs from the HMRs and according to Reclamation Flood Hydrology Manual and the Hydrologic Hazard Guidelines. Instead of site specific PMPs, Reclamation uses risk analysis.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: It is not a regulatory problem since changes in downstream development are reviewed during facility exams.

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: The risk analysis decision tree evaluates loads at various reservoir elevations. Antecedent moisture conditions are a parameter in modeling and are considered during the risk analysis process.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: The Guidelines do not require an incremental damage assessment but are used if appropriate.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: Any modifications to spillway design capacity would follow a risk-based approach using Reclamation's Risk Analysis Best Practices Manual.

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: For new design of high hazard dam, an EWS would probably not be allowed as an alternative for the regulatory spillway design flood. In cases of risk reduction, the cost to modify up to state-of-the-art may require the use of an EWS.

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

Comments: A better answer is Yes, our guidelines permit them.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

No

HYDROLOGIC SAFETY OF DAMS
QUESTIONNAIRE

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	US Fish and Wildlife Service
Name of Representative	Brad Iarossi
Title of Representative	Chief, Dam Bridge and Seismic Safety Branch
Phone number(s)	703-358-2211
Email address	Brad_Iarossi@fws.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	259
High Hazard Dams	17
Significant Hazard Dams	18
Low Hazard Dams	224
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1991

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: The U.S. Fish and Wildlife Service uses the definition of a dam found in the National Dam Safety Program Act to define a dam as "inventory dam". Impundment structures that do not meet these size/hazard criteria are considered "non-inventory" and are not subject to dam safety inspections etc.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

Comments: Intermediate (Medium) 40-100 feet high; 1000 - 50,000 acre feet

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: The U.S. Fish and Wildlife Service self regulates our dams, therefore the design guidelines are followed, but are not in statute as we are not a regulator.

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)? 09/12/2008

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: The guidelines will likely be revised to incorporate risk assessments and updates to the EAP format.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Incremental damage assessments are often used to establish inflow design floods.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Evaluated on a case by case basis

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

Comments: It is not a regulatory problem as we are not a regulator, however, as a responsible dam owner, we modify our dams appropriately based on hazard classification.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: If data is available

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum inflow design is the 100-year flood.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50-100	% of the	PMF
Existing Significant Hazard Dam must pass	50-100	% of the	PMF

Comments: Significant: Small (50% PMF), Intermediate (50% PMF), Large (50-100% PMF)

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Small (100-year), Intermediate (100-year), Large (100-year to 500-year)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Absolutely NOT!

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Easy

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Forest Service
Name of Representative	Clifford Denning
Title of Representative	Program Manager, Geotech and Dams
Phone number(s)	414-297-3305
Email address	cdenning@fs.fed.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	437
High Hazard Dams	31
Significant Hazard Dams	83
Low Hazard Dams	323
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? s dated 1993 and minimum inf

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Non-inventory dams are dams with a low or undertermined hazard potential classification that do not meet: a) Equal or exceed 25 feet in height and exceed 15 acre-feet in storage or b) Exceed 6 feet in height and equal or exceed 50 acre-feet in storage.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

Comments: New Forest Service Manual does not have published size classification criteria.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Would result in no probable loss of human life but could cause economic loss, disruption of lifeline facilities, or other significant impacts and would result in non-recoverable environmental damage.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: The level of design detail increases from preliminary to final design and with increasing size, value, and hazard potential classification of the structure. The level of detail of the geological and geotechnical investigation, design, design reports, and drawings must be adequate to construct the dam within acceptable safety parameters for its size and hazard potential classification. Utilize current U. S. Army Corps of Engineers or Bureau of Reclamation standards and procedures for dams in planning, investigating, and designing dams on National Forest System lands.

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: FEMA and USACE guidelines were consulted in the revision of our direction.

10 When were the guidelines last revised (MM/DD/YYYY)? 05/01/2011

Comments: The Forest Service guidelines are currently being revised and the above date is an estimated date of completion.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: They are currently being revised

12 Are the guidelines different for new and existing dams?

No

Comments: Existing dams which can accommodate at least 75 percent of the inflow design flood do not need to be modified to increase spillway capacity to the minimum requirements , until the dams undergo major reconstruction.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

Comments: At a minimum, utilize standards and procedures established by the Bureau or Reclamation, U. S. Army Corps of Engineers, or Natural Resources Conservation Service for determining the design storm event and sizing the spillway. Any appropriate Federal and State standards may be used case by case. Conduct site-specific evaluations to develop the inflow design hydrographs.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: At a minimum, utilize standards and procedures established by the Bureau or Reclamation, U. S. Army Corps of Engineers, or Natural Resources Conservation Service for determining the design storm event and sizing the spillway. Any appropriate Federal and State standards may be used case by case. Conduct site-specific evaluations to develop the inflow design hydrographs.

18 Do the guidelines specify any criteria for storm duration?

No

Comments: At a minimum, utilize standards and procedures established by the Bureau or Reclamation, U. S. Army Corps of Engineers, or Natural Resources Conservation Service for determining the design storm event and sizing the spillway. Any appropriate Federal and State standards may be used case by case. Conduct site-specific evaluations to develop the inflow design hydrographs.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: At a minimum, utilize standards and procedures established by the Bureau or Reclamation, U. S. Army Corps of Engineers, or Natural Resources Conservation Service for determining the design storm event and sizing the spillway. Any appropriate Federal and State standards may be used case by case. Conduct site-specific evaluations to develop the inflow design hydrographs.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: At a minimum, utilize standards and procedures established by the Bureau or Reclamation, U. S. Army Corps of Engineers, or Natural Resources Conservation Service for determining the design storm event and sizing the spillway. Any appropriate Federal and State standards may be used case by case. Conduct site-specific evaluations to develop the inflow design hydrographs.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: Conduct site-specific evaluations to develop the inflow design hydrographs.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: We have had several dams change classifications because of downstream development due to lack of zoning requirements.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: Consider and document reasonably foreseeable downstream development as well as existing development in the assessment.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Under no circumstances should the spillway capacity be reduced below the applicable minimum threshold (High=0.5PMF, Significant=100-year RP, Low=50-year RP).

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

Comments: Incremental Damage Analysis may allow spillway capacity to be reduced, but not any lower than the minimum threshold stated in question 27.

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: While we would not accept as an alternative the new direction states "To afford the maximum opportunity to alleviate problems that could threaten the integrity or operation of a dam remote sensing is required on all Forest Service operated dams with a high hazard potential classification."

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Unsure

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: While not impossible, changes require review and edits at different levels.

34 Are there any unique provisions in your regulations?

No

C.3. Completed State Surveys

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Alaska
Name of Representative	Charles Cobb
Title of Representative	State Dam Safety Engineer
Phone number(s)	(907) 269-8636
Email address	charles.cobb@alaska.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	171
Total Regulated Dams	79
High Hazard Dams	19
Significant Hazard Dams	30
Low Hazard Dams	30
Unregulated Dams	57
Other	35

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 2004

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 10 feet in height and poses no threat to lives and property; less than 20 feet in height, impounding less than 50 acre-feet and poses no threat to lives and property.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Certain tailings dams must meet highest design standard

6 Does the Organization have published size classification criteria?

No

If "Yes", check and complete as appropriate:

Class A (Small)	=<		feet high and stores =<		acre-feet
Class B (Medium)					
Class C (Large)	=>		feet high and stores =>		acre-feet
Other (Specify)					

Comments:

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Other (Please specify)

Comments: failure or improper operation of the barrier will result in: Significant danger to public health; Probable loss of or probable signifcant damage to homes, occupied structures, commercial property, high-value property, major highways, primary roads, railroads or public utilities, except those which belong to the barrier owner; other probable significant property losses or damage; probable loss of or significant damage to waters identified as important for the spawning, rearing or migration of anadromous fish.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Other (Please specify)

Comments: State published guidelines which do not have the force of law, and reference to FEMA 94 (1998) in published regulations (Alaska Administrative Code) which does have the force of law.

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: Alaska Dam Safety Program

10 When were the guidelines last revised (MM/DD/YYYY)? 06/01/2005

Comments:

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments:

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Depends

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

The department will at a minimum review submitted designs, and depending on the hazard potential of the structure will on a case-by-case basis perform an independent verification. In some unusual circumstances the department may perscribe the IDF if the owner of an existing dam lacks the resources to define it themselves.

14 How are the guidelines applied?

Based on hazard classification only

Comments:

15 For PMP/PMF designs, is freeboard required?

No

Comments:

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Comments:

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments:

18 Do the guidelines specify any criteria for storm duration?

No

Comments:

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments:

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments:

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

Comments: 100 year flood minimum IDF for all dams

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments:

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments:

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments:

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments:

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments:

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: 100 year flood is minimum IDF for all dams

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass		% of the	
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: Minimum Standard for any dam: 100 year flood
Maximum Standard for any dam: PMF

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments:

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: Yes for existing dam, No for new construction

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

Comments:

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

Comments:

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Requires public comment and review

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Protection of anadromous fish habitat included in hazard potential classification
Design criteria specifically excluded to allow engineers to develop reasonable designs

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Arizona
Name of Representative	Nicole Spence-Gibson
Title of Representative	Engineering Section
Phone number(s)	602-771-8658
Email address	nsgibson@azwater.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	252
High Hazard Dams	100
Significant Hazard Dams	36
Low Hazard Dams	116
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1978

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments:
(a) any barrier that is or will be less than six feet in height, regardless of storage capacity
(b) any barrier between 6 and 25 ft in height with a storage capacity of less than 50 AF
(c) any barrier that has or will have a storage capacity of fifteen acre-feet or less, regardless of height
(d) any barrier for the purpose of controlling liquid-borne material
(e) any barrier that is a release-contained barrier (f) any barrier that is owned, controlled, operated, maintained or managed by the United States Government or its agencies or instrumentalities if a safety program that is as least as stringent as the state safety program applies and is enforced against the agent or instrumentality.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Significant hazard potential is defined as failure or improper operation of a dam would be unlikely to result in loss of human life but may cause significant or high economic loss, intangible damage requiring major mitigation, and disruption or impact on lifeline facilities. Property losses would occur in a predominantly rural or agricultural area with a transient population but significant infrastructure.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 03/01/2004

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Our rules related to the magnitude of idf do differ for new and existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Largest of the following: i.) The sum of the inflow design flood maximum water depth above the spillway crest plus wave run up. ii.) The sum of the inflow design flood

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Our rules do not specifiy criteria for storm duration; however, we developed general guidelines to assist with for the evaluation of spillway adequacy. For the evaluation, we require PMF studies include the 6-hour local and 72-hour. Site-specific PMP depths and distributions are accepted if independently reviewed by a qualified third-party meteorologist.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: Time-distribution for the 6-hour local PMP follows the HMR 49 procedure. The 72-hour general storm PMP uses: A. 1st Day - Second Largest Day uniformly distributed. B. 2nd Day - Largest Day sequenced as follows: 1. 3rd largest 6-hr period uniformly distributed 2. 2nd largest 6hr period uniformly distributed 3. Largest 6-hour period uniformly distributed and 4. 4th largest 6-hr period uniformly distributed. c. 3rd Day - Smallest day uniformly distributed. Site-specific PMP depths and distributions may be accepted if independently reviewed by a qualified third party meteorologist.

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: See Comment 19.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: The evaluation shall include land use zoning and development projected for the affected area over the 10 year period following classification of the dam.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50-100	% of the	PMF
New Significant Hazard Dam must pass	25-50	% of the	PMF
Existing Significant Hazard Dam must pass	25-50	% of the	PMF

Comments: For significant hazard, design is determined by size classification. For high hazard, design is determined based on the number of persons at risk and the potential for downstream damage.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 25% of the PMF, Very low hazard potential dams it is the 100-year.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Our regulations do not specifically address this topic and it has never come up for consideration.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Any changes to our regulations would require stakeholder meetings and would go through the Governoring Regulatory Review Council.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: 1. Emergency Spillway Requirements. An applicant shall: a. Construct each spillway in a manner that avoids flooding in excess of the flooding that would have occurred in the same location under the same conditions before construction. The owner of a dam shall demonstrate that a spillway discharge would not result in incremental adverse consequences. In determining whether a spillway discharge of a dam would result in incremental adverse consequences, the Director shall evaluate whether the owner has taken any or all of the following actions: issuing public notice to downstream property owners, complying with flood insurance requirements, adopting emergency action plans, conducting mock flood drills, acquiring flow easements or other acquisitions of real property, or other actions appropriate to safeguard the dam site and flood channel. b. Include a control structure to avoid head cutting and lowering of the spillway crest for spillways excavated in soils or soft rock. In the alternative, the design may provide evidence acceptable to the Director that erosion during the inflow design flood will not result in a sudden release of the reservoir. c. Provide each spillway and channel with a minimum width of 10 feet and suitable armor to prevent erosion during the discharge resulting from the inflow design flood. d. Ensure that downstream spillway channel flows do not encroach on the dam unless suitable erosion protection is constructed.
e. Ensure that each spillway, in combination with outlets, is able to safely pass the peak discharge flow rate, as calculated on the basis of the inflow design flood. f. Not construct bridges or fences across a spillway unless the construction is approved in writing by the Director. The Director's approval may include conditions regarding the design and operation of the spillway and fencing, based on safety concerns. g. Not use a pipe or culvert as an emergency spillway unless the Director approves the use following review of the dam design and site characteristics.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Arkansas
Name of Representative	Alvin Simmons, Jr., P.E.
Title of Representative	Engineer Supervisor
Phone number(s)	501-682-3981
Email address	alvin.simmons@arkansas.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	406
High Hazard Dams	103
Significant Hazard Dams	95
Low Hazard Dams	208
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria?

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 25 feet dam height or less than 50 acre-feet of storage (top of dam)

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Appreciable (Significant structures, industrial, or commercial development, or cropland); $100,000 to $500,000.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

9 What is the origin of the guidelines?

Combination of the above (Please specify)

10 When were the guidelines last revised (MM/DD/YYYY)? 10/01/1993

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Within the next 2 years

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Existing dams will be evaluated periodically to determine if development of downstream areas warrants change in hazard classification and review of spillway design flood (SDF). Overtopping during the SDF may be allowed if properly prepared analyses demonstrate that: (1) overtopping will have a return interval greater than 25 years; and (2) the dam will withstand the projected overtopping without failure.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments: NRCS dams

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50-100	% of the	PMF
New Significant Hazard Dam must pass	25-100	% of the	PMF
Existing Significant Hazard Dam must pass	25-100	% of the	PMF

Comments: Percentage ranges are given and are based upon effective height of dam or maximum storage, whichever computed SDF is greated.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 0.25PMF to 0.75PMF depending on size of dam (small, intermediate, or large).

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	California
Name of Representative	David A. Gutierrez
Title of Representative	Chief, Division of Safety of Dams
Phone number(s)	916-227-9800
Email address	daveg@water.ca.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1247
High Hazard Dams	688
Significant Hazard Dams	274
Low Hazard Dams	285
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1930

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: We also have other execptions to jurisdiction.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: However, dams of different consequence class have varying design standards/requirements. For instance, a PMF is applied to very high hazard dams while a 1000 year level storm is for very low potential consequence. Same with earthquakes. Flood Control dams also have different requirements.

6 Does the Organization have published size classification criteria?

No

Comments: Damage potential classification based on capacity, height, estimated evacuation, and potential d/s damage

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Other (Please specify)

Comments: Damage potential classification based on capacity, height, estimated evacuation, and potential d/s damage

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

Comments: The force of law is not specifically outlined but California gives dam safety program broad authority to enforce these requirements. These are not "guidelines" as defined by the State of California, but Technical Reference how it is done at DSOD.

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 03/01/1981

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: There is no specific date yet determined

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: The technical reference does not outline variations, but DSOD has different policy for new and existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

15 For PMP/PMF designs, is freeboard required?

1.5'

Comments: Additional freeboard is required for severe wave conditions from wind effects. In addtion 1.5 feet is required on new dams while existing dams may not be required to have more than zero residual freeboard depending on wave runup.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

Comments: Our inhouse evaluations use HEC. Statiscial requirements for dams is dependent on potential consequence.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (72-hour)

Comments: In general, the total precipitation duration is taken to be 72 hours. If routing will not significantly affect the peak outflow, a shorter storm (e.g., 24 hours) can be considered since the peak inflow will be about the same in either case.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: The guidelines do not specify to this detail, but DSOD practice considers spatial storm distribution.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

Comments: Spillway design criteria is based on frequency of flooding up to the PMP

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments: On occasion downstream development changes the hazard classification, but in most cases in California, most of the dams are already at the highest level.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: For non flood control dams, reservoir is taken at spillway level. Antecendent moisture conditions are considered in evaluating the runoff coefficient.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

Comments: Guidelines don't specify, but DSOD has considered incremental damage in past and plans to develop guidelines for use.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: It is prudent to a allow a continuous range of design floods corresponding to the developed Total Class Weights. The minimum allowable design event required is a 1000 year storm which corresponds with a TCW of 4. The maximum event is a storm derived from the Probable Maximum Precipitation and is equated with a TCW of 30. The design event is interpolated between these limits at the computed TCW. Typically, probable maximum precipitation storms are required only for dams that impound 1000 acre-feet or more, are at least 50 feet high, would require an estimated evacuation of at least 1000 people, and have a damage potential of $25,000,000 or greater. However, most dams require a design storm falling between the 1000 year event and the probable maximum event. Figure 2 presents a histogram of TCW (as determined by DSOD) for all jurisdictional dams within California. As can be seen, less than 8 percent of all dams require a PMF.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 1000-year

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: We have allowed the use of early warning systems as part of interim measures until dam is repaired.

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

Comments: The definition of risk based hydrologic design is not defined in this question and means different things to different people. However based on the risk, DSOD applies statistical storms starting with a 1000 year level up to a PMP

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: We usually apply policy and give direction based on that policy. Regulations are too stiff and do not seem the appropriate way to deal with technical issues. Statutes are even worse and should never be used to dictate technical issues.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Colorado
Name of Representative	Mark R. Haynes
Title of Representative	Chief Dam Safety Engineer
Phone number(s)	303-866-3581
Email address	mark.haynes@state.co.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	3000
Total Regulated Dams	1935
High Hazard Dams	352
Significant Hazard Dams	322
Low Hazard Dams	1261
Unregulated Dams	1065
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1967

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 100 acre-feet or creates a reservoir with a surface area less than 20 acres at the high-water line, or is less than 10 feet in height.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	20	feet high and stores =<	100	acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>	4,000	acre-feet
Other (Specify)					

Comments: The three classes in increasing size are: Minor Dam, Small Dam, Large Dam.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: The classfications are as follows: High, Significant, Low, and No Public Hazard (NPH).

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

USBR guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2007

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments: Next update in 10 years

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Grandfather clause for dams built prior to 1988. Minimum IDF criteria of the 100-year storm.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Have final approval of IDF

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: The minimum freeboard requirements for new or enlarged dams shall be based upon the dam height required to prevent overtopping by wave action, or the sum of the inflow design flood maximum water surface level plus one foot of residual freeboard, but not less than five feet unless the State Engineer approves a lesser amount. Except for concrete dams where the design engineer has demonstrated that overtopping of the dam will not be detrimental to the safety of the dam, the inflow design flood can be accommodated with zero residual freeboard or the overtopping depth at which the dam still meets the stability and stress requirements of Rule 5.9.5.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: For high frequency storms.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: Depends on procedures in HMRs and Hydrologic Software

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Site Specific Hydrometeorologic Analysis (SSHMA) may be used to determine the appropriate site specific extreme storm precipitation (SSESP) for the determination of the IDF. Site-specific evaluations are subject to approval by the State Engineer. Any procedures developed and approved by the State Engineer shall be used to determine the applicable Extreme Precipitation Event. Snowmelt conditions shall be considered as base flow when appropriate. The percentage reduction of the PMP as shown in Rule 5.9.1.5 are not applicable or allowed in the determination of site specific extreme storm precipitation or PMP values determined by the procedures and analysis provided for in this Rule for all High Hazard dams and Large Significant Hazard dams. Specific percentages of the Site-specific PMP are required based on size and hazard classification.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: Constant

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: No for antecedent moisture conditions and yes for initial reservoir pool levels.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum IDF is the 100-year event

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	0.45-0.90	% of the	PMP
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass	0.45-0.68	% of the	PMP
Existing Significant Hazard Dam must pass		% of the	

Comments: Based on size classification as well. There are also percentages of the PMP for special cases involving reductions due to elevation and site specific PMPs.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 50 to 100 year depending on size classification.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Could require Statutory changes and would require public review and hearings.

34 Are there any unique provisions in your regulations?

No

FEMA

HYDROLOGIC SAFETY OF DAMS
QUESTIONNAIRE

Gannett Fleming
Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Connecticut
Name of Representative	Arthur P. Christian II, P.E.
Title of Representative	Supervising Civil Engineer
Phone number(s)	860-424-3880
Email address	art.christian@act.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	3024
High Hazard Dams	242
Significant Hazard Dams	267
Low Hazard Dams	2515
Unregulated Dams	1455
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria?

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Or all other dams with an impoundment capacity of three (3) acre-feet or less.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (Other)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Negligible (Class AA), Low (Class A), Moderate (Class BB), Significant (Class B), and High (Class C)

8 Does the Organization have guidelines for determining the spillway design flood?

No

If "Yes", what is the status of the guidelines; do they have the force of law?

Unpublished guidelines for consideration by the engineer/designer

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Written by Philip Moreschi

10 When were the guidelines last revised (MM/DD/YYYY)? n/a

Comments: Continuous revision

11 Are there any plans to update or revise the guidelines in the near future?

Comments: Continuous revision

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

Comments: No specific requirements although wave runup may be considered by the design engineer based on the specific dam.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Comments: The agency requires standard public domain software applications such as Hec-HMS or NRCS type modeling.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: The agency requires that the engineer demonstrates that the methodolgy/analysis is both appropriate and an accepted engineering standard.

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments: Hazard classifications get changed routinely however most changes occur within the category of low hazard dams. Therefore spillway design requirements do not need to be modified.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: Only if future development is known to be planned.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	50-100	% of the	PMF
New Significant Hazard Dam must pass	50-100	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

Comments: The above criteria assume that the impoundment sizes are large and intermediate as defined by the ACOE spillway design criteria.

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: With one foot of freeboard or passing two times the 100 year without overtopping.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

Comments: The agency has not considered risk-based hydrologic designs at this time.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

Comments: The agency has not considered risk-based hydrologic designs at this time.

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: It is a lengthy formal process that can take up to two years. It is time intensive and sensitive to deadlines and subject to the will of a legislative committee.

34 Are there any unique provisions in your regulations?

No

Comments: The agency's regulations only pertain to the periodic inspection of dams.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Delaware
Name of Representative	David R. Twing
Title of Representative	State Dam Safety Engineer
Phone number(s)	302-834-5557
Email address	david.twing@state.de.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	49
Total Regulated Dams	49
High Hazard Dams	44
Significant Hazard Dams	5
Low Hazard Dams	0
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 2009

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: any one of the following: privately owned; low hazard; less than 6 feet high; less than 15 acre-feet of storage

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: High Hazard includes any dam whose failure or misoperation will cause probable loss of human life. Significant Hazard includes any dam whose failure or misoperation will cause possible loss of human life, economic loss, environmental damage, and disruption of lifeline facilities. Low Hazard is unlikely to cause loss of human life but may cause minor economic and/or environmental losses.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 12/11/2009

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Incremental damage assessment may be used to reduce the spillway design flood of existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Performance criteria specified for pipe conduit spillways, vegetated auxiliary spillways, etc. Activation criteria are also specified.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: Not a problem for us yet because we just started our dam safety program; the hazard classifications for all dams in the state were determined in 2008

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: All Class II and III dams shall, where practicable, incorporate in the proposed design the ability to make modifications necessary to increase the spillway capacity of the facility or other alternative measures if the downstream hazard potential increases.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: For existing dams only.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum design storm for the dam shall be the 100-year storm.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Changes in the regulations that don't involve changing the enabling legislation still require public notice, so I would use "moderate" to describe that process.

34 Are there any unique provisions in your regulations?

No

HYDROLOGIC SAFETY OF DAMS
QUESTIONNAIRE

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Georgia
Name of Representative	Tom Woosley
Title of Representative	Program Manager
Phone number(s)	404-362-2678
Email address	tom_woosley@dnr.state.ga.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	3926
High Hazard Dams	474
Significant Hazard Dams	0
Low Hazard Dams	3452
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1978

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 25 feet or stores less than 100 acre-feet. Also those less than 6 feet in height regardless of storage capacity or which have storage capacity of less than 15 acre-feet regardless of height.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	25	feet high and stores =<	500	acre-feet
Class B (Medium)					
Class C (Large)	=>	35	feet high and stores =>	1000	acre-feet
Other (Specify)	Very Large Dams: > 100 feet and > 50,000 acre-feet				

7 Does the Organization have published hazard classification criteria?

Yes (Other)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Other (Please specify)

Comments: Only two categories: Category I means the classification where improper operation or dam failure would result in probable loss of human life. Category II means the classification where improper operation or dam failure would not be expected to result in probable loss of human life.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: The law states the requirement, the guidelines detail out how we would determine the PMP

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: Developed with help of consultants in 1998

10 When were the guidelines last revised (MM/DD/YYYY)? 06/01/2007

Comments: Version 3.1

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Talking about it, but not in the works right now.

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Based on visual inspection and detailed hydrologic and hydraulic evaluation, including documentation of completed design and construction procedures, up to 10 percent lower requirement (22.5, 30, 45, 90) may be accepted on existing PL566 (including RC&D structures) and PL 534 Project Dams at the discretion of the Director, provided the project is in an acceptable state of maintenance. The design storm may be reduced on existing dams if the applicant's engineer can successfully demonstrate to the Director, by engineering analysis, that the dam is sufficient to protect against probable loss of human life downstream at a lesser design storm. Earth emergency spillways shall not function until the 50 year storm.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on size classification only

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: 3-foot maximum

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HEC-1

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: Models other than HEC-1 must be approved prior to design.

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Earth emergency spillways shall not function until the 50 year storm. SITES integrity analysis is required for earthen spillway.

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC-III is to be used on the 6-hr storm

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: For existing dams only.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Requirement can be reduced by up to 10%.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

Comments: Very large dam (100% of PMP), Large dam (50% of PMP), Medium dam (33.3% of PMP), and Small dam (25% of PMP)

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

No; our regulations forbid them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Extremely, especially in the current political climate

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Hawaii
Name of Representative	Edwin Matsuda
Title of Representative	Civil Engineer
Phone number(s)	808-587-0268
Email address	edwin.y.matsuda@hawaii.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	138
High Hazard Dams	123
Significant Hazard Dams	3
Low Hazard Dams	12
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1992

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: < 25ft height & < 50acft volume at max water surface elevation; or < 6 ft height; or < 15 acft volume at max water surface elevation

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: "Significant hazard" means a dam's or reservoir's failure will result in no probable loss of human life but can cause major economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams or reservoirs are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Unpublished guidelines that are required

Comments: Design flows are specified in the draft administrative rules and pending approval will have the same authority as the law.

9 What is the origin of the guidelines?

Other (Please specify)

Comments: Originally specified in our guidelines and probably based on FEMA guidance material in the early 1990s. Current draft reflects previous guidelines with some minor

10 When were the guidelines last revised (MM/DD/YYYY)? 12/01/1992

Comments: Guidelines are currently being updated. Administrative rules have been drafted, passed through public hearings and is pending final approval.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Currently contracted out to consultant

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: Freeboard requirement determined on case by case requirement. Proposed Rules will specify "the greater of the following: (1) Two feet above the water level during the peak spillway flow associated with the inflow design flood; (2) Sum of the wave run-up and reservoir setup resulting from a 100 mph wind speed during the peak spillway flow associated with the inflow design flood."

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: Existing guidelines specify SCS type I distribution however not defined in current draft HAR. May be addressed in guidelines update.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50-100	% of the	PMF
Existing Significant Hazard Dam must pass	50-100	% of the	PMF

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 100 year for small and intermediate low hazard dams and 0.5PMF for large low hazard dams.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: There are provisions within our draft administrative rules for our approving board to grant variances to the requirements. Sufficient justification and assurances would likely be required for these to be approved.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Changes to our regulations can either be done through statute via our state legislature or through rules which require proceeding through the rule making process. Either change or revision will likely face a large amount of questions and possible resistance and require a lot of time and resources to address.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Our revisions do allow for our approving board to grant variances to the requirements stated. This was believed to be the best method of covering many of the specific issues in the regulations that we may not have addressed adequately. Also allows for owners of existing dams some other means of mitigating deficiencies which the dam may not have been required to meet when it was designed.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Idaho
Name of Representative	John Falk
Title of Representative	
Phone number(s)	208-287-4927 / 208-287-4800
Email address	John.Falk@idwr.idaho.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	569
High Hazard Dams	107
Significant Hazard Dams	149
Low Hazard Dams	313
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? Last revised 2006

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Statute definition is for Regulated Dams; i.e. 10 feet or more in height or with an impounding capacity of 50 acre-feet or more. Conversely, non-regulated dams are those less than 10' high AND less than 50 ac-ft.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Mine tailings impoundment structures which are, or will be, more than 30 feet high are regulated by the state dam safety program.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	20	feet high and stores =<	100	acre-feet
Class B (Medium)					
Class C (Large)	=>	40	feet high and stores =>	4,000	acre-feet
Other (Specify)					

Comments: Contained within Administrative Rules only

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Other (Please specify)

Comments: In the Administrative Rules, the term "Risk" is substituted for "Hazard" inappropriately. In Rule, "Significant Risk" is based on flood depth, velocity, and consequence of significant damage to intrastructure; loss of life is not mentioned.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

Comments: Contained within Administrative Rules

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2006

Comments: Administative Rules last revised in 2006

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments: Lack of staff resources to pursue revisions

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Exemptions if approved by Director, exemptions based on existence prior to the state's dam safety laws.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

...with reference to existing Administrative Rule.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: Problem will intensify because cost for rehabilitation is increasingly costly, permitting may be Catch-22, and lack of dam safety resources likely will not allow periodic review and/or enforcement.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	Q100-100	% of the	PMF
Existing High Hazard Dam must pass	Q100-100	% of the	PMF
New Significant Hazard Dam must pass	Q100-50	% of the	PMF
Existing Significant Hazard Dam must pass	Q100-50	% of the	PMF

Comments: High hazard dam: Q100-PMF, depending on size of dam; Significant hazard dam: Q100-0.5PMF, depending on size of dam.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Q50-Q500 depending on size of dam; these lower and upper boundaries are prescriptive and extreme, and badly in need of revision.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Comments: Cannot speculate as existing Statute and Rule do not address applicability. Organization would consider revising Rules to offer the opportunity, with conditions.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

Comments: The only review has been cursory for federal dams or federal regulated hydroelectric dams in which the State is a marginal participant.

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: The procedure appears to be moderately involved (formation of committee, legislative committee recognition, hearings/testimony prior to acceptace by legislature). However, dam safety staff has been significantly reduced making any proposed revisions unlikely without neglecting primary safety mission of routine inspection and design review.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Illinois
Name of Representative	Jason Campbell
Title of Representative	Senior Permit Engineer
Phone number(s)	217-558-4532
Email address	jason.campbell@illinois.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1485
High Hazard Dams	187
Significant Hazard Dams	299
Low Hazard Dams	999
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1980

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Also, if the drainage area of the dam is 6400 acres or less in a rural area, or 640 acres in an urban area

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Technical publications other than the Corps Guidelines may be used to assure the use of current and applicable data for the hydrologic and hydraulic review of dam design.

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2003

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Reduced spillway design requirements for dams built before September 2, 1980. Any submittal for variation from the reduced spillway design flood must include a detailed hydraulic risk assessment that shows that additional spillway capacity will not provide a decrease in potential loss of life or property damage or a detailed economic risk assessment that shows that the chosen spillway design alternative provides the minimum rehabilitation costs plus damage losses; a detailed early warning and emergency evacuation plan coordinated with the local ESDA; and a list (with mailing addresses) of all persons living within the dam breach wave inundation area.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Case-by-case basis considering many factors including duration of high water levels during the design flood, the effective wind fetch and reservoir depth available to support wave generation, the probability of high wind speed occurring from a critical direction, the potential wave runup on the dam based on roughness and slope, and the ability of the dam to resist erosion from overtopping waves.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

Comments: Procedures developed by US Army Corps of Engineers, US Dept of the Interior (Bureau of Reclamation), US Dept of Agriculture (Natural Resources Conservation Service), and the National Weather Service are recommended as acceptable. The programs typically used by OWR for review include: HEC-1, HEC-HMS, HEC-2, HEC-RAS and FLDWAV.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: At least a 24-hour duration.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Regulations distinguish between principal spillway design flood and total spillway design flood.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: Never been done at this point.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: Changing the classification / spillway design requirements is not difficult, occasionally there is some resistance to implementation of the new classification.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: For all proposed Class II or III dams, a determination of alternatives for increasing the total spillway capacity to accommodate the PMF shall also be submitted to OWR. The initial dam design shall provide for the capability of increasing the spillway capacity. future downstream land use, land use controls, and growth projections will be considered in the review of the spillway capacity design.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: No less than 100-year flood unless it is a small size, Class III structure with dam height multiplied by impounding capacity less than or equal to 300.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	30-60	% of the	PMF
New Significant Hazard Dam must pass	100yr-100	% of the	PMF
Existing Significant Hazard Dam must pass	100yr-60	% of the	PMF

Comments: Class I: 0.5PMF-1.0PMF; Class II: 100-yr-PMF; Class III: 100-yr-0.5PMF; Ranges depend on the size of dam.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Ranges from 100-yr for a small dam to 0.5PMF for a large dam.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: Any submittal for variation from the above-listed spillway design flood must include a detailed hydraulic risk assessment that shows that additional spillway capacity will not

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Unsure

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Theoretically, it should not be very difficult. However given the current state of State politics it would in all likelyhood be very difficult.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Indiana
Name of Representative	Kenneth E. Smith, P.E.
Title of Representative	Assistant Director
Phone number(s)	317-232-4224
Email address	kesmith@dnr.IN.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1088
High Hazard Dams	240
Significant Hazard Dams	249
Low Hazard Dams	599
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? not formally adopted

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: The drainage area above the dam site is less than one square mile; the height of the dam above the natural stream bed or the lowest point on the valley floor is less than 20 feet; the volume of water impounded by the dam to the emergency spillway level is less than 100 acre-feet; or the rights of other property owners are affected.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: coal mine related dams held to MSHA standards, by the Division of Reclamation

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Also includes a "Multiple Dams" classification. Where failure of a dam could contribute to failure of a downstream dam or dams, the minimum hazard class of the dam shall not be less than that of any such downstream structure.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: attempted to use typical national best management practices

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2001

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: will revise if a new unified national practice is published

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: The design storm for existing dams can be reduced using Incremental Damage Evaluation

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (Based on Tc)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (NRCS Standard)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: administrative legal processes, public notice and hearings required

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC II

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: For existing dams only. The owner and engineer should recognize that dam construction typically results in higher risks. If an Incremental Hazard Evaluation procedure is utilized,

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: 50% PMP minimum for High Hazard dams, 100-Year minimum for Low Hazard dams

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass	50	% of the	PMP
Existing Significant Hazard Dam must pass	50	% of the	PMP

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Ranges from 100-year to 50% PMP.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Iowa
Name of Representative	Mr. Jonathan Garton
Title of Representative	Senior Dam Safety Engineer
Phone number(s)	515-281-6940
Email address	jonathan.garton@dnr.iowa.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	3568
Total Regulated Dams	3568
High Hazard Dams	99
Significant Hazard Dams	222
Low Hazard Dams	3247
Unregulated Dams	341
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? Pre 1990

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Iowa Jurisdictional thresholds: a. Any dam designed to provide a sum of permanent and temporary storage exceeding 50 acre-feet at the top of dam elevation, or 25 acre-feet if the dam does not have an emergency spillway, and which has a height of 5 feet or more.
b. Any dam designed to provide permanent storage in excess of 18 acre-feet and which has a height of 5 feet or more.
c. Any dam across a stream draining more than 10 square miles.
d. Any dam located within 1 mile of an incorporated municipality, if the dam has a height of 10 feet or more, stores 10 acre-feet or more at the top of dam elevation, and is situated such that the discharge from the dam will flow through the incorporated area.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Major Dams have special requirements and are defined as: 1. Any high hazard dam.
2. Any moderate hazard dam with a permanent storage exceeding one hundred (100) acre-feet or a total of permanent and temporary storage exceeding two hundred fifty (250) acre-feet at the top of the dam elevation. 3. Any dam, including low hazard dams, where the height of the emergency spillway crest measured above the elevation of the channel bottom at the centerline of the dam (in feet) multiplied by the total storage volume (in acre-feet) to the emergency spillway crest elevation exceeds 30,000. For dams without emergency spillways, these measurements shall be taken to the top of dam elevation.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small) =< [ ] feet high and stores =< [ ] acre-feet

Class B (Medium)

Class C (Large) => [ ] feet high and stores => [ ] acre-feet

Other (Specify) [ ]

Comments: See comment above concerning major dam criteria.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Structures located in areas where failure may damage isolated homes or cabins, industrial or commercial buildings, moderately traveled roads or railroads, interrupt major utility services, but without substantial risk of loss of human life.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

NRCS guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 12/01/1990

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Yes, we are beginning the process this year of updating our entire dam safety program rules.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: For dams with emergency spillways, the top of dam elevation after settlement shall not be less than the highest peak pool elevation reached during the freeboard design flood. For dams without an emergency spillway, the top of dam elevation shall be two feet higher than the peak flood elevation expected to occur during passage of the freeboard design flood, unless it is specifically designed to withstand the overflow.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: 6 hour, 24 hour, and 10-day storm durations are specified and recommendations are made for each.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: Some acceptable methods of distributing the rainfall in Iowa are found in the U.S.D.A. Soil Conservation Service publication, TR-60, Earth Dams and Reservoirs; and the Illinois State Water Survey publication, Time Distribution of Rainfall In Heavy Storms by F. A. Huff.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Performance and activation criteria are given for both principal and emergency spillways.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Follow guidelines in HMR 51 and 52.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: Dam owners are required to upgrade the dam if hazard classification changes.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Conservative loss rates (interception, infiltration, etc.) and antecedent moisture conditions should be used in computing rainfall excess. Also, when applicable, snowmelt runoff rates should be estimated. The Soil Conservation Service (SCS) weighted curve number method is acceptable for determining rainfall losses and is explained in National Engineering Handbook Section 4 Hydrology, SCS, 1972.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Low hazard classified as major structures must also pass 50% of the PMF. Otherwise, a. Where the height of the emergency spillway crest* measured above the elevation of the channel bottom at the centerline of the dam (in feet) multiplied by the total storage volume (in acre-feet) to the emergency spillway crest elevation* is between 3,000 and 30,000, the flood shall correspond to the rainfall calculated from the following formula developed by the USDA Soil Conservation Service. Rainfall = P100 + 0.12 (PMP – P100) b. Where the height of the emergency spillway crest* measured above the elevation of the channel bottom at the centerline of the dam (in feet) multiplied by the total storage volume (in acre-feet) to the emergency spillway crest elevation* is less than 3,000, the flood shall be that resulting from the 50- year, 24-hour precipitation.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: There is a formal rule making process for the DNR that involves public input. It is a lengthy process but can be initiated at any time.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Kansas
Name of Representative	Kimberly A. Feldkamp, P.E.
Title of Representative	Dam Safety Team Leader
Phone number(s)	785-296-4625
Email address	kimberly.feldkamp@kda.ks.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	6058
High Hazard Dams	202
Significant Hazard Dams	238
Low Hazard Dams	5618
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1984

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: A jurisdictional “dam” means any artificial barrier including appurtenant works with the ability to impound water, waste water or other liquids that has a height of 25 feet or more; or has a height of six feet or greater and also has the capacity to impound 50 or more acre feet. Anything that does not meet this definition is non-jurisdictional.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<		feet high and stores =<	3000	acre-feet
Class B (Medium)					
Class C (Large)	=>		feet high and stores =>	30000	acre-feet

Other (Specify) Class 1 is less than 25 feet high and an effective storage of less

Comments: Each dam with an effective height of less than 25 feet and an effective storage of less than 50 acre-feet shall be considered to be a class size 1 dam. The class size of all other dams shall be determined from the following table:

Class size	Size factor
2	less than 3,000
3	3,000 through 30,000
4	more than 30,000

"Effective height" means the difference in elevation between the crest of an auxiliary spillway or service spillway and the lowest point of the downstream toe of a dam. If the dam does not have an auxiliary or service spillway, the effective height means the difference in elevation between the top of the dam and the lowest point of the downstream toe of the dam.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

NRCS guidelines

Comments: The NRCS guidelines was used as guidance to develop our own criteria

10 When were the guidelines last revised (MM/DD/YYYY)? 05/18/2007

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: There could be different guidelines on existing dams depending upon when they were permitted or constructed.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: It varies do to size class and hazard classification.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use SCS unit hydrograph

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Auxiliary spillway failure criteria are provided. The auxiliary spillway shall not fail by breaching during the spillway stability design event indicated in the following: Hazard Class A, Size 1, 2, or 3: 0.3PMP; Hazard Class A, Size 4: 0.4 PMP; Hazard Class B, All Sizes: 0.5 PMP; Hazard Class C, All Sizes: PMP.

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC II or III depending on location. The routing shall begin by assuming that the water surface elevation is at the elevation of the lowest uncontrolled spillway inlet, not including any low-flow augmentation works.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	40	% of the	PMP
Existing High Hazard Dam must pass	40	% of the	PMP
New Significant Hazard Dam must pass	25-30	% of the	PMP
Existing Significant Hazard Dam must pass	25-30	% of the	PMP

Comments: New and existing high hazard dams must pass 40% of PMP plus have 3 feet of freeboard. Significant hazard new and existing dam size class 1 and 2 must pass 25% of PMP plus have 2 feet of freeboard and significant hazard new and existing dams class 3 and 4 must pass 30% of PMP plus have 3 feet of freeboard.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Size class 1 50-year with 1 foot freeboard. Size class 2 100-yr plus 2 feet freeboard. Size Class 3 100-yr 3 feet of freeboard. Size class 4 25%PMP with 3 feet of freeboard.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: The proposed regulations would have to be approved by the following Department of Agriculture Legal, Department of Administration, Attorney General's Office, and the Administrative Rules and Regulations Joint Committee

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Kentucky
Name of Representative	Ms. Marilyn Thomas
Title of Representative	Environmental Engineer Consultant
Phone number(s)	502-564-3410
Email address	marilync.thomas@ky.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1066
High Hazard Dams	178
Significant Hazard Dams	217
Low Hazard Dams	671
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? pre-1978

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 25 feet in height and an impounding capacity of less than 50 acre-feet or no downstream hazard to human life.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Class A (High), Class B (Moderate), and Class C (High)

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

NRCS guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 06/01/1999

11 Are there any plans to update or revise the guidelines in the near future?

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: SITES, HMS, NWS DAMBRK, HEC-RAS are acceptable

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Criteria are given for activation, performance, and capacity of earth emergency spillways.

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMCII or greater

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: P Design (Class B, Significant) = P100 + 0.40*(PMP-P100)

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: P Design (Class A) =P100 + 0.12*(PMP-P100)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Dam owners may not properly maintain or operate warning systems, rendering them ineffective.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Reg changes must be approved by the legislature. If the legislature perceives the change as more demanding or expensive to dam owners that change likely won't be approved. We've worked for 10 years to get approval for Emergency Action Plans with no success.

34 Are there any unique provisions in your regulations?

No

HYDROLOGIC SAFETY OF DAMS
QUESTIONNAIRE

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Louisiana
Name of Representative	Zahir "Bo" Bolourchi, P.E.
Title of Representative	Director, P.W. & Water Resources Programs
Phone number(s)	225-274-4170
Email address	Bo.Bolourchi@la.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	599
Total Regulated Dams	555
High Hazard Dams	33
Significant Hazard Dams	72
Low Hazard Dams	450
Unregulated Dams	49
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1981

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: LA R.S. 38:22

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Appreciable damage to property or possible loss of life.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Other (Please specify)

10 When were the guidelines last revised (MM/DD/YYYY)? 03/01/1997

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Design storm is determined by down stream conditions

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

3.0' or more

Comments: Title 44, CRF 65.10 (B-1 Freeboard)

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: For the purpose of the Dam Safety Program, the Emergency Spillway shall be defined as being overtopped by the 100-year storm or greater and the Principal Spillway shall be defined as being overtopped by a storm less than the 100-year storm. Also, some damage to the emergency spillway is tolerable since they are activated only during major storm events.

22 Does the organization allow development of a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: Change in classification is based on down stream conditions

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50-100	% of the	PMF
New Significant Hazard Dam must pass	100-yr-100	% of the	PMF
Existing Significant Hazard Dam must pass	100-yr-100	% of the	PMF

Comments: These are minimum IDFs. Regulations stipulate that an incremental assessment be performed for all High Hazard and some Significant Hazard dams. The full PMF is the maximum IDF for both of these hazard classes.

29 For low hazard dams, the spillway design requirement is:

50-year flood

Comments: Minimum IDF (no incremental assessment required)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

No; our regulations forbid them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Change in regulations could be challenging at this time.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Maine
Name of Representative	Tony Fletcher, P.E.
Title of Representative	State Dam Inspector
Phone number(s)	207-624-4465
Email address	Tony.Fletcher@maine.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	860
High Hazard Dams	29
Significant Hazard Dams	71
Low Hazard Dams	536
Unregulated Dams	191
Other	33

3 What year did your Agency adopt minimum Inflow Design Flood criteria? n/a

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: No probable loss of life but major economic loss, environmental damage or disruption of lifeline facilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Other (Please specify)

Comments: The USACE are recommended when questions arise.

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

10 When were the guidelines last revised (MM/DD/YYYY)? n/a

Comments: Never revised

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Makes recommedations

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

24 Do guidelines require consideration or analysis of future development?

No

Comments: A hazard inspection is required every 6 years when the hazard of a dam is reviewed.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Comments:

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Maryland
Name of Representative	Harald W. Van Aller
Title of Representative	Geotechnical Engineer
Phone number(s)	410-901-4042
Email address	hvanaller@mde.state.md.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	406
Total Regulated Dams	382
High Hazard Dams	68
Significant Hazard Dams	87
Low Hazard Dams	227
Unregulated Dams	Unknown
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? About 1976

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: All dams in MD are juridictional regardless of size, although some low hazard dams less than 20 ft high can be approved by local soil conservation district in lieu of a state waterway construction permit.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	25	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>	20,000	acre-feet
Other (Specify)	Class IV, see comments.				

Comments: Category IV is reserved for small dams which have a drainage area of less than 1 square mile (640 acres), and a normal depth of water less than 15 feet above the original stream bed, a normal pool storage of less than 100 acre-feet, and a normal surface area less than 12 acres.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: "small possibility" of loss of life. Located in predominately rural or agricultural areas where failure may cause damage to isolated residences or cause interruption of use or service of public utilities or roads. Damage is within the financial capability of owner to repair

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

USBR guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 07/01/1979

Comments: Some minor changes have been made since 1979, but no substantial changes have been made to hazard classification and design storm requirements

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Current regs address only new dams. MD has been working on new regulations for about 15 years which would also include pre-existing dams.

12 Are the guidelines different for new and existing dams?

No

Comments: The new regulations would have different guidelines for pre-existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: No specific freeboard is required. The design shall allow for certain freeboard as a minimum, not to be reduced under any circumstances during the operation of the dam and reservoir. The design freeboard is for that reservoir stage which will exist when the pool has reached maximum level during the inflow design flood with the outlet works and overflow spillway operating as planned. The freeboard is to be calculated to prevent overtopping and protect the dam against the destructive forces of waves, frost, settlement, and surface erosion.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: For drainage areas less than or equal to 10 square miles, TR-20 or HEC-1 must be used. For drainage areas larger than 10 square miles, HMR-52 and HEC-1 is recommended.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: software must be in the public domain (not proprietary) so the results can be duplicated by agency staff

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

Comments: For drainage areas less than or equal to 10 square miles, use a 24-hour duration for the 100-year and brim-up storm events, and a 6-hour duration for the 50%PMF and PMF.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: 100-year unless it is a small dam

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: This has only been evaluated at one dam that I am aware of. use of FERC guidelines is suggested to other dam owners who ask about this issue.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: Current regulations are based on ultimate development of land based on current zoning.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

Comments: Although current regulations do not allow for incremental analysis, MD has been allowing this on a case by case basis

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

Comments: Class II (Significant): Regulations state: The design storm shall be the "standard project flood" or the largest flood of record, whichever is greater.

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: Plus 2 feet of freeboard, unless the design includes an open channel emergency spillway, in which case freeboard can be reduced to 1 foot.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: At one time we allowed that, but not currently.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

Comments: However, the Corps of Engineers has recently cited a risk-based analyses for rejecting the need to upgrade a large dam designed in the 1960's and constructed in MD in 1980 to safely pass the full PMF

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: We have been working on revised regulations for more than 15 years.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Massachusetts
Name of Representative	Michael D. Misslin
Title of Representative	Deputy Chief Engineer
Phone number(s)	617-626-4927
Email address	Mike.Misslin@state.ma.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1545
High Hazard Dams	304
Significant Hazard Dams	727
Low Hazard Dams	514
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria?

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: All dams are inventoried. The following are non-jurisdictional:1) any barrier which is not in excess of six feet in height, regardless of storage capacity, or which has a storage capacity at max water storage elevation not in excess of 15 acre feet, regardless of height. 2) any barrier with low hazard potential classification in the use of agriculture.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: FERC regulated dams are exempt from regulation

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	15	feet high and stores =<	50	acre-feet
Class B (Medium)					
Class C (Large)	=>	40	feet high and stores =>	1,000	acre-feet
Other (Specify)					

Comments: non-jurisdictional: not in excess of 15 ac ft regardless of ht & not in excess of 6 ft regardless of storage capacity; small: >= 15 ac ft and <50 ac ft storage & >= 6 ft and < 15

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Sig Haz Pot definition: Dams located where failure may cause loss of life and damge home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause interruption of use or service of relatively important facilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Other (Please specify)

Comments: Regulatory requirements for new and existing dams.

9 What is the origin of the guidelines?

Other (Please specify)

Comments: federal guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 11/04/2005

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Existing dams are required to pass a smaller spillway design flood.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: case by case

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: regulations reference US Army Corps, US Bureau of Reclamation and USDA NRCS.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Emergency spillway frequency and performance guidelines are provided.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Unsure

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	500-yr to 50	% of the	PMF
New Significant Hazard Dam must pass	500-yr to 50	% of the	PMF
Existing Significant Hazard Dam must pass	0-yr to 500	% of the	PMF

Comments: Varies depending on hazard classification, size, and whether it’s a new or existing dam. Variations range from 100 year to full PMF.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Ranges from 50-year to 100-year for existing dams; 100-year for new dams. Change in requirement depends on the size of dam.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Michigan
Name of Representative	Byron Lane
Title of Representative	Chief, Hydrologic Studies and Dam Safety Unit
Phone number(s)	517-241-9862
Email address	LANEB@michigan.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1034
High Hazard Dams	84
Significant Hazard Dams	138
Low Hazard Dams	812
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1990

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 6 feet in height or has an impounding capacity of 5 surface acres or less.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Inventory dams which have court ordered lake levels. There are 235 of them.

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)? 05/24/1995

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency acts as designer/engineer

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Michigan does not require PMP/PMF designs.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Agency must approve the design flood.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: No less than the 200-year flood or the flood of record, whichever is greater.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	200 yr-50	% of the	PMF
Existing High Hazard Dam must pass	200 yr-50	% of the	PMF
New Significant Hazard Dam must pass	200-yr	% of the	
Existing Significant Hazard Dam must pass	200-yr	% of the	

Comments: High hazard dams < 40 feet shall pass the 200-year flood or the flood of record whichever is greater. High hazard dams > 40 feet shall pass 0.5PMF. Significant hazard dams shall pass the 200-year flood or the flood of record whichever is greater.

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: Or the flood of record, whichever is greater.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Minnesota
Name of Representative	Jason Boyle, P.E.
Title of Representative	State Dam Safety Engineer
Phone number(s)	651-259-5715
Email address	Jason.Boyle@state.mn.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1161
High Hazard Dams	24
Significant Hazard Dams	126
Low Hazard Dams	1012
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? not formally adopted yet

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 6 feet high; or less than 15 acre-feet of storage; or less than 25 feet high and less than 50 acre-feet of storage with no potential for loss of life; or Federal dam

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Yes, tailings and coal ash dams are held to a different standard.

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Unpublished guidelines for consideration by the engineer/designer

Comments: Regulatory has final say.

9 What is the origin of the guidelines?

Other (Please specify)

Comments: Based on California or ICODS guidelines?

10 When were the guidelines last revised (MM/DD/YYYY)?

Comments: They have not been revised.

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments: It would be a good idea to update these.

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: There is some leeway for existing dams, depending on the situation.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

Comments: We try to ensure the most critical storm duration is used. Based on dam type and time of concentration.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Spillway design floods based on frequency of flooding.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Consistency with other methods.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: It has not been a problem to date.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments: We do check these assumptions.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	100-yr-100	% of the	PMF
Existing Significant Hazard Dam must pass	100-yr-100	% of the	PMF

Comments: Class II (Significant): 100 year to PMF.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 50-yr to 50% PMF

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: May consider it for existing dams.

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Changing regulations would be difficult, changing our internal guidelines would be fairly easy.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Mississippi
Name of Representative	James MacLellan
Title of Representative	Director of Dam Safety Division
Phone number(s)	601-961-5061
Email address	James_MacLellan@deq.state.ms.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	3755
Total Regulated Dams	3755
High Hazard Dams	257
Significant Hazard Dams	76
Low Hazard Dams	3422
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1982

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 8 feet in height, or impounds less than 25 acre-feet, or doesn't impound a stream and doesn't present a downstream threat

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	25	feet high and stores =<	150	acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>	1000	acre-feet
Other (Specify)					

Comments: The size criteria is in the guidance for the design of dams - general guidance

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Significant Hazard is a class of dam in which failure poses no threat to life but may cause significant damage to public infrastructure - roads, railroads, utilities

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: The portion of the regulations that determine the spillway design flood come from NWS HMR and NRCS design hydrograph as well as the hazard classification

10 When were the guidelines last revised (MM/DD/YYYY)? 08/25/2005

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: High hazard dams that were constructed prior to 1982 are allowed to remain in operation if they pass 50% of PMP and are structurally sound.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

Agency reviews submitted designs and performs independent verification if needed. Agency does independent analysis for state lakes.

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: Must use HMR and SCS unit hydrograph

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: Rational equation is not accepted in any case.

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (NRCS Standard)

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: Only if drainage area is greater than 10 square miles.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Principal spillway must pass 100 year 24 hour design storm without activating emergency spillway for High hazard dams.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Will only consider a site specific PMP if drainage area is greater than 10 square miles.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass	50	% of the	PMP
Existing Significant Hazard Dam must pass	50	% of the	PMP

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 35% of the PMP.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: It involves a lot of work on mine and our legal department's part. The difficulty to accepting the change would depend on public opposition and justifying to our Commission.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Missouri
Name of Representative	Paul Simon
Title of Representative	Civil Engineer - Dam Safety
Phone number(s)	573-368-2179
Email address	paul.simon@dnr.mo.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	5240
Total Regulated Dams	677
High Hazard Dams	457
Significant Hazard Dams	147
Low Hazard Dams	73
Unregulated Dams	4563
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1981

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Any artificial or man-made barrier which does or may impound water and is less than 35 feet in height.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: Design requirements are based on downstream hazard classification for all regulated dams.

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: They are: class I, which contains ten (10) or more permanent dwellings or any public building; class II, which contains one to nine (1–9) permanent dwellings, or one (1) or more campgrounds with permanent water, sewer and electrical services or one (1) or more industrial buildings; and class III, which is everything else.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: class 1 = 75% pmp, class 2 = 50% pmp, class 3 = 100 year event

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: NWS HMR 51 is used to define the pmp.

10 When were the guidelines last revised (MM/DD/YYYY)? 06/09/1994

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on hazard classification only

Comments: Also determined by dam type (conventional or industrial), stage of construction, and environmental class

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: The critical duration is used, normally 6, 12, or 24hr storm.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: Bulletin 71, Rainfall Frequency Atlas of the Midwest is recommended in the Engineering Analysis of Dams manual for Missouri, dated August 1989. Huff distribution is used.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: hmr 51 is recommended in the Engineering Analysis of Dams manual for Missouri, dated August 1989.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

Comments: 50-100 yr event is the minimum recommended to activate grass lined emergency spillway in the Engineering Analysis of Dams manual for Missouri, dated August 1989.

22 Does the organization allow development of a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: All cost is on the dam owner.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments: AMC 2 is recommended in the Engineering Analysis of Dams manual for missouri, dated August 1989.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	75-50	% of the	PMP
Existing High Hazard Dam must pass	75-50	% of the	PMP
New Significant Hazard Dam must pass	50-20	% of the	PMP
Existing Significant Hazard Dam must pass	50-20	% of the	PMP

Comments: Ranges depending on the stage of construction

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Ranges from 0.10PMP to 100 year depending on the stage of construction

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: We would have to go through a public hearing process.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Montana
Name of Representative	Laurence Siroky
Title of Representative	Chief, Water Operations
Phone number(s)	(406) 444-6816
Email address	lsiroky@mt.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	2893
High Hazard Dams	105
Significant Hazard Dams	152
Low Hazard Dams	2636
Unregulated Dams	
Other	

3 When did your Organization adopt minimum Inflow Design Flood criteria? 1999

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Less than 50 acre-feet of storage (top of dam)

Comments: All dams regardless of size are jurisdictional dams. Only High Hazard dams and 50 acre-feet or larger are required to be permitted.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: State minimum design standards apply only to HH dams.

6 Does the Organization have published size classification criteria?

Yes

Comments: We have regulations that specify the criteria for a HH dam and applies to dams 50 acre-feet or larger.

7 Does the Organization have published hazard classification criteria?

Yes (Other)

Comments: High Hazard if loss of human life is likely to occur within the breach flooded area as a result of failure of the dam. All other dams are classified separately. Significant and Low Hazard dams are not regulated or inspected by the state.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

Comments: We have agency regulations as well as guidelines.

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: Washington State's approach was consulted in the development of these guidelines.

10 When were the guidelines last revised (MM/DD/YYYY)? 10/01/2008

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments: We are in the process of adding siesmic standards.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

Comments: IDF is determined based on estimated loss of life downstream from the dam caused by spillway failure.

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Comments: Tech notes(guidelines are being developed)

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Regional)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: HMR

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: Minimum inflow design flood for estimated loss of life of 0.5 or less shall be the 500-year recurrence interval flood. Minimum inflow design flood for estimated loss of life greater

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Design standards apply to HH dams only.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Nebraska
Name of Representative	Mr. Patrick Diederich
Title of Representative	Chief of Dam Safety
Phone number(s)	402-471-1222
Email address	

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	2386
High Hazard Dams	134
Significant Hazard Dams	192
Low Hazard Dams	2061
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? unknown

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Unpublished guidelines that are required

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

10 When were the guidelines last revised (MM/DD/YYYY)?

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Currently underway

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Reduced spillway design flood for existing dams as outlined in Question 28

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use SITES

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (Based on Tc)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Regional)

Comments: Site-Specific PMP Study for Nebraska by Applied Weather Associates, LLC (Ed Tomlinson)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Follow industry standards

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Use normal pool with a TR-60 10-day drawdown requirement; AMC II

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	50	% of the	PMP
New Significant Hazard Dam must pass		% of the	
Existing Significant Hazard Dam must pass		% of the	

Comments: NRCS guidelines on SH dams

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: NRCS TR-60

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Nevada
Name of Representative	Robert K. Martinez, P.E.
Title of Representative	Chief, Engineering & Dam Safety
Phone number(s)	775-684-2844
Email address	robertm@water.nv.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	962
Total Regulated Dams	792
High Hazard Dams	171
Significant Hazard Dams	145
Low Hazard Dams	476
Unregulated Dams	0
Other	170

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1951 separate statutes; 2003 codified regulations

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: All dams are "jurisdictional" so non-inventory are: Less than 20 feet in height or less than 20 feet in height and impounds less than 20 acre-feet of water. Dams permitted under an older standard (10' high and 10AF of water) are also still inventoried.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Most effluent, process fluid, and tailing impoundments are exempt from having a spillway, but must be "ring dikes" or divert run-on water. Storm Water Detention dams may have reduced freeboard requirement for PMF.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	20	feet high and stores =<	100	acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>	10000	acre-feet
Other (Specify)					

Comments: "Class C" (Large) is "=>50 feet in height OR >= 10,000 acre feet of storage.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Reasonably low probability of loss of human life or high probability of extensive economic loss or disruption of a lifeline.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Office policy was incorporated into the regulations in 2003. Guidelines are expanded upon Chapter 535 of the Nevada Revised Statutes (NRS) and Chapter 535 of the Nevada Administrative Code (NAC). Policy was developed in association with COE, USBR, FERC, FEMA, and public input.

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2011

Comments: Minor revisions to reflect inventory numbers and changes to forms.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: We anticipate an update commencing in SFY2012.

12 Are the guidelines different for new and existing dams?

No

Comments: However; owners of existing dams are not expected to "instantly" cure any deficiencies due to regulatory thresholds, but be working towards a solution.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Models are not re-run but the asumptions/parameters and model type/suitability are reviewed.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: "Rule of thumb" is 3'. Wave runup calculations are preferred and required if the owner is requesting a smaller freeboard. Exceptions are tailings facilities for deposition (beach) side embankments and Storm Water detention facilities, as requested and supported by calculations then approval by this office.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: However we are discouraging use of TR-55 under most conditions.

18 Do the guidelines specify any criteria for storm duration?

NO

Comments: Loosely based on Tc. The consultant is expected to use reasonable and prudent criteria which are reviewed. The storm duration is more closely tied to the storage regime. 6hr and 24hr local storms are most common but regional storm may control in some circumstances.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: NRCS type II and type III most commonly used but HMR approach also utilized.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: Areal reduction for large watersheds is allowed/expected. Generally under HMR 49 guidelines.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

Comments: Individual operating criteria are developed by the owner and local jurisdictions regarding allowed flow rates/spillway activation and reviewed for adequacy. Operating criteria drives storm selection for design aspects of an individual structure. In all regards the facility must "accomodate" the IDF and the means by which that is accomplished is largely up to the owner and designer.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

Comments: As urbanization occurs, previously compliant or what may be called "safe" structures become noncompliant or "unsafe" due to hydrologic or other inadequacy.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: Likely downstream land use is considered in determining hazard classification and IDF selection.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments: Again, individual operating regime drives antecedent conditions. Response to a specific recurrence interval storm and antecedent moisture are handled on a case-by-case basis. For the intermountain west, the most common antecedent moisture condition is "dry" for convection-type storms but "rain on snow" events often are most severe.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: However, if in the review it is determined that the downstream area is likely to see development in the near future (10-20 years) potential impacts are expected to be discussed. It is largely a local government land-use planning issue. Again, it is on a case-by-case basis. Future anticipated conditions often are the driving force in new dam design.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Never less than a 1% chance of exceedence storm.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	500yr-100	% of the	PMF
Existing Significant Hazard Dam must pass	500yr-100	% of the	PMF

Comments: Significant Hazard: 100% PMF if no provision for a spillway is incorporated into the design or it is classified as a "large" dam. The greater of 0.5PMF or a 500 year flood for "medium" and "small" dams.

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: But we may allow one to help mitigate for certain unsafe conditions (such as an increased hazard situation at an existing dam) depending on the specific need and situation if it is proposed and is reasonable.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Although exempt from the "normal" statutory process to adopt or modify regulations, we do follow them. That requires workshops and public comment. Not impossible but time consuming and somewhat costly.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Nevada specifically prohibits use of CMP within a dam embankment unless it is the interior "form" for a CIP concrete pipe. Dam owners are prohibited from abandoning a dam. All dams are jurisdictional and notice of construction must be made for "below permitting threshold" dams. Owners of a dam are defined as any person who has a water right impounded by the dam, owns land on which the dam lies or owns land on which the reservoir lies.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	New Hampshire Dam Bureau
Name of Representative	Jim Gallagher
Title of Representative	Chief Engineer
Phone number(s)	(603) 271-1961
Email address	James.Gallagher@des.nh.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	2615
High Hazard Dams	134
Significant Hazard Dams	164
Low Hazard Dams	554
Unregulated Dams	
Other	1773

3 When did your Organization adopt minimum Inflow Design Flood criteria? 1981

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 6 feet high.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: FEMA guidelines customized by program

10 When were the guidelines last revised (MM/DD/YYYY)? 08/20/2005

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Reviewed and updated or readopted every 5 to 7 years. Currently in the review process.

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Dams constructed prior to 2/19/1981 are required to pass the following flows with 1 foot of freeboard and without manual operations: Class A (50-year flood or site specific), Class B (100-year flood or site specific), Class C (250% of 100-year flood or site specific)

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

Comments: A combination of the 2nd, 3rd, and 4th options. Our agency also designs and performs the repair and reconstruction of 274 state-owned dams

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: For existing dams and new Low Hazard and Non-Menace dams, owners have option of one foot of freeboard rather than maximum wave run up.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (Based on Tc)

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: Hazard Creep has caused an increase in hazard classification for some dams in the state requiring an increase in spillway discharge capacity,

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: 50-year and 100-year storms shall incorporate antecedent moisture condition 2 as defined in the USDA NRCS NEH, 210-VI-NEH-630.10, August 1, 1969

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

Comments: Not currently, but we are currently evaluating whether or not tot require minimum spillway discharge standards regardless of downstream consequences.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass		% of the	

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: 100-year for Low Hazard, 50-year for Non-Menace

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Regulations are reviewed and updated if necessary every 5 to 7 years. Rulemaking process includes assembling an Advisory Committee of dam owners, consultants, and other interested parties; review and approval by the Agency Legal Unit; and review and approval by Legislative Committee on Administrative Rules.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: waiver provisions

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	New Jersey Office of Engineering and Construction
Name of Representative	John Moyle
Title of Representative	Manager, Dam Safety and Flood Control
Phone number(s)	609-984-0859
Email address	john.moyle@dep.state.nj.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1721
High Hazard Dams	215
Significant Hazard Dams	338
Low Hazard Dams	1168
Unregulated Dams	
Other	

3 When did your Organization adopt minimum Inflow Design Flood criteria? 1981

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Any dam which raises the waters of a stream five feet or more above its usual, mean, low water height

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

10 When were the guidelines last revised (MM/DD/YYYY)? 06/16/2008

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Every 5 years the state must readopt the standards.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

1.0'

Comments: Greater than 1' is required if special conditions of severe frost damage, ice damage or wave action may occur

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: For Classes III and IV only

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (NRCS Standard)

Comments: Type III storm or later

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Pipe conduits used as principal spillways must meet different criteria than auxiliary spillways. For example, all pipe conduits shall convey water at the maximum design velocity without damage to the interior surface. On the other hand, vegetated or unlined auxiliary spillways must be able to pass the design storm without jeopardizing the safety of the structure. Frequency of use criteria are also specified for auxiliary spillways.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Only for existing dams

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: All Class II and III dams shall, where practicable incorporate in the proposed design, the ability to make modifications necessary to increase the spillway capacity of the facility or other alternative measures if the downstream hazard potential increases.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: Not specified - used for existing dams only.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum design storm shall be the 100 year storm.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass	50	% of the	PMP
Existing Significant Hazard Dam must pass	50	% of the	PMP

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: 24-hour, Type III storm

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: There is a public notification process that takes approximately a year to change a rule.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	New Mexico
Name of Representative	Elaine C. Pacheco, P.E.
Title of Representative	Dam Safety Bureau Chief
Phone number(s)	505-827-6111
Email address	elaine.pacheco@state.nm.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	297
High Hazard Dams	149
Significant Hazard Dams	62
Low Hazard Dams	86
Unregulated Dams	101
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1985

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: NM Law was changed in 2009 to mirror the National Inventory Criteria for the size of a jurisdictional dam.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: With the change in NM Law the exemptions for Stock and erosion control dams were no longer needed.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

Comments: NM Classes are small, intermediate and large.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: No probable loss of life but can cause economic loss, environmental damage, disruption of lifeline facilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Other (Please specify)

Comments: Combination of federal and other western states.

10 When were the guidelines last revised (MM/DD/YYYY)? 12/31/2010

Comments: Changes to the Incremental Damage Assessment language to try and clarify the process.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Hope to develop guidelines for evaluating incremental damage. It would be great if FEMA's proposed guidelines provided details rather than a general approach.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Agency will perform independent verification on a case by case basis.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: Anticipated wave runup resulting from a 100 mph wind with reservoir level at the spillway crest will not overtop the dam; Anticipated wave runup resulting from a 50 mph wind with maximum reservoir level from routed SDF will not overtop the dam; Clay core cover and capillary rise requirements are satisfied; A minimum of 3 feet of freeboard remains after seismic deformation; In any case, at least 4 feet of freeboard shall be provided.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: AHYMO a black box program customized from HYMO for hydrology in the Albuquerque area. Program is a black box hard wired and is no longer allowed because intermediate results could not be verified.

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: NM requires that both the Local Storm (6 hours) and General Storm (72 hours) be considered and the more critical storm (results in highest routed water level in the reservoir) be used.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

Comments: Local Storm: HMR 55A and HMR 49 recommend the distribution in HMR5 or USACE EM 1110-2-1411. The more critical distribution is selected. General Storm: The HMRs do not specify a distribution. Center peaking or USBR 2/3 peak is acceptable.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: No damage to the spillway during normal operation. Damage to the spillway during the SDF is acceptable as long as the damage does not result in an uncontrolled release of the reservoir.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: However, analysis will be evaulated for appropriateness. NM is also developing a tool for site specific Extreme Precipitation for areas west of the continental divide to the eastern plains.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

Comments: Hazard creep is a major problem for dams designed and constructed by the NRCS and for other entities

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Initial reservoir pool must be at normal operation or at the crest of the spillway for permanent water storage reservoirs.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Lower limit is the 100-year event.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass	50-75	% of the	PMP
Existing Significant Hazard Dam must pass	50-75	% of the	PMP

Comments: Significant varies with size classification

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Our regulations state no, but waivers could be requested and we might consider the request if adequate justification is provided and the owner has a history of reliability

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

Comments: We would be open to consider this option.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Process is defined in statute. Funds would need to be identified and the change presented to stakeholders to get support (or at least no opposition) during the hearing process.

34 Are there any unique provisions in your regulations?

No

HYDROLOGIC SAFETY OF DAMS QUESTIONNAIRE

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	New York
Name of Representative	Alon Dominitz
Title of Representative	
Phone number(s)	518-402-8130
Email address	axdomini@gw.dec.state.ny.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	5624
High Hazard Dams	390
Significant Hazard Dams	750
Low Hazard Dams	4484
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1970's or earlier

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: A construction permit is required unless the dam is 6 ft high or may impound less than 1 million gallons, or is less than 15 ft high AND may impound less than 3 million gallons.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: Inventory contains structures not considered dams - dams that were never built, failed, or removed.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	40	feet high and stores =>	1,000	acre-feet
Other (Specify)					

Comments: No Medium Size Classification. Storage refers to normal storage

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: A dam failure may result in damage to isolated homes, main highways, and minor railroads; may result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and/or is otherwise likely to pose the threat of personal injury and/or substantial economic loss or substantial environmental damage. Loss of human life is not expected.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Appear to be mostly NRCS criteria, plus for gravity dams USBR Design of Small Dams and USACE

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/1989

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: In early stages of internal development now

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Low (100-year), Significant (150% of 100-year), High (50% PMF)

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

May do independent verification for certain projects

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: 1 ft minimum for small dam, 2 ft minimum for large dam

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: Do not allow Rational Method

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Service Spillway Design Flood vs. Spillway Design Flood

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Have allowed a couple, combined with Incremental Hazard Assessment.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: 2009 revised regulations give hazard class much more importance, so change hazard classes is a growing problem.

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

Comments: New guidance on Engineering Assesment Reports mentions this - DOW TOGS 3.1.4

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments: Typically assume normal initial pool

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

Comments: When site-specific PMP is combined with 1/2 PMF Existing Dam spillway capacity standard, we have asked for an incremental damage assessment. In other cases, dam owners have conducted incremental damage assessment on own initiatiative, to reduce spillway design flood or hazard classification

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

Comments: Nothing in guidelines but have never accepted less than 100-year storm

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50	% of the	PMF
New Significant Hazard Dam must pass	225% of 100yr-40	% of the	PMF
Existing Significant Hazard Dam must pass	150% of 100yr	% of the	

Comments: Depending on size and hazard classification

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Not for new dam. Maybe for existing, if all other options were exhausted. Have never approved this.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Authority for state to regulate any dam whose failure could cause significant damage, regardless of size

HYDROLOGIC SAFETY OF DAMS
QUESTIONNAIRE

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	North Carolina
Name of Representative	Steve McEvoy
Title of Representative	State Dam Safety Engineer
Phone number(s)	919-733-4574
Email address	Steve.McEvoy@ncdenr.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	4640
High Hazard Dams	1125
Significant Hazard Dams	655
Low Hazard Dams	2860
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1980

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 15 feet in structural height or less than 10 acre-feet of storage at top of dam elevation unless high hazard. All high hazard dams are jurisdictional.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Dams designed in accordance with NRCS Engineering Standard 378 are allowed to deviate from frequency of use criteria for unlined emergency spillways

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	35	feet high and stores =<	750	acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>	7500	acre-feet
Other (Specify)	Very Large: > 100 feet high and stores > 50000 acre-feet				

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Includes interruption to public utilities and minor damage to isolated homes or commercial and industrial buildings

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: Developed by state dam safety staff and codified through appropriate legal procedure

10 When were the guidelines last revised (MM/DD/YYYY)? 12/01/1994

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: The guidelines specify activation and performance criteria for vegetated earth or unlined emergency spillways.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Utilize Hyrdometeorological Report (HMR) Numbers 51, 52, 56

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

Comments: The spillway should be sized so that the increased downstream damage resulting from overtopping failure of the dam would not be significant as compared with the damage caused by the flood in the absence of dam overtopping failure. SDF for high hazard dams cannot be more frequent than the 100-year return frequency.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: A design storm more frequent than once in 100 years will not be acceptable for any Class C dam.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	33-100	% of the	PMP
Existing High Hazard Dam must pass	33-100	% of the	PMP
New Significant Hazard Dam must pass	100yr - 75	% of the	PMP
Existing Significant Hazard Dam must pass	100yr - 75	% of the	PMP

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Ranges from 50 year to 1/2PMP, depending on size of dam.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: Dams will be subject to reclassification if the Director determines that the hazard potential has changed. Non-structural provisions of adequately demonstrated effectiveness and reliability such as flood plain zoning, and early warning systems may be considered by the Director in making this determination.

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

Comments: Our agency will review incremental damage analysis for SDF selection which could be considered as somewhat related to risk analysis

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

Comments: Nothing other than incremental damage analysis

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Change requires public comment process and legislative scrutiny. Process takes approximately two years.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	North Dakota
Name of Representative	Mr. Jonathan Kelsch
Title of Representative	Engineer / Manager
Phone number(s)	701-328-4948
Email address	jkelsch@nd.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1165
High Hazard Dams	30
Significant Hazard Dams	94
Low Hazard Dams	1041
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? unknown

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: under 12.5 acre-feet of storage

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Existing dams that are functioning correctly and built to a different standard.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	10	feet high and stores =<	12.5	acre-feet
Class B (Medium)					
Class C (Large)	=>		feet high and stores =>		acre-feet

Other (Specify): Five categories: Less than 10 ft, 10-24 ft, 25-39 ft, 40-55 ft, and Over 55 ft

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 06/01/1985

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

Comments: Exceptions can be made for existing dams to be repaired.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (Based on Tc)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Activation and damage criteria for principal vs. emergency spillways.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Recommended guidelines have been published (not required)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC II or III

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: Probably location dependent, not usually required for rural areas

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass		% of the	PMP
Existing High Hazard Dam must pass		% of the	PMP
New Significant Hazard Dam must pass		% of the	PMP
Existing Significant Hazard Dam must pass		% of the	PMP

Comments: Dam Design Classification I: 25-yr, II: 50-yr, III: 30% PMP, IV: 50% PMP, V: 100% PMP

29 For low hazard dams, the spillway design requirement is:

Not specified

Comments: See above criteria for five classifications.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Ohio
Name of Representative	Dena Barnhouse
Title of Representative	Project Manager
Phone number(s)	614-265-6723
Email address	Dena.Barnhouse@dnr.state.oh.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	3572
Total Regulated Dams	1564
High Hazard Dams	368
Significant Hazard Dams	554
Low Hazard Dams	642
Unregulated Dams	991
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1967

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Dam less than 6 feet in height OR less than 15 acre-feet in storage OR greater than 6 feet and less than 10 feet in height and less than 50 acre-feet in storage are exempt from Ohio's dam safety laws.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Ohio has jurisdiction over dams less than 25 feet in height and less than 50 acre-feet in storage with downstream hazard limited to the dam itself and agricultural land (Class IV). There is no minimum inflow design flood for Class IV dams specified in Ohio's dam safety laws.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	500	acre-feet
Class B (Medium)					
Class C (Large)	=>	60	feet high and stores =>	5000	acre-feet
Other (Specify)	Small > 25 feet high and stores > 50 acre-feet				

Comments: The "other" category above is a Class IV dam as described in question 5 above.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Class I (High), Class II (Significant), Class III (Low), and Class IV (limited).

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

9 What is the origin of the guidelines?

Combination of the above (Please specify)

10 When were the guidelines last revised (MM/DD/YYYY)?

Comments: Critical flood guidelines added in the 1990's.

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

For existing dams, this agency performs rough calculations to determine whether the dam owner must hire an engineer to do further calculations. For dams being permitted, the dam owner's engineer submits an analysis which we review and sometimes perform our own calculations to verify the results.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: All methodologies must follow current publications from ODNR, USCOE, USGS, NOAA, or others acceptable to ODNR.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: All methodologies must follow current publications from ODNR, USCOE, USGS, NOAA, or others acceptable to ODNR.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: All methodologies must follow current publications from ODNR, USCOE, USGS, NOAA, or others acceptable to ODNR.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Emergency spillway channels must flow less than once in 50 years for Class I dams, once in 25 years for Class II dams, and less than once in 10 years for Class III dams.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: ODNR has currently hired a consultant to provide site specific PMP study for 2 department-owned dams. The results will be used to provide revised PMP values for roughly 2/3 of the state. The study will be indepdently reviewed before adopted.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Class I (40% PMF minimum), Class II (20% PMF minimum), Class III (100-year minimum)

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

Comments: Can be reduced to the critical flood through an incremental damage assessment.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 25% PMF down to no less than 100 year based on incremental damage assessment.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

No; our regulations forbid them

Comments: This type of analysis is not addressed in regulations. By omission, the regulations forbid them.

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Oklahoma
Name of Representative	Robert S. Fabian
Title of Representative	Technical Section Program Manager
Phone number(s)	405-530-8800
Email address	rsfabian@owrb.ok.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	4672
Total Regulated Dams	4543
High Hazard Dams	320
Significant Hazard Dams	202
Low Hazard Dams	4021
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 26828

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: 15 af or less of impounding capacity irregardless of height of dam and 6 feet to 25 feet in height and with an impounding capacity of less than 50 acre-feet.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	50	feet high and stores =<	10,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: A written guidance document is under development describing criteria to be used for determination of a dam's hazard potential.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)? 07/01/1995

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Any dam constructed prior to June 13, 1973 and which is classified as intermediate size and high hazard potential according to 785:25-3-3 shall be required to pass a minimum design of 50% of the PMF. Any dam constructed prior to June 13, 1973 and which is classified as large size and high hazard potential according to 785:25-3-3 shall be required to pass a minimum design flood of 75% of the PMF.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Minimum freeboard varies from 1 to 3 feet based on both hazard and size classification

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: This is in a guidance document being develop and is not part of dam safety rules and regulations at this time.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: If watershed above dam is greater than 10 sq. mi. then use concentric elipse pattern. This is in a guidance document being develop and is not part of dam safety rules and regulations at this time.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Dam safety rules specify a PMF and freeboard requirement based on size and hazard classification of the dam.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: This is in a guidance document being develop and is not part of dam safety rules and regulations at this time.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a major problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Specify saturated antecedent moisture condition and initial reservoir pool at normal levels.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50-75	% of the	PMF
New Significant Hazard Dam must pass	40-75	% of the	PMF
Existing Significant Hazard Dam must pass		% of the	

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 25-50% of PMF depending on size classification

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: A non-structural alternative will only be considered as a temporay solution until such time as structural changes could be made.

31 Does your organization permit risk-based hydrologic designs?

Yes; although our regulations do not specifically address this topic, we review risk-based designs o

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

Comments: We rarely have a request for a risk-based hydrologic analysis.

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: This is a time consuming process that includes an analysis of impacts, including financial impacts, on the regulated community.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Oregon
Name of Representative	Keith Mills
Title of Representative	Dam Safety Engineer
Phone number(s)	503-986-0840
Email address	millska@wrd.state.or.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1318
High Hazard Dams	126
Significant Hazard Dams	197
Low Hazard Dams	995
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? N/A

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 10 feet in height or that impounds less than 9.2 acre-feet.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

If "Yes", check and complete as appropriate:

Class A (Small) =< feet high and stores =< acre-feet

Class B (Medium)

Class C (Large) => feet high and stores => acre-feet

Other (Specify) Oregon classifies dams into two categories: large and small.

Comments: Small dams are those less than 9.2 acre-feet and 10 feet in height. They are not subject to state dam safety oversight. All large dams must be designed by an engineer licensed in Oregon.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Unpublished guidelines for consideration by the engineer/designer

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Some custom as well

10 When were the guidelines last revised (MM/DD/YYYY)? N/A

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

We ask for PMF - High Hazard; 1/2 PMF Significant Hazard; 100 year flood with 2 feet of spillway freeboard for low hazard. All are minimum design criteria.

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

2.0'

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

Comments: We need compelling evidence the analysis is appropriate.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments: Likely to become more of a problem with new development.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass		% of the	

Comments: We ask owners to upgrade spillway capacity when the hazard rating is upgraded. If it is necessary, would use a legal process to compel an owner to upgrade.

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: 100 year with 2 feet of freeboard in the emergency spillway.

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

HYDROLOGIC SAFETY OF DAMS
QUESTIONNAIRE

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Pennsylvania
Name of Representative	Roger P. Adams, P.E.
Title of Representative	Chief, Division of Dam Safety
Phone number(s)	717-772-5951
Email address	roadams@state.pa.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	Unknown
Total Regulated Dams	3213
High Hazard Dams	782
Significant Hazard Dams	277
Low Hazard Dams	2154
Unregulated Dams	Unknown
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1913

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than or equal to 15 feet and the impounding capacity at maximum storage elevation is less than or equal to 50 acre-feet and the drainage area is less than or equal to 100

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Under PA mining laws, coal waste slurry dams have added regulations on time to dewater.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

Comments: Note: In PA, Class A is large and Class C is small.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Category 1 = substantial population at risk (PAR) and/or excessive economic loss (EL); Category 2 = few PAR and/or appreciable EL; Category 3 = no PAR and or significant EL; and Category 4 = no PAR and minimal EL.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: By regulation

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 01/08/2011

Comments: Regulations revised.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Developing a process to conduct an incremental dam break analysis.

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: Rational Method

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: By regulations.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: For projects increasing spillway capacity, we may require no increase in outflows up to the 100-year frequency flood.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Must be approved by NOAA.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: By Regulation

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

Comments: Incremental dam break analysis is required for high hazard dams. SDF is based on no additional impact to homes.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: 100-year frequency flood is considered a minimum SDF for high hazard dam.

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	IDBA	% of the	PMF
Existing High Hazard Dam must pass	IDBA	% of the	PMF
New Significant Hazard Dam must pass	50-100	% of the	PMF
Existing Significant Hazard Dam must pass	50-100	% of the	PMF

Comments: New regulations require Incremental Dam Break Analysis (IDBA) to determine spillway design flood.

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Medium (100-year to 1/2 PMF); Small (50-year to 100-year)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Other (Please explain)

Comments: Regulations do not address this issue; however, our procedures do not allow for this type of analysis

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: We just went through a change so we are familiar with the procedure.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Requiring an incremental dam break analysis for the spillway design flood for high hazard dams.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Puerto Rico
Name of Representative	Luis A. Suarez Sanchez
Title of Representative	Administrator, Dams & Reservoirs Safety Program
Phone number(s)	787-521-3256
Email address	l-suarez@prepa.com

2 Number of dams under Organization's jurisdiction by type:

Total Dams	36
Total Regulated Dams	36
High Hazard Dams	35
Significant Hazard Dams	0
Low Hazard Dams	1
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1979

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Is 25 feet or less in height or has an impounding capacity at the maximum water storage elevation of 50 acre-feet or less.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	25	feet high and stores =<	50	acre-feet
Class B (Medium)					
Class C (Large)	=>	25	feet high and stores =>	50	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

FEMA/FERC federal guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/1998

Comments: In 1998 the Guidelines Development Subcommittee update the FEMA Guidelines.

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

15 For PMP/PMF designs, is freeboard required?

1.0'

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: Can use the computer software of the Corp of Engineer and analysis methodologies developed by USBR to Puerto Rico.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

Comments: We use 24-hr too.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Antecedent moisture condition III and normal pool level.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass		% of the	
New Significant Hazard Dam must pass	100	% of the	PMF
Existing Significant Hazard Dam must pass		% of the	

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

No

HYDROLOGIC SAFETY OF DAMS
QUESTIONNAIRE

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Rhode Island
Name of Representative	Paul Guglielmino
Title of Representative	Senior Sanitary Engineer
Phone number(s)	401-222-1360 xt. 7122
Email address	paul.guglielmino@dem.ri.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	671
Total Regulated Dams	538
High Hazard Dams	97
Significant Hazard Dams	83
Low Hazard Dams	492
Unregulated Dams	94
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? N/A

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: RI defines a 'regulated' dam as a low hazard dam that is six (6) feet or more in height or has fifteen (15) acre-feet or more of storage capacity; or a high hazard dam; or a significant hazard dam. 'Not regulated' doesn't meet the criteria. 'Non-jurisdictional' dams are FERC (for example), not RI, regulated. 'Non-inventory' are dams that we don't have in our database (typically small dams that wouldn't be regulated.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

Comments: RI doesn't have specific design standards.

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: A dam where failure or misoperation results in no probable loss of human life but can cause major economic loss, disruption of lifeline facilities or impact other concerns detrimental to the public's health, safety or welfare.

8 Does the Organization have guidelines for determining the spillway design flood?

No

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)?

n/a

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: No to changing the hazard classification. N/a to design requirements.

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: None.

29 For low hazard dams, the spillway design requirement is:

Not specified

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: It would be more difficult if the regulation change required a change in the law.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Although dam safety law has been in place since 1800's, our first set of regulations were promulgated in 2007. We're just entering puberty.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	South Carolina
Name of Representative	Steven M. Bradley, P.E.
Title of Representative	Dam Safety Hydrologist
Phone number(s)	803-898-4027
Email address	

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	2317
High Hazard Dams	153
Significant Hazard Dams	481
Low Hazard Dams	1683
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1980

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Less than 25 feet in height or shall have an impounding capacity at maximum water storage elevation of less than 50 acre-feet.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)	Very Small < 25 feet high and stores < 50 acre-feet				

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Published guidelines, but still subject to a lot of engineering judgment.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

FEMA/FERC federal guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? n/a

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: New dams are conservatively classified.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

Comments: For 50 mph wind. For small dams, we usually use 1 ft.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

Comments: Usually check it using HEC-1 (transitioning to HEC-HMS)

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: Has to pass review

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: Great majority of drainage areas are very small (<10 square miles). For these we use 24-hour duration.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: Use of SCS Type II is common.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Activation criteria for earth spillways: Low hazard (1 year), Significant Hazard (10 year), High (25 year)

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Depends on credentials on person performing analysis

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC-II, Normal pool

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	500yr-100	% of the	PMF
New Significant Hazard Dam must pass	100yr-50	% of the	PMF
Existing Significant Hazard Dam must pass	100yr-50	% of the	PMF

Comments: High Hazard: Very Small (100yr to 1/2PMF), Small (1/2PMF to PMF, Intermediate and Large (PMF). Significant Hazard: Small (100yr to 1/2PMF), Intermediate (1/2PMF to PMF), Large (PMF).

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Small (50-yr to 100-yr), Intermediate (100-yr to 1/2 PMF), Large (1/2 PMF to PMF)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Current political climate makes it very difficult

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: We supply forms for EAPs to dam owners. All high hazard dams are being updated to meet FEMA rules

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	South Dakota
Name of Representative	Timothy G. Schaal
Title of Representative	Natural Resources Engineer
Phone number(s)	605-773-3352
Email address	tim.schaal@state.sd.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	2349
High Hazard Dams	47
Significant Hazard Dams	144
Low Hazard Dams	2158
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1986

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: A barrier is not considered a dam if height does not exceed 6 feet regardless of storage capacity of if storage capacity does not exceed 15 acre-feet.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Design requirements for category 1 tailings dams. Dams constructed to store, without discharge, tailings as defined by 45-6B-3 (14) shall be sized to retain the PMF plus at least a 100-year flood

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

Comments: SDCL 46-2-5 & 46-7-3

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

Comments: Corps of Engineers Phase I Inspections Recommemded Guidelines

10 When were the guidelines last revised (MM/DD/YYYY)? 4/23/1989

11 Are there any plans to update or revise the guidelines in the near future?

No

Comments: not in the "Near Future"

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Category 3 dams constructed before October 27, 1986 are exempt from minimum spillway requirements unless the dam fails and is rebuilt.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

Comments: we are open to other suggestions/methods

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (24-hour)

Comments: For 25-year, 50-year, and 100-year frequency floods.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: 74:02:08:02 states that if the classification of a dam changes, the dam must comply with spillway requirements of the higher catergory

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: SDCL 46-7-5.3

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: SDCL -46-7-5.3

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMF
Existing High Hazard Dam must pass	50-100	% of the	PMF
New Significant Hazard Dam must pass	100yr-100	% of the	PMF
Existing Significant Hazard Dam must pass	100yr-100	% of the	PMF

Comments: High Hazard: Small (0.5PMF), Intermediate (0.5PMF), Large (PMF). Significant Hazard: Small (100-year), Intermediate (0.5PMF), Large (PMF).

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Small (50-year), Intermediate (100-year), Large (0.5 PMF)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Comments: That would be a Water Management Board decision

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

Comments: SDCL 46-7-5.3

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Legislative Research Council review and approval, public notice and Water Management Board approval, Legislative Oversite Committee review and approval

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Tennessee
Name of Representative	Lyle Bentley
Title of Representative	Chief, Dam Safety Program
Phone number(s)	615-532-0154
Email address	Lyle.Bentley@tn.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	1227
Total Regulated Dams	662
High Hazard Dams	150
Significant Hazard Dams	210
Low Hazard Dams	302
Unregulated Dams	565
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1987

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Dam means any artificial barrier, together with appurtenant works, which does or may impound or divert water, and which either (1) is or will be twenty (20) feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the Commissioner, or (2) has or will have an impounding capacity at maximum water storage elevation of thirty (30) acre-feet or more. Provided, however, that any such barrier which is or will be less than six (6) feet in height, regardless of storage capacity, or which has or will have a maximum storage capacity not in excess of fifteen (15) acre-feet, regardless of height, shall not be considered a dam, nor shall any barrier, regardless of size, be considered a dam, if, in the judgment of the Commissioner, such barrier creates an impoundment used only as a farm pond.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Dams designed and mostly paid for by the federal government, such as watershed district dams, cannot be required to have changes made in the design.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	49	feet high and stores =<	999	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: Category 1 (High), Category 2 (Significant), and Category 3 (Low).

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

Comments: The Corps standards used in the Phase 1 investigations I the late 1970's and early 1980's.

10 When were the guidelines last revised (MM/DD/YYYY)? 02/19/2001

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Different Freeboard Design Storms for new and existing dams.

13 Which of the following best describes your agency's role in determining the spillway design flood:

It's specified in the regualtions.

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Sufficient freeboard shall be provided to prevent overtopping with the passage of the freeboard hydrograph plus the additional freeboard required by the site for wave action.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Activation and performance guidelines are provided for vegetated earth or unlined emergency spillways

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

Comments: No, although it has been a source on contention at times.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: This only applies if development is actually planned - not if development could occur "one day."

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	50-100	% of the	PMP
Existing High Hazard Dam must pass	50-100	% of the	PMP
New Significant Hazard Dam must pass	50-100	% of the	PMP
Existing Significant Hazard Dam must pass	33-100	% of the	PMP

Comments: Existing, High Hazard: Large and Intermediate (PMP), Small (1/2 PMP). Significant Hazard: Large (PMP), Intermediate (1/2 PMP), Small (1/3 PMP). New (regardless of hazard class): Large and Intermediate (PMP), Small (1/2 PMP)

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Existing: Large (1/2 PMP), Intermediate (1/3PMP), Small (100-year).
New (regardless of hazard class): Large and Intermediate (PMP), Small (1/2 PMP)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

No; our regulations address this topic and we have made an administrative decision not to conside

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: It can be done through our rulemaking process.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Texas
Name of Representative	Warren D. Samuelson, P.E.
Title of Representative	Dam Safety Program Coordinator
Phone number(s)	512-239-5195
Email address	warren.samuelson@tceq.texas.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	7212
High Hazard Dams	1002
Significant Hazard Dams	735
Low Hazard Dams	5485
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1986

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet

Other (Specify): Intermediate = Equal to or Greater than 1,000 AF & Less than 50,000 AF or Equal to or Greater than 40 ft & Less than 100 ft

Comments: Small = Equal to or Greater than 15 AF & Less than 1,000 AF; Equal to or Greater than 50 AF & Less than 1,000 AF; Equal to or Greater than 25 ft & Less than 40 ft; or Greater than 6 ft & Less than 40 ft

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Loss of one to six lives or one or two habitable structures in the breach inundation area downstream of the dam

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

Comments: Guidelines entitled "Hydrologic and Hydraulic Guidelines for Dams in Texas"

9 What is the origin of the guidelines?

Custom developed by Organization

10 When were the guidelines last revised (MM/DD/YYYY)? 01/01/2007

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: An owner of a large- or high-hazard existing dam that was required to meet 100% of the probable maximum flood (PMF) before the effective date of these rules and that is shown by an evaluation by a professional engineer to meet 75% or more of the PMF will not be required to upgrade the dam to meet minimum hydrologic criteria in paragraph (1)(A) of this subsection.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on both size and hazard classification

15 For PMP/PMF designs, is freeboard required?

Based on wave run up computations

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: HEC-HMS, HEC-1, SITES, WIN TR20, WIN TR55, HEC-RAS, and NWS Dynamic Wave Models. Other models may be acceptable upon written approval.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Minimum storm duration is specified based on drainage area. All durations from the minimum up to the 72-hour duration shall be used to determine the most critical duration or the duration that produces the maximum reservoir level.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: PMP distributions are provided for 1-hr to 72-hr duration events. More conservative distributions (such as the HMR-51 or NRCS distributions) can be used.

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: Based upon drainage area

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: It is often accepted that erosion damage will occur should the emergency spillway operate, but that the effective cost of the very infrequent repairs is much lower than the upfront capital costs of the means to prevent the erosion. Most emergency spillways are built to prevent passage of flows for less than about the 50- or 100-year flood.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: We get comments from Legislative staff due to changing hazard classification. Owners also have a problem understanding floods that have "never occurred".

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Superimpose the PMP upon watershed soils assumed to be saturated. This will equate to losses at the beginning of the design storm equal to zero or Natural Resources Conservation Service Antecedent Runoff Conditions III (ARC III), or some other equivalent and approved assumptions. In Texas, there is no need to analyze snowmelt contributions to runoff or frozen ground conditions for infiltration for design-flood calculations.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	75-100	% of the	PMF
Existing High Hazard Dam must pass	75-100	% of the	PMF
New Significant Hazard Dam must pass	50-75	% of the	PMF
Existing Significant Hazard Dam must pass	50-75	% of the	PMF

Comments: Significant: Small (50% PMF), Intermediate (50-75% PMF), Large (75% PMF)
High: Small (75% PMF), Intermediate (75-100% PMF), Large (100% PMF)

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: Small (25% PMF), Intermediate (25-50% PMF), Large (50-75% PMF)

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: It happened one time a number of years ago. The owners would have to provide much more justification for it to be approved today.

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: The last change to the rules took four years and four different stakeholder meetings. The process is done internal to the agency, but takes a long time. Today, there would be considerable input from the Legislature. It would be difficult to get some of the changes we got in 2009 today.

34 Are there any unique provisions in your regulations?

No

FEMA

HYDROLOGIC SAFETY OF DAMS
QUESTIONNAIRE

Gannett Fleming — Your Trusted Advisor Since 1915

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Utah
Name of Representative	Everett Taylor
Title of Representative	Dam Safety
Phone number(s)	801-538-7372
Email address	everetttaylor@utah.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	5031
Total Regulated Dams	5031
High Hazard Dams	196
Significant Hazard Dams	301
Low Hazard Dams	4534
Unregulated Dams	0
Other	0

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1990

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Owned by Bureau of Reclamation

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Low Hazard, Flood control, less than 20 ac-ft & not high hazard

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (Other)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Other (Please specify)

Comments: Those dams which, if they fail, have a low probablility of causing loss of human life, but would cause appreciable property damage, including damage to public utilities.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

Comments: Found within State Administrative Rules

9 What is the origin of the guidelines?

Other (Please specify)

Comments: HMR 49 with state approved adjustments based on commissioned studies.

10 When were the guidelines last revised (MM/DD/YYYY)? 12/31/2003

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Must use HMRs for developing PMP

Comments: The 72 hour SEF using HMR49/ USUL as well as the 6 hour SEF using HMR49/ USUS.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: Reserve the right to question methodologies

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Route the 72 hour SEF using HMR49/ USUL as well as the 6 hour SEF using HMR49/ USUS to determine the more extreme event.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (HMR)

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: In designing the spillway for a dam to pass the IDF, the State Engineer will consider the use of a principal spillway in conjunction with emergency spillways. The principal spillway must be designed so that no structural damage will occur during passage of the IDF. Emergency spillways, including Fuse Plug Spillways, may be designed so that some damage may be expected during use provided the anticipated damage does not represent a threat to the dam. Sunny day failure modeling of Fuse Plug Spillways may be required to determine if they are creating an additional unacceptable risk. Overtopping of the dam will not be considered as an emergency spillway on earthfill dams, unless it can be demonstrated that the dam is protected from erosion, and the duration of overtopping will not saturate the dam and reduce its stability.

22 Does the organization allow development of a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Reservoir pool at spillway crest (except flood control) AMC III for 100 year flood criteria

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: 100-year flood

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: The IDF for all High and Moderate Hazard Dams will be the SEF. It will be necessary to calculate both the 72 hour SEF using HMR49/ USUL as well as the 6 hour SEF using HMR49/ USUS. Both of these hydrographs must be routed through the reservoir to determine which one represents the most extreme event. Once the critical SEF has been determined, it must be compared to a flood generated by the 100 year, 6 hour (for local storms), or 100 yr, 24 hour (for general storms) precipitation applied on a saturated watershed. If the routed 100 year event, including appropriate allowances for freeboard, is more critical than the SEF it must be used as the minimum IDF.

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

Yes

Comments: Possibly on upgrading existing structure to meet minimum standards. Not for new construction.

31 Does your organization permit risk-based hydrologic designs?

No; our regulations forbid them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Changed through administrative rule process

34 Are there any unique provisions in your regulations?

No

HYDROLOGIC SAFETY OF DAMS
QUESTIONNAIRE

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Vermont
Name of Representative	Stephen Bushman
Title of Representative	Environmental Engineer IV
Phone number(s)	802-241-3450
Email address	steve.bushman@state.vt.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	572
High Hazard Dams	55
Significant Hazard Dams	136
Low Hazard Dams	379
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria?

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Non jurisdictional: Capable of impounding 500,000 cubic feet or less of water. No non-inventory dam in VT, all dams we know of are included in inventory.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

9 What is the origin of the guidelines?

Combination of the above (Please specify)

Comments: Primarily USACE and NRCS.

10 When were the guidelines last revised (MM/DD/YYYY)?

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: New dams must meet appropriate SDF. We have allowed reconstruction of existing dams to meet less than SDF required for a new dam, but at least Q100, and usually improvement over existing.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Freeboard, as appropriate, but not less than 1.5 feet with a routed Q100 inflows, and not less than 3.0 feet from principal spillway crest.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

Comments: No, but typically 24-hr is used.

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: No, but typically HMR is used.

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: As appropriate (USCOE, NRCS)

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

Comments: Typically use normal pool level

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: SDF and outlet works capacities should be consistent with guidelines or service criteria established by Federal agencies such as the Corps of Engineers, Soil Conservation Service and the Bureau of Reclamation for a given size and hazard classification, with the following additional requirements: 1) SDF, as appropriate, but in no case less than a routed Q100 (one hundred-year frequency) inflow (Ref: FERC Engineering Guidelines . . . , October 1993, Paragraph 2-3.3.). 2) Freeboard, as appropriate, but not less than 1.5 feet with a routed Q100 inflows, and not less than 3.0 feet from principal spillway crest (usually NWL). Applies to all embankment dams and other dams where appropriate.

29 For low hazard dams, the spillway design requirement is:

100-year flood

Comments: SDF

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Unsure

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Statute change required. Would require amendment to individual sections of the law or addition of new sections. Difficulty increases with complexity of change.

34 Are there any unique provisions in your regulations?

No

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Virginia
Name of Representative	Robert T. Bennett, P.E., R.A., C.F.M.
Title of Representative	Director, Div. of Dam Safety & Floodplain Man.
Phone number(s)	804-786-3914
Email address	Robert.Bennett@dcr.virginia.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	11,568
Total Regulated Dams	1,568
High Hazard Dams	162
Significant Hazard Dams	382
Low Hazard Dams	1024
Unregulated Dams	10,000 +/-
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1982

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Owned or regulated by the Federal Government, or Permitted Mining Dam, or size exempt. Size exempt: <6', or <50 ac-ft for dams 6' - 25', or <15 ac-ft for dams >25'

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Pemitted Dams by VA Dept. Mines, Minerals, & Energy, and Agricultural Use Dams that are <25' high and Agricultural Use Dams < 100ac-ft.

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	40	feet high and stores =<	1,000	acre-feet
Class B (Medium)					
Class C (Large)	=>	100	feet high and stores =>	50,000	acre-feet
Other (Specify)					

Comments: Medium is between Large and Small. Small is further defined as >=6'

7 Does the Organization have published hazard classification criteria?

Yes (Other)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: From 4VAC50-20-40: Significant Hazard Potential is defined where an impounding structure failure may cause the loss of life or appreciable economic damage. "May cause loss of life" means that impacts will occur that could cause a loss of human life, including but not limited to impacts to facilities that are frequently utilized by humans other than residences, businesses, or other occupied structures, or to secondary roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, secondary roadways, railroads, personal property, and agricultural interests. "Secondary roadways" include, but are not limited to, secondary highways, low-volume urban streets, service roads, or other low-volume roadways.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

9 What is the origin of the guidelines?

USACE guidelines (including Phase I Study guidelines)

10 When were the guidelines last revised (MM/DD/YYYY)? 12/22/2010

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Will be forming a Technical Advisory Committee (TAC) to revise regulations in 2011, may or may not change guidelines on determining SDF.

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: Existing high hazard dams maximum SDF required = Flood resulting from the 90%PMP, new high hazard dams maximum required SDF = PMF.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

Agency advises dam owners through the required certificate to operate renewal process that upgrades are needed if applicable.

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Yes, in conformance with Fed. Guidelines (See USBR Design of Small Dams) Freeboard determination and justification must be addressed by the owner's engr.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: Federal guidelines unless alternate method pre-approved by Dam Safety.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: Any software not approved by Fed. or non Fed. Approved and not pre-approved by Dam Safety

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: PMF hydrographs for 6-, 12-, and 24-hr. The hydrograph that creates the largest peak outflow used to determine capacity for nonfailure and failure analysis.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Other - please specify)

Comments: Must comply with federal standard being used for calculations.

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: Must comply with federal standard being used for calculations.

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Freeboard Design Flood may be used for NRCS Flood Control Struct. Only. All others must use spillway design flood and applicable Fed. Guidelines.

22 Does the organization allow development of a site specific PMP?

No

Comments: Not yet.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Both of the above)

Comments: Both is for impacts on watershed hydrology and impacts on downstream hazards.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Regs. 4VAC50-20-50 …."C. PMF: Probable Maximum Flood is the flood that might be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region."

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Minimum threshold for IDA: High (100-yr), Significant (100-yr), Low (50-yr)

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	90	% of the	PMP
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

Comments: The above numbers are without guidelines for incremental damage analysis reduction of spillway capacity requirements.

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Other (Please explain)

Comments: No

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Other (Please explain)

Comments: Proposed by dam owner, but concept rejected without consideration.

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: See: http://www.dcr.virginia.gov/dam_safety_and_floodplains/documents/dsregs.pdf

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Washington State
Name of Representative	Jerald LaVassar, P.E.
Title of Representative	Unit Lead, Dam Safety Office
Phone number(s)	360-407-6625
Email address	jlsd461@ecy.wa.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	1381
Total Regulated Dams	1217
High Hazard Dams	137
Significant Hazard Dams	224
Low Hazard Dams	856
Unregulated Dams	164
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1989

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Non-jurisdictional - Less than 10 acre-feet of storage (top of dam); USACE or USBR ownership; or FERC regulation. Of the unregulated dams, 106 are high hazard USACE, USBR or FERC dams.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

Yes

If "Yes", check and complete as appropriate:

Class A (Small)	=<	15	feet high and stores =<		acre-feet
Class B (Medium)					
Class C (Large)	=>	50	feet high and stores =>		acre-feet

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

Loss of life potential is "few" with "appreciable" economic loss

Comments: Population at Risk = 1 to 6 people. 1 or 2 inhabited structures. Other criteria include notable agriculture or work sites, secondary highway and/or rail lines, limited water quality degradation and only short term environmental impacts.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: Guidelines establish design minimums as a function of the downstream hazard setting.

9 What is the origin of the guidelines?

Custom developed by Organization

Comments: Dam Safety Guidelines, Technical Note 3: Design Storm Construction. Washington State Department of Ecology Publication No. 99-55G.

10 When were the guidelines last revised (MM/DD/YYYY)? 10/30/2009

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

Yes (Please elaborate)

Comments: New dams typically have the rainfall depth increased by 15%.

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on a combination of risk analysis and hazard/size classification

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Usually based on wave run up computations; if computed freeboard is too low, may be superseded by minimum requirements; minimums depend on size of dam, range from 0.5 feet to 1.0 feet. Ref: Dam Safety Guidelines, Part IV: Dam Design and Construction. Washington State Department of Ecology Publication No. 99-55D. See Section 4.6, Reservoir Freeboard.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: WSDSO's basic requirement is to use good engineering practice. Usually means using HEC-HMS with our Tech Note 3 dam safety storms. On occasion, we have accepted HSPF with our Tech Note 3 dam safety storms inserted into the rainfall record. We have also accepted NRCS storms that captured the same (or greater) total rainfall volume and peak rainfall intensity as our Tech Note 3 dam safety storms. As noted in item 13, we often do our own calculations to verify the designer's calculations.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

Other (Please specify)

Comments: Three storm scenarios must be considered: a short 4- to 6-hour storm, an intermediate 18-hour storm, and a long 72-hour storm. The IDF is the scenario that yields the highest peak water level in the reservoir.

19 Do the guidelines specify any criteria for temporal storm distribution?

Yes (Regional)

Comments: Design storm hyetographs are provided in Technical Note 3, at 5-minute intervals for the short storms and at 15-minute intervals for the intermediate and long storms.

20 Do the guidelines specify any criteria for spatial storm distribution?

Yes (Please specify)

Comments: Again, WSDSO's basic requirement is to use good engineering practice. One method is to use Areal Adjustments to Account for Storm Spatial Distributions as a Percent of At-Site Precipitation Amount - see Dam Safety Gudelines Tech Note 3: Design Storm Construction, Section 1.2.3

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: Because of infrequent operation, economy in design and construction can sometimes be accomplished for small and intermediate size dams by utilizing the concept of survivability. That is, erosional damage can often be tolerated provided the damage does not jeopardize the structural integrity of the impounding barrier or allow an uncontrolled release of the reservoir waters.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

Yes (Please specify)

Comments: Must be more conservative than Washington State DSO Design Storm Criteria as described in Tech Note 3. The 2009 update to Tech Note 3 is more recent than HMR-57 (NWS, Oct. 1994),and is based on a larger database of storms.

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

Comments: There are several dimensions to this issue: (a) Downstream development may require simply a reclassification based on the existing flood analysis and inundation mapping, or may require us to do a new dam breach flood study. (b) The new hazard rating will require us to do a new hydrology study to determine the spillway dimensions required to pass the new (larger) inflow design flood. (c) The dam owner must modify or reconstruct the spillway(s) to the new dimensions. The inundation and IDF studies (a, b) may be a problem for us (Dam Safety Office) depending on our other inspection and plan review workload. The physical work on the spillway (c) may be a problem for the dam owner, depending on their ability to fund the reconstruction. If we (Dam Safety) perform the engineering analyses, we have found that this fosters something of a partnership attitude with the dam owner so that they may be more willing to devote their funds to the physical construction (a more tangible product). A few dam owners may require specific enforcement action to nudge them into making the spillway modifications, which creates additional workload for the Dam Safety Office.

24 Do guidelines require consideration or analysis of future development?

No

Comments: Our Design Step Worksheet asks the engineer of record to consider the potential for future development and his/her assessment then is reflected in the minimum design level. If the engineer's assessment is grossly at odds with what we judge the potential for future development to be, we will raise the concern with the owner. Our position is that the owner is then making an informed judgment of whether to pay some more now or much more later if they ignore growth potential.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: Should be representative of typical conditions during the season when the storm might occur. This usually means normal pool elevation, typical snowpack, and AMC-II soil moisture conditions.

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Must select a Inflow Design Flood with reservoir routing through the embankment's spillways, determine the flood levels and areal extent of dam failure inundation vs stream flood inundation, proceed to the next design step if it exceeds 2 ft and assess against the US Bureau of Reclamation Hazard Assessment Curves (Ref: Dam Safety Guidelines, Part IV, Section 2.4). If any population at risk, minimum Design Step is Step 3, recurrence interval 1 in 3,000 years. (Ref: Dam Safety Guidelines Technical Note 2, Selection of Design/Performance Goals for Critical Project Elements. Washington State Department of Ecology Publication No. 99-55F. See Section 5.1.5 on page 22.)

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: Consquence rating points determine the design flood based on a sliding scale. The scale ranges from the 500-year flood to the PMF or theoretical maximum event.

29 For low hazard dams, the spillway design requirement is:

500-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

Comments: Generally, safety design must be passive.

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Difficult

Comments: Administrative procedures are quite detailed and time-consuming, with considerable public involvement, at a time when we have no extra staff to devote to that effort.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Risk-based design storm levels; design storm hyetographs based on Washington State historical storms; numerical rating scheme for design/performance goals. Also, the level of detail in our guidance documents is more detailed typically than other states.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	West Virginia Dam Safety Section
Name of Representative	Brian Long
Title of Representative	Section Manager
Phone number(s)	(304) 926-0499 ext1005
Email address	brian.r.long@wv.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	524
Total Regulated Dams	355
High Hazard Dams	253
Significant Hazard Dams	80
Low Hazard Dams	22
Unregulated Dams	44
Other	125

3 When did your Organization adopt minimum Inflow Design Flood criteria? 1982

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: Exemptions for federal owned dam, farm pond dams, and road fills that do not normally impound water

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: Coal refuse dams vary in freeboard requirements

6 Does the Organization have published size classification criteria?

No

Comments: An impoundment exceeding forty (40) feet in height or four hundred (400) acre-feet storage volume shall not be classified as a Class 3 (low hazard) dam.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, Low, Limited Hazard)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations that are required

Comments: Rule guidelines are passed by Legislature, signed by Gov with force of law

9 What is the origin of the guidelines?

Other (Please specify)

Comments: NRCS & MSHA

10 When were the guidelines last revised (MM/DD/YYYY)? 06/01/2009

Comments: Revision to create a revolving loan fund

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency performs independent verification of submitted designs

14 How are the guidelines applied?

Based on hazard classification only

Comments: Risk assessment is allowed with justification

15 For PMP/PMF designs, is freeboard required?

No

Comments: Coal refuse dams are required to include additional freeboard.

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

Comments: Applicant may use any procedure. WVDEP advises procedures used to review applications.

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

Comments: Applicant may use any software. WVDEP advises software used to review applications.

18 Do the guidelines specify any criteria for storm duration?

Yes (6-hr)

19 Do the guidelines specify any criteria for temporal storm distribution?

No

Comments: Type II storm distribution used in review

20 Do the guidelines specify any criteria for spatial storm distribution?

No

Comments: Point rainfall reduction assumed in review for watersheds exceeding 10 square miles

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

Unknown (never requested)

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a moderate problem

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

Yes (Please specify)

Comments: AMC II unless a different condition is required by the Secretary

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

Yes

Comments: Future downstream conditions are required as part of the dam break analysis

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

Yes (Please specify)

Comments: Class I - no less than 70% of the PMP; Class II - no less than 25% of the PMP; Class III - no less than P100

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMP
Existing High Hazard Dam must pass	100	% of the	PMP
New Significant Hazard Dam must pass	50	% of the	PMP
Existing Significant Hazard Dam must pass	50	% of the	PMP

29 For low hazard dams, the spillway design requirement is:

Other (Please specify)

Comments: 25% of the PMP; Class IV required to pass P100

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

Comments: Rule permits reduction of hazard potential or design storm (see #27) based upon risk assessment analysis subject to agency approval

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Both approved and rejected)

33 How difficult would it be to change your regulations? Please explain.

Difficult

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Statute require additional "Criteria" to govern design, construction, repair, inspection & maintenance of proposed dams with annual review to consider improved technology.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Wisconsin
Name of Representative	Meg Galloway
Title of Representative	State Dam Safety Engineer
Phone number(s)	608-266-7014
Email address	Meg.galloway@dnr.state.wi.us

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	3653
High Hazard Dams	189
Significant Hazard Dams	170
Low Hazard Dams	3294
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? 1985

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Both of the above

Comments: The state definition of Large Dam matches the NID criteria.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

Yes (Please explain)

Comments: We do not have jurisdictional authority under our dam statutes over dams associated with cranberry operations, manure storage facilities, tailings facilities and dams not on watercourses.

6 Does the Organization have published size classification criteria?

Yes

Comments: Large: >6 feet and =>50 acre feet or =>25 feet and >15 acre-feet.

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

Comments: We may also call a dam signifcant if failure would cause significant environmental harm.

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published within State Laws

Comments: Rules are in Administrative Code NR 333

9 What is the origin of the guidelines?

Unknown

10 When were the guidelines last revised (MM/DD/YYYY)? 7/1/2001

11 Are there any plans to update or revise the guidelines in the near future?

No

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency utilizes a combination of the above approaches, possibly on a case-by-case basis

In most cases we do a review of submitted design. In some cases we may do independent analysis. Agency engineers may do analysis on department-owned dams; however, the analysis will receive an independent review by another agency engineer.

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

Other (Please specify)

Comments: Do not use PMP/PMF. We do not have written freeboard criteria but we will push for freeboard to be included in design on a case-by-case basis

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

Yes

If "Yes", what are the specific analysis methodologies, procedures, or computer software that must be used?

Other (Please specify)

Comments: Must use methods identified as acceptable in our Floodplain regulations (NR 116)

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

Yes (Please specify)

Comments: If it is not acceptable by the floodplain regulations the decision would be made on a case-by-case basis

18 Do the guidelines specify any criteria for storm duration?

No

Comments: We have occasionally commented on and requested a change in storm duration during the review process

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

No

22 Does the organization allow development of a site specific PMP?

No

Comments: Do not use PMP criteria

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

Yes, a minor problem

Comments: It should never be a problem as the design criteria are tied into existing land use and future land use controls. It is occasionally an issue for an existing dam if land use controls do not get put in place in a timely manner to prevent hazard creep.

24 Do guidelines require consideration or analysis of future development?

Yes (Impacts of development on hazard classification or failure consequences)

Comments: NR 333 and NR 116 tie dam safety and floodplain regulations together to try and minimize development potential in the hazard area downstream of dams.

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

Yes

If "Yes", do guidelines require analyses to include future downstream conditions within the dam failure inundation zone?

No

Comments: Any owner may provide documentation to justify a different spillway capacity from that specified in Table I. The department shall review such documentation and may approve the spillway capacity proposed by the owner if it determines that such capacity will not result in an additional hazard to life, health or property when compared to the capacity specified in Table I.

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

No

Comments: High (Q1000), Significant (Q500)

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Our regulations do not specifically address this topic and it has never come up for consideration

32 Has your agency ever reviewed a risk-based hydrologic analysis?

No

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Unless done for emergency purposes the rule making process typically takes at least 18 months.

34 Are there any unique provisions in your regulations?

Yes (Please explain)

Comments: Linking the hazard potential to both existing land use and land use controls downstream of the dam.

ON THE RECORD

1 Respondent information:

State/Federal Dam Safety Organization	Wyoming
Name of Representative	Mr. Larry L. Stockdale
Title of Representative	Safety of Dams Engineer
Phone number(s)	307-777-3500
Email address	lstock@seo.wy.gov

2 Number of dams under Organization's jurisdiction by type:

Total Dams	
Total Regulated Dams	1512
High Hazard Dams	79
Significant Hazard Dams	112
Low Hazard Dams	1321
Unregulated Dams	
Other	

3 What year did your Agency adopt minimum Inflow Design Flood criteria? n/a

4 How does the Organization define a non-inventory or non-jurisdictional dam? Minimum criteria:

Other (Please specify)

Comments: Anything less than 15 acre-feet regardless of height, less than or equal to 6 feet in height regarless of capacity, or less than 20 feet in height and less than 50 acre-feet.

5 Are there types/categories of dams(other than federally-owned or non-jurisdictional dams) that are held to different design standards than the majority of dams under your jurisdiction? (e.g. tailings dams)

No

6 Does the Organization have published size classification criteria?

No

7 Does the Organization have published hazard classification criteria?

Yes (High, Significant, and Low)

If "Yes", and Significant Hazard is defined, how is Significant Hazard defined?

No potential for loss of life with significant but not excessive economic loss

8 Does the Organization have guidelines for determining the spillway design flood?

Yes

If "Yes", what is the status of the guidelines; do they have the force of law?

Published guidelines/regulations for consideration by the engineer/designer

Comments: Regulations in draft form.

9 What is the origin of the guidelines?

Combination of the above (Please specify)

10 When were the guidelines last revised (MM/DD/YYYY)? n/a

Comments: Still in draft form.

11 Are there any plans to update or revise the guidelines in the near future?

Yes (Please specify)

Comments: Will be revised when review comments are received

12 Are the guidelines different for new and existing dams?

No

13 Which of the following best describes your agency's role in determining the spillway design flood:

Agency reviews submitted designs

14 How are the guidelines applied?

Based on hazard classification only

15 For PMP/PMF designs, is freeboard required?

No

16 Do the guidelines or Organization stipulate specific analysis methodologies, procedures or computer software that must be used?

No

17 Do the guidelines or Organization stipulate specific analysis methodologies, procedures, or computer software that cannot be used?

No

18 Do the guidelines specify any criteria for storm duration?

No

19 Do the guidelines specify any criteria for temporal storm distribution?

No

20 Do the guidelines specify any criteria for spatial storm distribution?

No

21 Do the guidelines specify spillway performance/design criteria based on the frequency of flooding (e.g. spillway design flood vs. freeboard design flood)?

Yes (Please specify)

Comments: High and Significant hazard are a performance design. Frequency is based on the 100-year.

22 Does the organization allow development of a site specific PMP?

Yes

If "Yes", are there any restrictions, requirements, or guidelines for performing a site specific PMP?

No

23 Is changing dam classifications/spillway design requirements because of downstream development a regulatory problem?

No

24 Do guidelines require consideration or analysis of future development?

No

25 Do guidelines specify antecedent moisture conditions or initial reservoir pool levels?

No

26 Do guidelines allow the use of incremental damage assessments to establish the spillway design flood?

No

27 Are there any restrictions or guidelines on the use of incremental damage assessments or risk analyses such as a minimum percent of the PMP, regardless of downstream consequences?

No

28 Do any of the guidelines specify the spillway design capacity for any dam classification as a percentage of the PMP or PMF?

Yes

If "Yes", complete as appropriate. If "No", describe below how spillway design capacity is determined.

New High Hazard Dam must pass	100	% of the	PMF
Existing High Hazard Dam must pass	100	% of the	PMF
New Significant Hazard Dam must pass	50	% of the	PMF
Existing Significant Hazard Dam must pass	50	% of the	PMF

29 For low hazard dams, the spillway design requirement is:

100-year flood

30 Would your organization accept the use of an early warning system as an alternative to designing a high hazard dam for the regulatory spillway design flood?

No

31 Does your organization permit risk-based hydrologic designs?

Yes; our regulations permit them

32 Has your agency ever reviewed a risk-based hydrologic analysis?

Yes (Reviewed and approved)

33 How difficult would it be to change your regulations? Please explain.

Moderate

Comments: Moderately difficult due to public comment, etc.

34 Are there any unique provisions in your regulations?

No

Appendix D. Federal Guidelines

FEMA

Appendix E. State Guidelines

E.1 Alabama
E.2 Alaska
E.3 Arizona
E.4 Arkansas
E.5 California
E.6 Colorado
E.7 Connecticut
E.8 Delaware
E.9 Georgia
E.10 Hawaii
E.11 Idaho
E.12 Illinois
E.13 Indiana
E.14 Iowa
E.15 Kansas
E.16 Kentucky
E.17 Louisiana
E.18 Maine
E.19 Maryland
E.20 Massachusetts
E.21 Michigan
E.22 Minnesota
E.23 Mississippi
E.24 Missouri
E.25 Montana
E.26 Nebraska
E.27 Nevada
E.28 New Hampshire
E.29 New Jersey
E.30 New Mexico
E.31 New York
E.32 North Carolina
E.33 North Dakota
E.34 Ohio
E.35 Oklahoma
E.36 Oregon
E.37 Pennsylvania
E.38 Puerto Rico
E.39 Rhode Island
E.40 South Carolina
E.41 South Dakota
E.42 Tennessee
E.43 Texas
E.44 Utah
E.45 Vermont
E.46 Virginia
E.47 Washington
E.48 West Virginia
E.49 Wisconsin
E.50 Wyoming

July 2012

Appendix F. Association of State Dam Safety Officials (ASDSO) Summaries

F.1 Size Classification Schemes
F.2 Hazard Classification Schemes

F.1. Size Classification Schemes

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES

Association of State Dam Safety Officials - www.damsafety.org

Compiled September 2010

	Very Large	Large	Intermediate	Small	Minor	Notes
AL						*Not defined; Alabama currently has no dam safety legislation or formal dam safety program. Source: Dam Safety Model Program Jurisdictional definition: Section 6. (a) The following low hazard potential dams are not required to be included in the inventory of dams maintained pursuant to this act: (1) Any dam which is less than six feet in height, regardless of its storage capacity. (2) Any dam which has an impounding storage capacity at maximum water storage elevation of less than 15 acre-feet, regardless of its height.
AK						Source: Dam Safety Model Program To determine if a dam is under state jurisdiction, AS 46.17.900(3) defines a dam as an “artificial barrier and its appurtenant works, which may impound or divert water” and which meets at least one of the following three descriptions “(A) Has or will have an impounding capacity at maximum water storage elevation of 50 ac-ft and is at least 10 ft in height measured from the lowest point at either the upstream or downstream toe of the dam to the crest of the dam.” A dam with a jurisdictional height (H) of 10 feet or taller and that stores 50 acre-feet or more of water meets this description, as illustrated in figure 2-1. “(B) is at least 20 feet in height measured from the lowest point at either the upstream or downstream toe of the dam to the crest of the dam.” A dam that is 20 ft or more in height meets this dexcription regardless of its storage capacity, as illustrated in figure 2-2. “(C) Poses a threat to lives and property as determined by the department after an inspection.” In other words, a barrier with a Class I (high) or Class II (significant) hazard potential classification is considered a dam, even if it does not meet the geometric criteria of A or B, above. See section 2.4 for guidance in determining the hazard potential classification.
AZ	N/A	“Large Dam”- Maximum storage greater than or equal to 50,000 ac-ft; height greater than or equal to 100 ft.	“Intermediate Dam”- Maximum storage between 1,001 and 50,000 ac-ft; height between 41 and 100 ft.	“Small dam”- Maximum storage between 50 and 1,000 ac-ft; height between 25 and 40 ft.	N/A	Source:http://www.azwater.gov/AzDWR/SurfaceWater/DamSafety/HazardandSizeClassifications.htm Owner or engineer determines size by storage capacity or height, whichever results in the larger size.
AR	N/A	“Large Dam”- Maximum storage greater than or equal to 50,000 ac-ft; height greater than or equal to 100 ft.	“Intermediate Dam”- Maximum storage between 1,000 and 50,000 ac-ft; height between 40 and 100 ft.	“Small dam”- Maximum storage between 50 and 1,000 ac-ft; height between 25 and 40 ft.	N/A	Source: http://www.anrc.arkansas.gov/TITLEVII.pdf Section 705.3

STATE DAM SAFETY SIZE CLASSIFICATION SCHEMES
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

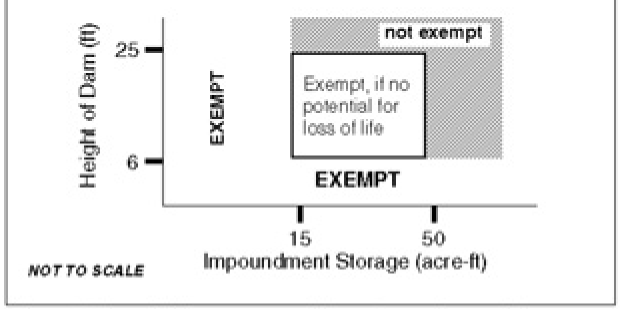
CA						Source: Dam Safety Model Program “Dam means any artificial barrier, together with appurtenant works, which does or may impound or divert water, and which either a) os pr will be 25 feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the department, or from the lowest department, if it is not across a stream channel or watercourse, to the maximum possible water storage elevation or b) has or will have an impounding capacity of 50 acre-feet or more.” A chart indicating jurisdictional and non-jurisdictional dam and reservoir sizes can be found at http://www.water.ca.gov/damsafety/images/JurisChart5.jpg
CO	N/A	"Large Dam" is a dam greater than 50 feet in jurisdictional height, and/or greater than 4,000 acre-feet in capacity.	N/A	“Small Dam" is a dam with a jurisdictional height greater than 20 feet but less than or equal to 50 feet and/or a reservoir capacity greater than 100 acre-feet, but less than 4,000 acre-feet.	"Minor Dam" is a jurisdictional size dam that does not exceed 20 feet in jurisdictional height and/or 100 acre-feet in capacity.	Source: http://water.state.co.us/pubs/rule_reg/ds_rules07.pdf Rules and Regulations for Dam Safety and Dam Construction, Rule 4. Jurisdictional height is defined in Rule 4.2.19. The State Engineer shall have final authority over determination of the jurisdictional height of the dam.
CT						Not defined Source: Dam Safety Model Program Jurisdictional definition: Any barrier of any kind whatsoever capable of impounding or controlling the flow of water, including but not limited to storm water retention or detention dams, flood control structures, dikes, & incompletely breached dams.
DE						Not defined Source: Dam Safety Model Program Jurisdictional definition: "Dam" shall mean any artificial barrier, including appurtenant works, with the ability to impound or divert water, wastewater, or liquid-borne materials. No obstruction in a canal used to raise or lower water shall be considered a dam. A fill or structure for highway or railroad use, or for any other purpose that may impound water, may be subject to review by the Department and shall be considered a dam if the criteria in these Regulations are found applicable and if it is classified as a high hazard potential or significant hazard potential dam.
FL						Source: http://www.damsafety.org/map/state.aspx?s=9 A dam is "any artificial or natural barrier, with appurtenant works, raised to obstruct or impound, or which does obstruct or impound, any of the surface waters of the state." There was nothing is the legislation concerning height and volume definitions. Dam height is not defined in the laws. Dams are not classified by any type of criteria in the laws.
GA	“Very large	“Large dam"-	“Medium dam"-	“Small dam"-	N/A	Source: http://rules.sos.state.ga.us/docs/391/3/8/02.pdf

	dam"- storage capacity exceeding 50,000 acre-feet; height exceeding 100 feet.	storage capacity exceeding 1000 acre-feet but not exceeding 50,000 acre-feet; height exceeding 35 feet but not exceeding 100 feet.	storage capacity exceeding 500 acre-feet but not exceeding 1000 acre-feet; height exceeding 25 feet but not exceeding 35 feet.	storage capacity not exceeding 500 acre-feet; height not exceeding 25 feet.		Georgia Code Title 12 Section 12-5-376.1. Applies to Category I dams only. (Category II dams – those for which improper operation or failure would not be expected to result in probable loss of human life - are not classified by size.) Georgia Code Title 12 Section 12-5-376.1.
HI	N/A	"Large Dam"- Storage capacity of 50,000 acre-feet or greater; height of 100 ft or greater.	"Intermediate Dam"- Storage capacity exceeding 1,000 acre-feet but less than 50,000 ac-ft; height of at least 40 ft, and less than 100 ft.	"Small Dam"- Storage capacity of at least 50 acre-feet but not exceeding 1000 acre-feet; height of at least 25 ft, but not exceeding 40 ft.	N/A	Source: http://state.hi.us/dlnr/eng/ds/guides/HI%20Inspection%20Guidelines.pdf Chapter 2, Guidelines for Safety Inspection of Dams
ID	N/A	"Large Dam"- Storage capacity of 4000 ac-ft. or more OR a height of 40 ft. or more.	"Intermediate Dam"- Storage capacity of 100 ac-ft or more, but less than 4000 ac-ft, OR more than 20 ft. in height, but less than 40 ft.	"Small Dam"- Storage capacity less than 100 ac-ft and 20 ft. or less in height.	N/A	Source: http://www.adm.idaho.gov/adminrules/rules/idapa37/0306.pdf 37.03.06- Safety of Dam Rules
IL	N/A	"Large Dam"- Storage capacity more than 50,000 ac-ft; height more than 100 ft.	"Intermediate Dam"- Storage capacity ranging from 1,000 to 50,000 ac-ft; height of 40-100 ft.	"Small Dam"- Storage Capacity less than 1000 ac-ft; height less than 40 ft.	N/A	Source: Dam Safety Model Program
IN						Not listed Source: Dam Safety Model Program Jurisdictional definition: IDNR currently regulates all dams that meet any one of the following criteria: (1) the drainage area above the dam is greater than 1 square mile (2) the dam embankment is greater than 20 feet high (3) the dam impounds more than 100 acre-feet
IA		"Major dam structure" means		"Low head dam" means any dam		Source: Dam Safety Model Program

		a dam meeting any of the following criteria: 1. Any high hazard dam. 2. Any moderate hazard dam with a permanent storage exceeding 100 acre-feet or a total of permanent and temporary storage exceeding 250 acre-feet at the top of the dam elevation. 3. Any dam, including low hazard dams, where the height of the emergency spillway crest measured above the elevation of the channel bottom at the centerline of the dam (in feet) multiplied by the total storage volume (in acre-feet) to the emergency spillway crest elevation exceeds 30,000. For dams without emergency spillways, these measurements shall be taken to		essentially contained within the channel of a river or stream and which is overtopped by normal stream flows.		

		the top of dam elevation.				
KS	N/A	"Class Size 4"- A size factor of more than 30,000.	"Class Size 3"- A size factor of 3,000 to 30,000	"Class Size 2"- A size factor of less than 3,000.	"Class Size 1"- Height of less than 25 feet and an effective storage of less than 50 acre-feet.	Source: Dam Safety Model Program
KY						Not defined Source: Dam Safety Model Program Jurisdictional definition: Kentucky statutes (KRS 150.100) defines a dam as any artificial barrier (including appurtenant works) which does, or can, impound or divert water and is, or will be 1) 25 feet or more high from the natural bed of the stream or watercourse at the downstream tow of the barrier, as determined by the Department for Environmental Protection, or 2) has, or will have an impounding capacity of fifty acre-feet or more at the maximum water storage elevation.
LA						Correlated with hazard classification Source: Dam Safety Model Program Jurisdictional definition: For the purposes of this Chapter, a dam is any artificial barrier, including appurtenant works, which does or will impound or divert water or any other liquid substance and which (1) is or will be twenty-five feet or more in height from the bed of the watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has or will have an impounding capacity at maximum water storage elevation of fifty acre-feet or more. This definition does not include any dam or barrier that is not or will not be in excess of six feet in height, regardless of storage capacity or which has or will have a storage capacity of maximum water storage elevation not in excess of fifteen acre-feet, regardless of height.
ME						Not listed Source: Dam Safety Model Program Jurisdictional definition: "Dam" means any artificial barrier, including appurtenant works, the site on which it is located and appurtenant rights of flowage and access, that impounds or diverts water, and that: A. Is 25 feet or more in height from the natural bed of the watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier to the maximum water storage elevation and impounds at least 15 acre-feet of water; or [2001, c. 460, §3 (NEW).] B. Is 6 feet or more in height from the natural bed of the watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier to the maximum water storage elevation and has an impounding capacity at maximum water storage elevation of 50 acre-feet or more. [2001, c. 460, §3 (NEW).]
MD	N/A	"Category I" is a	"Category II" is a	"Category III" is	N/A	Source: Dam Safety Model Program

		dam with a normal pool storage of 20,000 ac-ft or more, a normal vol. depth of 50 ft or more, probable loss of life, and potential for serious damage to residential, industrial, or commercial buildings, public roads, or RR.	dam with a normal pool storage greater than 1000 ac-ft and less than 20,000 ac-ft, a normal vol. depth greater than 25 ft and less than 50 ft, small possibility for loss of life, and located in predominately rural or agricultural areas where failure may cause damage to isolated residence or cause interruption of use or service of public utilities or roads. Damage is within financial capability of owner to repair.	a dam with a normal pool storage less than 1000 ac-ft, a normal vol. depth less than 25 ft, and potential loss of life is very unlikely. Damage is of same magnitude as cost of dam and within financial capability of owner to repair.		
MA	N/A	"Large Dam"- 1000 ac-ft of storage or greater; height greater than or equal to 40 ft.	"Intermediate Dam"- Storage of at least 50 ac-ft, but not exceeding 1000 ac-ft; height of at least 15 ft but not greater than 40 ft.	"Small Dam"- Storage of at least 15 ac-ft but not exceeding 50 ac-ft; height of at least 6 ft but not greater than 15 ft.	"Non-jurisdictional Dam"- Storage not in excess of 15 ac-ft regardless of height; height not in excess of 6 ft, regardless of storage capacity.	Source:http://www.mass.gov/dcr/pe/damSafety/downloads/DCR%20Dam%20Safety%20Regulations.pdf For dams not in excess of 25 feet in height or having maximum impounding capacity not in excess of 50 acre-feet, the Commissioner shall make jurisdictional determination by taking into consideration factors or combination of factors such as height, type of structure, volume of the impoundment, extent of downstream development, and other factors deemed appropriate by the Commissioner.
MI						Not defined Source: Dam Safety Model Program Jurisdictional definition: Dams are regulated by Part 315 when they are over 6 feet in height and over 5 acres are impounded during the design flood. Dams are regulated by Part 307 when a circuit court issues an order establishing the level at which the lake is to be maintained.
MN						Source: Dam Safety Model Program

						Jurisdictional definition: State dam safety regulations apply only to structures that pose a potential threat to public safety or property. The potential for damage downstream if a dam fails increases as the height of the dam and the volume of impounded water increases. State dam safety rules do not apply to dams that are so low or retain so little water as to not pose a threat to public safety or property. Figure 1. DAMS SUBJECT TO DNR DAM SAFETY REGULATIONS. *Federally-owned dams and non-hazard dams are exempt.* About 900 dams in Minnesota are subject to dam safety regulations. Dams 6 feet high or less, regardless of the quantity of water they impound, and dams that impound 15 acre-feet of water or less, regardless of their height, are exempt from state dam safety rules. Dams that are less than 25 feet high and impound less than 50 acre-feet are also exempt from state dam safety rules unless there is a potential for loss of life due to failure or misoperation. Figure 1 shows these criteria in a graphical form.
MS		Large dams are greater than 50 feet in height. and Large lakes are greater than 1,000 acre-feet maximum storage.	Medium dams are greater than 25 feet and less than 50 feet in height. Medium lakes are greater than 150 acre-feet maximum storage and less than 1,000 acre-feet maximum storage.	Small dams are those less than 25 feet in height. Small lakes are less than 150 acre-feet maximum storage.		Source: MS DEQ, Sept. 2010 Size classification found in design guidelines. Requirements depend on hazard classification (Low, Significant or High), the dam height (Small dams are those less than 25 feet in height, Medium dams are greater than 25 feet and less than 50 feet in height and Large dams are greater than 50 feet in height), and the storage volume (Small lakes are less than 150 acre-feet maximum storage, Medium lakes are greater than 150 acre-feet maximum storage and less than 1,000 acre-feet maximum storage and Large lakes are greater than 1,000 acre-feet maximum storage). Size and hazard classifications shown dictate requirements for plans and engineering reports. Jurisdictional definition: Dam—Any artificial barrier, including appurtenant works, constructed to impound or divert water, waste-water, liquid borne materials, or solids that may flow if saturated. All structures necessary to maintain the water level in an impoundment or to divert a stream from its course will be considered one dam.

<table>
<tr><td>MO</td><td></td><td></td><td></td><td></td><td></td><td>
Required Spillway Design Flood Precipitation Values
<table>
<tr><th rowspan="2">Dam Type</th><th rowspan="2">Stage of Construction</th><th rowspan="2">Special Descriptions</th><th colspan="3">Environmental Class</th></tr>
<tr><th>1</th><th>2</th><th>3</th></tr>
<tr><td>Conventional or Industrial</td><td>Completed</td><td>Dams built prior to August 13, 1981</td><td>.75PMP</td><td>.5PMP</td><td>100 Yr.</td></tr>
<tr><td></td><td></td><td>New dams built after August 13, 1981</td><td>.75PMP</td><td>.5PMP</td><td>100 Yr.</td></tr>
<tr><td>Industrial</td><td>Starter Dam</td><td>Any</td><td>.5PMP</td><td>.2PMP</td><td>.1PMP</td></tr>
<tr><td></td><td>After starter dam is finished and before final dam is completed</td><td>Any</td><td>.75PMP</td><td>.5PMP</td><td>.2PMP</td></tr>
</table>
Source: Dam Safety Model Program
Jurisdictional definition: "Dam", any artificial or manmade barrier which does or may impound water, and which impoundment has or may have a surface area of fifteen or more acres of water at the water storage elevation, or which is thirty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or dam, if it is not across a streambed or watercourse, together with appurtenant works. Sections 236.400 to 236.500 shall not apply to any dam which is not or will not be in excess of thirty-five feet in height or to any dam or reservoir licensed and operated under the Federal Power Act.
</td></tr>
<tr><td>MT</td><td></td><td></td><td></td><td></td><td></td><td>Not defined
Source: Dam Safety Model Program
Jurisdictional definition: "Dam" means any artificial barrier, including appurtenant works, used to impound or divert water with an impounding capacity of 50 acre-feet or greater measured to the crest of the dam embankment.</td></tr>
<tr><td>NE</td><td></td><td></td><td></td><td></td><td></td><td>Not listed
Source: http://www.dnr.state.ne.us/floodplain/DamSafety/Title_458_1008.pdf
001.09 Dam means any artificial barrier, including appurtenant works, with the ability to impound water, wastewater, or liquid-borne materials and which (a) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum storage elevation or (b) has an impounding capacity at maximum storage elevation of fifty acre feet or more, except that any barrier described in this subsection which is not in excess of six feet in height or which has an impounding capacity at maximum storage elevation of not greater than fifteen acre-feet shall be exempt, unless such barrier, due to its location or other physical characteristics, is classified as a high hazard potential dam.
Dam does
not include: (1) an obstruction in a canal used to raise or lower water; (2) a fill or structure for highway or railroad use, but if such structure serves, either primarily or secondarily, additional purposes commonly associated with dams it shall be subject to review by the department; (3) canals, including the diversion structure, and levees; or (4) water storage or evaporation ponds regulated by the United States Nuclear Regulatory Commission.</td></tr>
</table>

NV	N/A	"Large Dam" - has an embankment height greater than 50 feet or a reservoir capacity greater than 10,000 acre-feet.	"Medium Dam" is any dam that is neither small nor large.	"Small Dam" has an embankment less than 20 feet in height and reservoir capacity less than 100 acre-feet.	N/A	Source: http://water.nv.gov/Engineering/Dams/dam_size.cfm ; **Please note** that if an embankment height dictates one size dam and the reservoir capacity dictates a different size dam, the larger of the two designations shall apply, e.g. a dam that has an embankment height of 2 feet and a reservoir capacity of 9,000 acre-feet shall be designated a medium size dam.
NH	N/A	"Class C Structure" means a dam that has a high hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in probable loss of human life as a result of: (a) Water levels and velocities causing the structural failure of a foundation of a habitable residential structure or a commercial or industrial structure which is occupied under normal conditions; (b) Water levels rising above the first floor elevation of a habitable residential structure or a commercial or industrial	"Class B structure" means a dam that has a significant hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in any of the following: (a) No probable loss of life; (b) Major economic loss to structures or property; (c) Structural damage to a Class I or II road which could render the road impassable or otherwise interrupt public safety services; (d) Major environmental or public health losses, including: (1) Damage to a public water system, as defined by RSA	"Class A structure" means a dam that has a low hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in any of the following: (a) No probable loss of life; (b) Low economic loss to structures or property; (c) Structural damage to a town or city road or private road accessing property other than the dam owner's which could render the road impassable or otherwise interrupt public safety services; (d) The release of liquid industrial, agricultural, or commercial wastes, septage,	"Class AA structure" means a dam that is not a menace because it is in a location and of a size that failure or misoperation of the dam would not result in probable loss of life or loss to property, provided the dam is: (a) Less than 6 feet in height if it has a storage capacity greater than 50 acre-feet; or (b) Less than 25 feet in height if it has a storage capacity of 15 to 50 acre-feet.	Source: Dam Safety Model Program; http://www.damsafety.org/map/state.aspx?s=29 Hazard classification included with size classifications. Jurisdictional definition: RSA chapter 482 defines the term *dam* as "(a) any artificial barrier, including appurtenant works, which impounds or diverts water, and which has a height of 4 feet or more, or a storage capacity of 2 acre-feet or more, or is located at the outlet of a great pond. A roadway culvert shall not be considered a dam if its invert is at the natural bed of the water course, it has adequate discharge capacity, and it does not impound water under normal circumstances. Artificial barriers which create surface impoundments for liquid industrial or liquid commercial wastes, septage or sewage, regardless of height or storage capacity, shall be considered dams. (b) An artificial barrier at a storm water detention basin, which impounds 0.5 acre-feet or less of water during normal conditions, shall not be considered a dam unless its height is 10 feet or greater or its maximum storage is 6 acre-feet or greater." Part ENV-WR 101 of the Administrative Code (regulations) contains definitions for the terms *great pond*, which is a "water body of more than 10 acres in its natural condition", and *height of dam*, which means the "vertical distance from the lowest point of natural ground on the downstream side of the dam to the highest part of the dam which would impound water". Part ENV-WR 301 further defines "a roadway embankment whose culvert is set at the natural streambed shall be considered a dam if during the 25 year storm; (1) the water surface elevation at the culvert inlet is 6 feet or more above the water surface elevation at the culvert outlet; and (2) it impounds 2 acre-feet or more of water over the crown, or top of the culvert." RSA Chapter 482 lists the classifications of dams as "non-menace", "low hazard potential", "significant hazard potential", or "high hazard potential". The determination of hazard classification of structures is based on the potential threat to life and extent of property damage, and is further explained in part ENV-WR 101 of the regulations.

		structure which is occupied under normal conditions when the rise due to dam failure is greater than one foot; (c) Structural damage to an interstate highway which could render the roadway impassable or otherwise interrupt public safety services; (d) The release of a quantity and concentration of materials which qualify as "hazardous waste" as defined by RSA 471-A:2 VI; or (e) Any other circumstance which would more likely than not cause one or more deaths.	485:1-a, XV, which will take longer than 48 hours to repair; or (2) The release of liquid industrial, agricultural, or commercial wastes, septage, sewage, or contaminated sediments if the storage capacity is 2 acre-feet or more; or (3) Damage to an environmentally-sensitive site that does not meet the definition of reversible environmental losses.	or contaminated sediment if the storage capacity is less than 2 acre-feet and is located more than 250 feet from a water body or water course; or (e) Reversible environmental losses to environmentally-sensitive sites.		
NJ		"Large dams": Dams that raise the waters of any stream more than 70 feet above its usual mean low water height or which impound more than 10,000 acre feet of water.			A "Class IV" dam is any project which impounds less than 15 ac-ft of water to the top of the dam, and has less than 15 feet height-of-dam (as measured to the top of the dam) and which ahs a drainage area above the	Source: http://www.state.nj.us/dep/damsafety/standard.pdf ; http://www.state.nj.us/dep/damsafety/dampres1/index.htm Jurisdictional definition: "Dam" means any artificial dike, levee or other barrier, together with appurtenant works, which is constructed for the purpose of impounding water on a permanent or temporary basis, that raises the water level five feet or more above the usual, mean, low water height when measured from the downstream toe-of-dam to the emergency spillway crest or, in the absence of an emergency spillway, the top-of dam.

					dam of 150 acres or less in extent.	
NM	N/A	A "large dam" is greater than 100 feet in height, or greater than 50,000 acre-feet of storage.	An "intermediate dam" is greater than 40 feet but less than or equal to 100 feet in height, or greater than 1000 acre-feet but less than or equal to 50,000 acre-feet of storage.	A "small dam" is 25 ft or greater but less than or equal to 40 ft in height, or 50 acre-ft or greater but less than or equal to 1000 acre-ft of storage.	N/A	Source: NM Dam Safety Bureau, Sept 2010 and http://www.ose.state.nm.us/PDF/19-25-12-NMAC.pdf A dam shall be less than or equal to the maximum height and storage to qualify for the size classification.
NY	Large Class "C" Dams: For dams that have been assigned a Hazard Classification of Class "C" as of the effective date of this Part; the dam either has a height greater than or equal to 40 feet or impounds 1000 acre-feet or more at normal water surface.	Small Class "C" Dams. For dams that have been assigned a Hazard Classification of Class "C" as of the effective date of this Part; the dam has a height of less than 40 feet and impounds less than 1000 acre-feet at normal water surface.	*"Class "B" Dams: For dams that have been assigned a Hazard Classification of Class "B" as of the effective date of this Part.	**"Class A" dam is a low hazard dam.	A "Class D" dam is a "negligible or no hazard" dam.	Source: http://www.dec.ny.gov/docs/water_pdf/damguideli.pdf ; Dam Safety Model Program Size classification will be determined by either storage or height, whichever gives the larger size category. Classification also refers to the hydrologic design criteria table, in correlation with hazard classifications. *A small class B dam has a spillway design flood of 225% of 100 year; minimum freeboard is 1; service spillway design flood is 25 years. A large class B dam has a spillway design flood of 40% of PMF; minimum freeboard is 2; service spillway design flood is 50 years. **A small class A dam has a spillway design flood of 100 years; minimum freeboard is 1; service spillway design flood is 25 years. A large class A dam has a spillway design flood of 150% of 100 yr; minimum freeboard is 2; service spillway design flood is 10 yr. A "small dam" has a height of less than 40 feet. Storage at normal water surface less than 1000 acre feet. A "large dam" will have a height at dam equal to or greater than 40 feet. Storage at normal water surface equal to or greater than 1000 acre feet.
NC	A "very large dam" will have a total storage equal to or greater than 50,000 ac-ft; a height equal to or greater than 100 ft.	A "large dam" will have a total storage equal to or greater than 7,500 and less than 50,000 ac-ft; height equal to or greater than 50 ft, and	A "medium dam" will have a total storage equal to or greater than 750 and less than 7,500; height equal to or greater than 35 ft and less	A "small dam" will have a total storage less than 750 ac-ft; height less than 35 ft.	N/A	Source: http://www.damsafety.org/media/Documents/STATE_INFO/LAWS_&_REGS/NorthCarolina_L&R.pdf The factor determining the larges size shall govern.

		less than 100 ft.	than 50 ft.			
ND						Source: ND State Water Commission, Sept. 2010 North Dakota's Dam Design Classifications are based on both the size of the dam and the hazard classification, as shown in the following table (Source: ND Dam Design Handbook, 1985). **Table 4-1. Dam Design Classifications** Dam Height (Feet) / Hazard Categories: Low, Medium, High Less than 10: I, II, IV 10 to 24: II, III, IV 25 to 39: III, III, IV 40 to 55: III, IV, V Over 55: III, IV, V
OH	N/A	A “Class I dam” a total storage volume greater than five thousand acre-feet or a height of greater than sixty feet.	A “Class II dam” will have a total storage volume greater than five hundred acre-feet or a height of greater than forty feet.	A “Class III dam” will have a total storage volume greater than fifty acre-feet or a height of greater than twenty-five feet.	A “Class IV dam” will be twenty-five feet or less in height and have a total storage volume of fifty acre-feet or less.	Source: http://www.dnr.state.oh.us/water/dsafety/whatdam/tabid/3342/Default.aspx Size classifications are combined with hazard classification definitions.
OK	N/A	A “large dam” has maximum storage over 50,000 ac-ft; maximum height over 100 ft.	An “intermediate dam” has a maximum storage between 10,000 and 50,000 ac-ft; height between 50 and 100 ft.	A “small dam” has a maximum storage less than 10,000 ac-ft; height less than 50 ft.	N/A	Source:http://www.owrb.ok.gov/util/rules/pdf_rul/2010adopted/Adopted2010_Ch25.pdfm
OR	N/A	“Large Dam” for dam safety purposes, means a dam with a height of 10 feet or more and impounding	N/A	“Small dam” for dam safety purposes, means a dam with a height of less than 10 feet or impounding	N/A	Source: http://arcweb.sos.state.or.us/rules/OARS_600/OAR_690/690_020.html

		3,000,000 gallons (9.2 acre-feet) or more of water		less than 3,000,000 gallons (9.2 acre-feet) of water		
PA	N/A	A "Class A" dam will have an impoundment storage equal to or greater than 50,000 ac-ft; height equal to or greater than 100 ft.	A "Class B" dam will have an impoundment storage less than 50,000 ac-ft but greater than 1000 ac-ft; height less than 100 ft but greater than 40 ft.	A "Class C" dam will have an impoundment storage equal to or less than 1000 ac-ft; height equal to or less than 40 ft.	N/A	Source: http://www.pacode.com/secure/data/025/chapter105/s105.91.html *Note: Size classification may be determined by either storage or height of structure, whichever gives the higher category.
PR						
RI						Not defined Source: http://www.dem.ri.gov/pubs/regs/regs//compinsp/dams07.pdf ; Dam Safety Model Program Jurisdictional definition: "**Dam**" means any barrier made by humans, including appurtenant works, that impounds or diverts water.
SC	N/A	A "large dam" will have an impoundment storage greater than or equal to 50,000 ac-ft OR a height greater than or equal to 100 ft.	An "intermediate dam" will have an impoundment storage greater than or equal to 1000 ac-ft, and less than 50,000 ac-ft OR a height greater than or equal to 40 ft, and less than 100 ft.	A "small dam" will have an impoundment storage greater than or equal to 50 ac-ft, and less than 1000 ac-ft OR a height greater than or equal to 25 ft and less than 40 ft.	A "very small dam" will have an impoundment structure less than 50 ac-ft AND a height less than 25 ft.	Source: http://www.scdhec.gov/environment/water/regs/R72-1.doc Size classification may be determined by either storage or height, whichever gives the larger size capacity.
SD	N/A	A "large dam" will have a storage capacity greater than 50,000 ac-ft; height greater than 100 ft.	An "intermediate dam" will have a storage capacity between 1001 and 50,000 ac-ft; height between 41 and 100 ft.	A "small dam" will have a storage capacity between 50 and 1000 ac-ft; height between 25 and 40 ft.	N/A	Source: http://legis.state.sd.us/rules/DisplayRule.aspx?Rule=74:02:08:06 The classification of dams by size is as follows: The size classification is determined by either the maximum storage capacity or the height, whichever gives the larger size category.
TN	N/A	A "large dam" will have a storage of	An "intermediate dam" will have a storage between	A "small dam" will have a storage between	N/A	Source: http://tn.gov/sos/rules/1200/1200-05/1200-05-07.pdf The classification for size is based on the height of the dam and storage capacity in accordance with the table below. The height of the dam is established with respect to

		50,000 ac-ft or greater; height of 100 ft or greater.	1,000 and 49,999 ac-ft; height between 50 and 99 ft.	30 and 99 ac-ft; height between 20 and 49 ft.		the maximum water storage elevation measured from the natural bed of the stream or watercourse at the downstream toe of the barrier, or if it is not across a stream or watercourse, the height from the lowest elevation of the outside limit of the barrier, to the maximum water storage elevation. For the purpose of determining project size, the maximum storage elevation will be considered equal to the top of dam elevation as defined in Rule 1200-5-7-.02(26). Size classification will be determined by either storage or height, whichever gives the larger size category. For size classification purposes, fractions of heights and storages shall be rounded down to the nearest whole number, e.g., 49.9 feet would be classified in the 20 to 49 feet category.
TX	N/A	A "large dam" will have an impoundment storage equal to or greater than 50,000 ac-ft; height equal to or greater than 100 ft.	An "intermediate dam" will have an impoundment storage equal to or greater than 1,000 ac-ft and less than 50,000 ac-ft; height equal to or greater than 40 ft and less than 100 ft.	A "small dam" will have an impoundment storage equal to or greater than 50 ac-ft and less than 1,000 ac-ft; height greater than 6 ft and less than 40 ft OR an impoundment storage equal to or greater than 15 ac-ft and less than 1,000 ac-ft; height equal to or greater than 25 ft and less than 40 ft.	N/A	Source: http://www.tceq.state.tx.us/assets/public/legal/rules/rules/pdflib/299b.pdf The executive director shall classify dams for size based on the larger of the height of the dam or the maximum storage capacity.
UT						Not defined Source: Dam Safety Model Program Jurisdictional definition: DAM is any artificial barrier or obstruction, together with appurtenant works, if any, which impounds or diverts water.
VT	N/A	A "large dam" will have a storage of 50,000 ac-ft or greater; height of 100 ft or greater.	A "medium dam" will have a storage equal to or greater than 1,000 ac-ft and less than 50,000 ac-ft; height equal to or greater than 40 ft and less than 100 ft.	A "small dam" will have a storage less than 1,000 ac-ft; height less than 40 ft.	N/A	Source: http://psb.vermont.gov/sites/psb/files/rules/OfficialAdoptedRules/4500_Dam_Safety.pdf (4.500 Safety of Hydroelectric Dams,1990) 4.510 Dams shall be categorized by size. The size category shall be determined by height or storage, whichever gives the larger size category. The height of a dam and its storage shall both be established with respect to its maximum storage potential, measured from the natural bed of the water course to the maximum water storage elevation. For the purpose of determining size category, the maximum water storage elevation shall be considered to be the height above streambed as defined in section 4.521(B).
VA	N/A	A "large	A "medium	A "small	N/A	Source: http://www.dcr.virginia.gov/documents/dsfinregs092608.pdf

		impounding structure" will have an impounding capacity greater than or equal to 50,000 ac-ft; height greater than or equal to 100 ft.	impounding structure" will have an impounding capacity greater than or equal to 1,000 ac-ft and less than 50,000 ac-ft; height greater than or equal to 40 ft and less than 100 ft.	impounding structure" will have an impounding capacity greater than or equal to 15 ac-ft, and less than 1,000 ac-ft; height greater than or equal to 6 ft and less than 40 ft.		For the purposes of categorizing and reporting information to national and other dam safety databases, impounding structure size shall be classified as noted.
WA	N/A	A "large dam" is 50 ft or greater in height.	An "intermediate dam" is 15 ft or greater but less than 50 ft.	A "small dam" is less than 15 ft.	N/A	Source: http://www.ecy.wa.gov/pubs/9255b.pdf The size classification and reservoir operation classification of the proposed project should be listed as defined by Tables 2 and 3. These classifications are used throughout *Part IV of the Dam Safety Guidelines* for determining the degree of conservatism of design, and the sophistication of the methodologies to be used in analyses.
WV						Not defined Source: Dam Safety Model Program Jurisdictional definition: *"Dam" means an artificial barrier or obstruction --including any works appurtenant to it and any reservoir created by it -- which is or will be placed, constructed, enlarged, altered, or repaired so that it does or will impound or divert water and is or will be twenty-five (25) feet or more in height from the natural bed of a stream or watercourse measured at the downstream toe of the barrier and which does or can impound fifteen (15) acre-feet or more of water or is or will be six (6) feet or more in height from the natural bed of such stream or watercourse measured at the downstream toe of the barrier and which does or can impound fifty (50) acre-feet or more of water. (List is given of items that are NOT dams as well) The "**coal related** dam safety" rule is as follows: "Dam" means an artificial barrier or obstruction including works appurtenant to it and be placed, constructed, enlarged, altered or repaired so that it does or will impound or divert water and is or will be twenty-five (25) feet or more in height from the natural bed of a stream or watercourse measured at the downstream toe of the barrier and which does or can impound fifteen (15) acre-feet or more of water or is or will be six (6) feet or more in height from the natural bed of such stream or watercourse measured at the downstream toe of the barrier and which does or can impound fifty (50) acre-feet or more of water.
WI		A dam is considered to be a "large dam" if either of the following applies:				Source: http://www.legis.state.wi.us/statutes/Stat0031.pdf ; http://www.damsafety.org/media/Documents/PDF/WI.pdf Jurisdictional definition: Dam is defined in Chapters NR 333 as "any artificial barrier, together with appurtenant works, built across a waterway that has the primary purpose of impounding or diverting water". Jurisdiction for the dam inspection program described in Chapter NR 333 is established by defining large dams as those with 1) a structural

		(a) It has a structural height of 25 feet or more and impounds more than 15 acre−feet of water. (b) It has a structural height of more than 6 feet and impounds 50 acre−feet or more of water.				height of 25 feet or more and that can impound more than 15 acre-feet of water or, 2) structural height of more than 6 feet and that can impound more than 50 acre feet of water. Source: Dam Safety Model Program All large dams in the state, except those owned by the US Government or inspected, approved and licensed by a federal agency, are under Department of Natural Resources jurisdiction and must conform to Chapter NR 333 "Dam Design and Construction Standards".
WY						Source: http://www.damsafety.org/media/Documents/PDF/WY.pdf Jurisdictional definition: Section 41-3-307 of the statutes defines the term dam as any artificial barrier, including appurtenant works, used to impound or divert water and which is or will be greater than twenty (20) feet in height or with an impounding capacity of fifty (50) acre-feet or greater. Dams less than 15 acre-feet in capacity or 6 feet or less in height are excluded. No system of dam classification is provided for in either the laws or the regulations.

F.2. Hazard Classification Schemes

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION

Association of State Dam Safety Officials - www.damsafety.org

Compiled September 2010

	Extreme	High	Significant	Low	Very Low	Citation/ Notes
AL	NA	High-Hazard Potential	Moderate-Hazard Potential	Low-Hazard Potential	NA	Source: Alabama Dam Inventory and Classification Act, Section 5 (a). The office may gather necessary updated information regarding the characteristics of a dam and its surroundings in order to verify classification. The office may use information furnished to it by other persons to accomplish the purpose of this act and this section including, but not limited to, the classification of dams as set forth in subsection (a).
AK	NA	Class I (high) hazard potential classification, if the department determines that the failure or improper operation of the barrier will result in probable loss of human life.	Class II (significant) hazard potential classification, if the department determines that the failure or improper operation of the barrier will result in(A) a significant danger to public health; (B) the probable loss of or probable significant damage to homes, occupied structures, commercial property, high-value property, major highways, primary roads, railroads, or public utilities, other than losses described in (3)(B) of this subsection; (C) other probable significant property losses or damage, other than losses described in (3)(B) of this subsection; or (D) probable loss of or significant damage to waters identified under 5 AAC 95.011(a) as important for the spawning, rearing, or migration of anadromous fis	Class III (low) hazard potential classification if the department determines that the failure or improper operation of the barrier will result in (A) limited impacts to rural or undeveloped land, rural or secondary roads, and structures; (B) property losses or damage limited to the owner of the barrier; or (C) insignificant danger to public health.	NA	Source: 11 AAC 93.157. Hazard classification
AZ	NA	High Hazard Potential. Failure or improper operation of a dam would be likely to cause loss of human life because of residential, commercial, or industrial development. Intangible losses may	Significant Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life but may cause significant or high economic loss, intangible damage requiring major mitigation, and disruption or impact on lifeline facilities.	Low Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life, but would produce low economic and intangible losses, and result in no disruption of	Very Low Hazard Potential. Failure or improper operation of a dam would be unlikely to result in loss of human life and would produce no lifeline losses and very low economic and intangible losses. Losses	Source: AZ DWR, Sept. 2010 Hazard classification based on evaluation of probable present & future incremental adverse consequences of failure or improper operation of the dam or appurtenances regardless of the condition of the dam or appurtenances. Evaluation includes land use zoning & projected development over 10 years following classification. All of the following are considered: probable loss of human life, economic/ lifeline losses, & intangible losses identified & evaluated by a public resource management or protection agency. -Probable incremental loss of human life determined primarily on the number of permanent structures for human

		be major and potentially impossible to mitigate, critical lifeline services may be significantly disrupted, and property losses may be extensive. (Loss of human life is probable, with one or more expected. Economic, lifeline & intangible losses can range from low to high; they are not necessary for this classification.)	Property losses would occur in a predominantly rural or agricultural area with a transient population but significant infrastructure.	lifeline services that require more than cosmetic repair. Property losses would be limited to rural or agricultural property, including equipment, and isolated buildings.	would be limited to the 100 year floodplain or property owned or controlled by the dam owner under long-term lease. The Department considers loss of life unlikely because there are no residences or overnight camp sites.	habitation impacted in the event of failure or improper operation of a dam. Loss of human life considered unlikely if: Persons are only temporarily in the potential inundation area; There are no residences or overnight campsites; & the owner has control of access to the potential inundation area & provides an EAP with a process for warning in the event of failure or improper operation. -Probable economic, lifeline & intangible loss determined by property losses, interruptions of services, & intangible losses likely to result from failure or improper operation of a dam. -Hazard class evaluated during each inspection & revised in accordance with current conditions.
AR	NA	Loss of human life expected. Excessive economic loss (extensive public, industrial, commercial, or agricultural development); over $500,000	No loss of life expected. Appreciable economic loss (significant structures, industrial, or commercial development, or cropland); $100,000 to $500,000	No loss of life expected. Minimal economic loss (No significant structures, pastures, woodland, or largely undeveloped land); less than $100,000	NA	Section 705.4. All dams will be classified or reclassified as required to assure appropriate safety considerations. Hazard classification shall be based on the more stringent of either potential loss of human life or economic loss. If doubt exists concerning classification, the more hazardous category must be selected. Loss of human life is based on presence of habitable structures.
CA	Extreme	High	Moderate	Low	NA	Dams are classified as to damage potential (hazard) and condition. This classification is used to determine frequency of inspection and for selection of the return period for hydrology studies. A weighted point system is used to divide the damage potential into four classifications: extreme, high, moderate, and low. Reservoir capacity, dam height, estimated evacuation and potential damage are the factors used to classify the damage potential. A similar point system is used to classify the condition of the dam as: poor, fair, good, and excellent. Age, general condition, geologic, and seismic setting are the factors evaluated to classify the condition of the dam. Hazard classification is reevaluated when development occurs downstream and when the condition of the dam changes, either by identifying deficiencies or when alteration/repair work is completed.
CO	NA	High Hazard - Loss of human life is expected to result from failure of the dam. Designated recreational sites located downstream within the bounds of possible inundation	Significant Hazard - Significant damage is expected to occur, but no loss of human life is expected from failure of the dam. Significant damage is defined as damage to structures where people generally live, work, or	Low Hazard - Loss of human life is not expected, and significant damage to structures and public facilities as defined for a "Significant Hazard" dam is not expected to	No Public Hazard (NPH) - A dam for which no loss of human life is expected, and which damage only to the dam owner's property will result from failure of the dam.	Rule 5.4. Hazard potential is derived from an evaluation of the probable incremental adverse consequences due to failure or improper operation of the dam. Conditions for evaluation are absent flooding, and the reservoir is assumed to be full to the high water line. Classification does not reflect the current condition of the dam with regard to safety, structural integrity, or flood routing capacity. The Hazard Classification evaluation method must be approved by the State Engineer.

		should also be evaluated for potential loss of human life.	recreate, or public or private facilities. Significant damage is determined to be damage sufficient to render structures or facilities uninhabitable or inoperable.	result from failure of the dam.		
CT	Class C - A high hazard potential dam which, if it were to fail, would result in any of the following: (i) probable loss of life; (ii) major damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.; (iii) damage to main highways (greater than 1500 ADT); or(iv) great economic loss.	Class B - A significant hazard potential dam which, if it wee to fail, would result in any of the following: (i) possible loss of life; (ii) minor damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.; (iii) damage to or interruption of the use of service of utilities; (iv) damage to primary roadways (less than 1500 ADT) and railroads; or (v) significant economic loss.	Class BB - A moderate hazard potential dam which, if it were to fail, would result in any of the following: (i) damage to normally unoccupied storage structures; (ii) damage to low volume roadways (less than 500 ADT); or (iii) moderate economic loss.	Class A - A low hazard potential dam which, if it were to fail, would result in any of the following: (i) damage to agricultural land; (ii) damage to unimproved roadways (less than 100 ADT); (iii) minimal economic loss.	Class AA - A negligible hazard potential dam which, if it were to fail, would result in the following: (i) no measurable damage to roadways; (ii) no measurable damage to land and structures; and (iii) negligible economic loss.	The Commissioner shall assign each dam to one of five classes according to its hazard potential. Such classification shall be determined by the Commissioner during the initial periodic inspection. Source: Guidelines for Inspection and Maintenance of Dams
DE	NA	Class I - "High Hazard Potential Dam" shall mean any dam whose failure or misoperation will cause probable loss of human life.	"Significant Hazard Potential Dam " shall mean any dam whose failure or mis-operation will cause possible loss of life, economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.	"Low-hazard potential dam" means any dam whose failure or misoperation is unlikely to cause loss of human life but may cause minor economic and/or environmental losses.	NA	
FL	NA	Direct loss of life: Certain (one or more extensive residential, commercial or industrial development) Lifeline losses: Disruption of critical facilities and access Property Losses:	Direct loss of life: Uncertain (rural location with few residences & only transient or industrial development) Lifeline losses: Disruption of essential services & access Property Losses: Major public and private facilities Environmental losses: Major	Direct loss of life: None expected (due to rural location with no permanent structures for human habitation) Lifeline losses: No disruption of services Property Losses: Private agricultural lands,	NA	Source: Design Criteria Memorandum: DCM-1 and “Final Hazard Potential Memorandum” by URS (August 2007)

		Extensive public and private facilities Environmental losses: Extensive mitigation cost or impossible to mitigate	mitigation required	equipment, & isolated buildings Environmental losses: Minimal incremental damage		
GA	NA	Category I – Improper operation or dam failure would result in probable loss of human life. Situations constituting 'probable loss of life' are those situations involving frequently occupied structures or facilities, including but not limited to, residences, commercial and manufacturing facilities, schools, and churches."	NA	Category II - Improper operation or dam failure would not be expected to result in probable loss of human life."	NA	391-3-8-.03 When an existing Category II dam may be reclassified to a Category I dam because of proposed development, the governing authority issuing the permit for the development shall provide for review by the Safe Dams Programs: (a) location of the Category II dam and the proposed development; (b) a surveyed cross-section of the stream valley at the proposed development location, including proposed finished floor elevations; (c) a dam breach analysis to establish the height of the flood wave in the floodplain. If reclassification is deemed appropriate, the owner of the existing Category II dam may request an inspection from the Director within 10 days of notification of the proposed development. Detailed surveys, hydrologic and hydraulic analyses will not be performed, but the Director may provide an opinion on the hydraulic adequacy of the dam. A written evaluation of the existing Category II dam's compliance with Category I requirements will be provided to the owner of the dam and the local governing authority based on preliminary visual inspection by the Safe Dams Program.
HI	NA	High Hazard: Loss of life: Probable, one or more expected Economic/ Environmental Losses: Yes, but not necessary for this classification	Significant: Loss of life: None expected Economic/ Environmental Losses: Yes	Low: Loss of life: None expected Economic/ Environmental Losses: Low and generally limited to owner property	NA	Rules S.13-190-2
ID	NA	High-Hazard Dams: Catastrophic failure and sudden release of water likely would result in direct loss of human life.	Significant Hazard Dams: Failure would cause significant economic damage to existing infrastructure, or may contribute to the indirect loss of life.	Low Hazard Dams: No permanent habitable structures within inundation zone; failure would cause only minor damage to infrastructure, with low probability for loss of life.	NA	Provided by ID Program, 9/3/2010.
IL	NA	Class I - Failure has a high probability of causing loss of life or substantial economic loss, similar to that of	Class II - Failure has a moderate probability for causing loss of life or substantial economic loss, similar to USACE Significant	Class III - failure has a low probability for causing loss of life or substantial economic loss, similar to USACE	NA	

		USACE High Hazard Potential or USDA/NRCS Class (c) dams	Hazard Potential or USDA/NRCS Class (b) dams.	Low Hazard Potential or USDA/NRCS Class (a) dams.		
IN	NA	High hazard - If an uncontrolled release of the structure's contents due to a failure of the structure may result in any of the following: (A) The loss of human life. (B) Serious damage to: (i) homes; (ii) industrial and commercial buildings; or (iii) public utilities. (C) Interruption of service for more than one (1) day on any of the following: (i) A county road, state two-lane highway, or U.S. highway serving as the only access to a community. (ii) A multilane divided state or U.S. highway, including an interstate highway. (D) Interruption of service for more than one (1) day on an operating railroad. (E) Interruption of service to an interstate or intrastate utility, power or communication line serving a town, community, or significant military and commercial facility, in which disruption of	Significant hazard - If an uncontrolled release of the structure's contents due to a failure of the structure may result in any of the following: (A) Damage to isolated homes. (B) Interruption of service for not more than one (1) day on any of the following: (i) A county road, state two-lane highway, or U.S. highway serving as the only access to a community. (ii) A multilane divided state or U.S. highway, including an interstate highway. (C) Interruption of service for not more than one (1) day on an operating railroad. (D) Damage to important utilities where service would be interrupted for not more than one (1) day, but either of the following may occur: (i) Buried lines can be exposed by erosion. (ii) Towers, poles, and aboveground lines can be damaged by undermining or debris loading.	Low hazard - If an uncontrolled release of the structure's contents due to a failure of the structure does not result in any of the items given in subdivision (1) or (2) and damage is limited to either farm buildings, agricultural land, or local roads.	NA	The division may modify an assignment of hazard classification, made previously under this article, if changes in the downstream development affect the potential for loss of human life and property. (Natural Resources Commission; 312 IAC 10.5-3-1; filed Jan 26, 2007, 10:45 a.m.: 20070221-IR-312060092FRA) Source: *General Guidelines For New Dams and Improvements To Existing Dams in Indiana* (2010)

		power and communication would adversely affect the economy, safety, and general well-being of the area for more than one (1) day.				
IA		High Hazard - Located in an area where dam failure may create a serious threat of loss of human life.	Moderate Hazard - Failure may damage isolated homes or cabins, industrial or commercial buildings, moderately traveled roads, interrupt major utility services, but are without substantial risk of loss of human life. Dams are also classified as Moderate Hazard where the dam and its impoundment are themselves of public importance, such as dams associated with public water supply systems, industrial water supply or public recreation or which are an integral feature of a private development complex.	Low Hazard - Damages from a failure would be limited to loss of the dam, livestock, farm outbuildings, agricultural lands and lesser used roads and where loss of human life is considered unlikely.	NA	www.iowadnr.gov/water/floodplain/damsafety.html
KS	NA	Class C dam - A dam located in an area where failure could result in any of the following: Extensive loss of life; Damage to more than one home; Damage to industrial or commercial facilities; Interruption of a public utility serving a large number of customers; Damage to traffic on high-volume roads that meet the requirements for hazard class C dams as specified in subsections (b) and (c) or a high-volume railroad line;	Class B - A dam located in an area where failure could endanger a few lives, damage an isolated home, damage traffic on moderate-volume roads that meet the requirements for hazard class B dams as specified in subsections (b) and (c), damage low-volume railroad tracks, interrupt the use or service of a utility serving a small number of customers, or inundate recreation facilities, including campground areas intermittently used for sleeping and serving a relatively small number of persons.	Class A - A dam located in an area where failure could damage only farm or other uninhabited buildings, agricultural or undeveloped land including hiking trails, or traffic on low-volume roads that meet the requirements for hazard class A dams as specified in subsections (b) and (c). including campground areas intermittently used for sleeping and serving a relatively small number of persons.	NA	K.A.R. 5-40-20. Vehicle-per-day counts used to determine potential hazard created by the roadway: Roads on any part of the embankment or spillway: Class A: 0 through 100 Class B: 101 through 500 Class C: more than 500 Any roadway not on the dam but in the inundation area: Class A: 0 through 500 Class B: 501 through 1,500 Class C: more than 1,500

		Inundation of a frequently used recreation facility serving a relatively large number of persons; or Two or more individual hazards described in hazard class B.				
KY	NA	Class (C) High Hazard - Structures for which failure would cause loss of life or serious damage to homes, commercial buildings, utilities, highways or railroads.	Class (B) Moderate Hazard - Structures for which failure would cause significant damage to property and project operation, but loss of life is not envisioned.	Class (A) Low Hazard - Structures for which failure would result in loss of the structure itself, but little or no additional damage to other property.	NA	
LA	NA	Potential loss of life: Likely. Potential economic loss: Excessive	Potential loss of life: Possible Potential economic loss: Appreciable	Potential loss of life: Not likely Potential economic loss: Minimal	NA	
ME		Impounding structures in the "high hazard" potential category will be those located where failure may cause serious damage to homes, extensive agricultural, industrial, and commercial facilities, important public utilities, main highways, railroads, or other impounding structures. Urban development: Exists, with more than a small number of habitable structures. Economic loss: Excessive (extensive community, industry, or	"Significant hazard" potential category structures will be those located in predominantly rural or agricultural areas where failure may damage isolated homes, secondary highways, minor railroads, or other impounding structures or cause interruption of use of service of relatively important pubic utilities. Urban development: None. No more than a small number of habitable structures. Economic loss: Appreciable (notable agriculture, industry, or structures)	Structures conforming to criteria for the "low hazard" potential category generally will be found in rural or agricultural areas where failure may damage some farm buildings, limited agricultural land, or country roads. Urban development: None. No permanent structure for human habitation. Economic loss: Minimal (undeveloped to occasional structures or agriculture)	NA	Present and projected development of the flood plain downstream from the impounding structure shall be considered in determining the classification. Evaluation. The commissioner shall evaluate all dams to assign or reassign a hazard potential classification in accordance with the following schedule: A. New or reconstructed dams, within 6 months of construction or reconstruction; [2001, c. 460, §3 (NEW).] B. All other dams, at least once every 6 years; [2001, c. 460, §3 (NEW).] C. Any dam, within 30 days of a request for an evaluation from the dam owner, the municipality in which the dam is located or the emergency management director of the county in which the dam is located; and [2001, c. 460, §3 (NEW).] D. At any time a dam for which, in the judgment of the commissioner, such an evaluation is appropriate.

		agriculture)				
MD	NA	High hazard (Class 1) where loss of life and extensive property damage are probable should the dam fail,.	Significant hazard (Class 2) where failure would cause extensive damage to public or private property but the loss of life is very unlikely	Low hazard (Class 3) where failure would not cause the loss of life and the damage is within the financial capability of the owner to repair	NA	COMAR 26.17.04-03[B] MD Dam Safety Manual (rev Nov 1993)
MA	NA	High Hazard Potential dam refers to dams located where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).	Significant Hazard Potential dam refers to dams located where failure may cause loss of life and damage home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause interruption of use or service of relatively important facilities.	Low Hazard Potential dam refers to dams located where failure may cause minimal property damage to others. Loss of life is not expected.	NA	
MI	NA	High Hazard Potential: Failure may cause serious damage to inhabited homes, agricultural buildings, campgrounds, recreational facilities, industrial or commercial buildings, public utilities, main highways or class I carrier railroads, or where environmental degradation would be significant, or where danger to individuals exists with the potential for loss of life. (Sec.31503 [11])	Significant Hazard Potential: failure may cause damage limited to isolated inhabited homes, agricultural buildings, structures, secondary highways, short line railroads, or public utilities, where environmental degradation may be significant, or where and danger to individuals exists. (Sec. 31505 [5])	Low Hazard Potential: failure may cause damage limited to agriculture, uninhabited buildings, township or county roads, where environmental degradation would be minimal, and danger to individuals is slight or nonexistent. (Sec. 31504 [2])	NA	
MN	NA	Class I - any loss of life or serious hazard, or damage to health, main highways, high-value industrial or commercial	Class II - possible health hazard or probable loss of high-value property, damage to secondary highways, railroads or other public utilities, or	Class III- property losses restricted mainly to rural buildings and local county and township roads, which	No hazard - no potential for loss of life and no impacts to health, safety, and welfare.	

		properties, major public utilities, or serious direct or indirect economic loss	limited direct or indirect economic loss to the public other than that described in Class III	are an essential part of the rural transportation system serving the area involved		
MS	NA	High Hazard–A class of dam in which failure may cause loss of life, serious damage to residential, industrial, or commercial buildings; or damage to, or disruption of, important public utilities or transportation facilities such as major highways or railroads. Dams which meet the statutory thresholds for regulation that are proposed for construction in established or proposed residential, commercial, or industrial areas will be assigned this classification, unless the applicant provides convincing evidence to the contrary.	Significant Hazard—A class of dam in which failure poses no threat to life, but may cause significant damage to main roads, minor railroads, or cause interruption of use or service of public utilities.	Low Hazard—A class of dam in which failure would at the most result in damage to agricultural land, farm buildings (excluding residences), or minor roads.	NA	
MO	NA	Class 1 – Downstream of the dam contains at least 10 or more permanent dwellings or any public building.	Class 2 – Downstream of the dam contains 1 to 9 public dwellings or 1 or more campgrounds with permanent water, sewer and electrical services or 1 or more industrial building.	Class 3 – No lives, campgrounds, public dwellings, public buildings or industrial buildings are threatened from a dam failure.	NA	
MT	Dams in Series - (1) The worst case scenario shall govern for determining the hazard classification of	High-hazard - Impoundment capacity is 50 acre-feet or larger and loss of human life is likely to occur within the breach flooded area as a result of failure of	NA	NA	NA	(History: Sec. 85-15-110 , MCA; IMP , Sec. 85-15-209 , MCA; NEW , 1988 MAR p. 2489, Eff. 11/24/88.)

	dams in series where more than one mode of failure is possible among the dams. Classification shall be based on potential for failure under combined and, if applicable, individual dam breach scenarios. (2) If an upstream dam has the capability to create failure in a downstream high-hazard dam because of its failure flood wave, the upstream dam must be classified as a high-hazard dam. (3) If the failure flood wave of the upstream dam will cause failure of the downstream dam, and the combined flows will likely cause a loss of life, the upstream dam must be classified as a high-hazard dam.	the dam. The breach flooded area, for the purpose of this classification only, is the flooded area caused by a breach of the dam with the reservoir full to the crest of the emergency spillway. The evaluation of the effects of flood inundation, for the purpose of classification, will continue downstream until the flood stage is equal to that of the 100-year floodplain. The breach flow hydrograph and downstream routing of the breach flows, for the purpose of classification, will be estimated by the department either by visual determination or dam breach modeling techniques. Loss of life is assumed to occur if the following structures are present or planned for as a matter of public record or notice in the breach flooded area: occupied houses and farm buildings, stores, gas stations, parks, golf courses, stadiums, ball parks, interstate, principal, and other paved highways, and including railroads, highway rest areas, RV areas, developed campgrounds; and excluding unpaved				

		county roads and all private roads.				
NE	NA	High hazard - Failure or misoperation of the dam resulting in loss of human life is probable.	Significant hazard - Failure or misoperation of the dam would result in no probable loss of human life but could result in major economic loss, environmental damage, or disruption of lifeline facilities.	Low hazard potential - Failure or misoperation of the dam would result in no probable loss of human life and in low economic loss.	NA	Laws 2005, LB 335, § 19, § 32, § 21. Effective Sept 4, 2005. ~ Revised Statutes Supplement 2005, Sections 46-1632, 46-1621
NV	NA	High hazard – when there is reasonable potential for loss of life and/or extreme economic loss.	Significant hazard designation is assigned to a dam if there is a low potential for loss of life but an appreciable economic loss.	Low hazard designation is assigned to a dam if there is a vanishingly small potential for loss of life and the economic loss is minor or confined entirely to the dam owner's own property.	NA	http://water.nv.gov/Engineering/Dams/hazard_designations.cfm NAC 535.140
NH		"**Class C Structure**" means a dam that has a high hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in probable loss of human life as a result of: (a) Water levels and velocities causing the structural failure of a foundation of a habitable residential structure or a commercial or industrial structure which is occupied under normal conditions; (b) Water levels rising above the first floor elevation of a habitable residential structure or a commercial or industrial structure which is occupied	"**Class B structure**" means a dam that has a significant hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in any of the following: (a) No probable loss of life; (b) Major economic loss to structures or property; (c) Structural damage to a Class I or II road which could render the road impassable or otherwise interrupt public safety services; (d) Major environmental or public health losses, including: (1) Damage to a public water system, as defined by RSA 485:1-a, XV, which will take longer than 48 hours to repair; or (2) The release of liquid industrial, agricultural, or	"**Class A structure**" means a dam that has a low hazard potential because it is in a location and of a size that failure or misoperation of the dam would result in any of the following: (a) No probable loss of life; (b) Low economic loss to structures or property; (c) Structural damage to a town or city road or private road accessing property other than the dam owner's which could render the road impassable or otherwise interrupt public safety services; (d) The release of liquid industrial, agricultural, or commercial wastes, septage, or contaminated sediment	"**Class AA structure**" means a dam that is not a menace because it is in a location and of a size that failure or misoperation of the dam would not result in probable loss of life or loss to property, provided the dam is: (a) Less than 6 feet in height if it has a storage capacity greater than 50 acre-feet; or (b) Less than 25 feet in height if it has a storage capacity of 15 to 50 acre-feet.	NHCAR, Env-Wr 100-800

		under normal conditions when the rise due to dam failure is greater than one foot; (c) Structural damage to an interstate highway which could render the roadway impassable or otherwise interrupt public safety services; (d) The release of a quantity and concentration of materials which qualify as “hazardous waste” as defined by RSA 471-A:2 VI; or (e) Any other circumstance which would more likely than not cause one or more deaths	commercial wastes, septage, sewage, or contaminated sediments if the storage capacity is 2 acre-feet or more; or (3) Damage to an environmentally-sensitive site that does not meet the definition of reversible environmental losses.	if the storage capacity is less than 2 acre-feet and is located more than 250 feet from a water body or water course; or (e) Reversible environmental losses to environmentally-sensitive sites.		
NJ	NA	Class I - High Hazard Potential - Dams, the failure of which may cause probable loss of life or extensive property damage.	Class II - Significant Hazard Potential - Dams, the failure of which may cause significant damage to property and project operation, but loss of human life is not envisioned..	Class III - Low Hazard Potential - Dams, the failure of which would cause loss of the dam itself but little or no additional damage to other property.	Class IV - Small Dams - Any project which impounds less than 15 acre-feet of water, is less than 15 feet in height, and has a drainage area above the dam of less than 150 acres.	N.J.A.C. 7:20-1.8.
NM	NA	High hazard potential: Dams where failure or misoperation will probably cause loss of human life.	Significant hazard potential: Dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in populated areas with significant infrastructure.	Low hazard potential: Dams where failure or misoperation results in no probable loss of life and low economic or environmental losses. Losses are principally limited to the dam owner’s property.	NA	[19.25.12.10 NMAC - N, 3/31/2005] Rating is based on loss of life, damage to property and environmental damage that is likely to occur in the event of dam failure. No allowances for evacuation or other emergency actions by the population should be considered.

STATE DAM SAFETY HAZARD POTENTIAL CLASSIFICATION
Association of State Dam Safety Officials - www.damsafety.org
Compiled September 2010

NY	NA	Class "C" or "High Hazard" dam: A dam failure may result in widespread or serious damage to home(s); damage to main highways, industrial or commercial buildings, railroads, and/or important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; or substantial environmental damage; such that the loss of human life or widespread substantial economic loss is likely.	Class "B" or "Intermediate Hazard" dam: A dam failure may result in damage to isolated homes, main highways, and minor railroads; may result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and/or is otherwise likely to pose the threat of personal injury and/or substantial economic loss or substantial environmental damage. Loss of human life is not expected.	Class "A" or "Low Hazard" dam: A dam failure is unlikely to result in damage to anything more than isolated or unoccupied buildings, undeveloped lands, minor roads such as town or county roads; is unlikely to result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and/or is otherwise unlikely to pose the threat of personal injury, substantial economic loss or substantial environmental damage.	NA	Source: NY DEC, Sept. 2010 673.5 Hazard Classifications (2009) Revises language related to the hazard classifications that may be assigned to a dam, and the factors that the Department may consider in assigning a hazard classification, for clarity. Requires that the Department must notify a dam owner when it changes the hazard classification, and that the Department will make available a list of dams and the hazard classifications assigned to them. Provides a process for appealing a hazard classification. Also includes Class "D" or "Negligible or No Hazard" dam: A dam that has been breached or removed, or has failed or otherwise no longer materially impounds waters, or a dam that was planned but never constructed. Class "D" dams are considered to be defunct dams posing negligible or no hazard. The department may retain pertinent records regarding such dams.
NC	NA	Class C – High-hazard: Dams located where failure will likely cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, primary highways, or major railroads.	Class B – Intermediate-hazard: Dams located where failure may damage highways or secondary railroads, cause interruption of use or service of public utilities, cause minor damage to isolated homes, or cause minor damage to commercial and industrial buildings. Damage to these structures will be considered minor only when they are located in back water areas not subjected to the direct path of the breach flood wave; and they will experience no more than 1.5 feet of flood rise due to breaching above the lowest ground elevation adjacent to the outside foundation walls or no more than 1.5 feet of flood rise due to breaching above the	Class A – Low-hazard: Dams located where failure may damage uninhabited low value non residential buildings, agricultural land, or low volume roads.	NA	Rule .0105

			lowest floor elevation of the structure, the lower of the two elevations governing. All other damage potential will be considered serious.			
ND	NA	High - Dams located upstream of developed and urban areas where failure may cause serious damage to homes, industrial and commercial buildings & major public utilities. There is potential for loss of more than a few lives if the dam fails.	Medium – Dams located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, railroads or cause interruption of minor public utilities. The potential for loss of a few lives may be expected if the dam fails.	Low – Dams located in rural or agricultural areas where there is little possibility of future development. Failure of low hazard dams may result in damage to agricultural land, township and county roads, and farm buildings other than residences. No loss of life expected.	NA	Source: ND State Water Commission, Sept. 2010 North Dakota's Dam Design Classifications are based on both the size of the dam and the hazard classification, as shown in the following table (Source: ND Dam Design Handbook, 1985). **Table 4-1. Dam Design Classifications** Dam Height (Feet) — Hazard Categories: Low / Medium / High Less than 10: I / II / IV 10 to 24: II / III / IV 25 to 39: III / III / IV 40 to 55: III / IV / V Over 55: III / IV / V
OH	NA	Class I: Sudden failure of the dam would result in probable loss of human life or structural collapse of at least one residence or one commercial or industrial business. Dams having a total storage volume greater than five thousand acre-feet or a height of greater than sixty feet shall be placed in class I.	Class II: Dams having a total storage volume greater than 500 acre-ft or a height of greater than 40 ft. Loss of human life is not probable. Failure of the dam would result in at least one of the following conditions: (a) Disruption of a public water supply or wastewater treatment facility, release of health hazardous industrial or commercial waste, or other health hazards. (b) Flooding of residential, commercial, industrial, or publicly owned structures. (c) Flooding of high-value	Class III: Dams having a height of greater than 25 ft, or a total storage volume greater than 50 acre-ft. Loss of human life is not probable. Sudden failure of the dam would result in at least one of the following conditions: (a) Property losses including but not limited to rural buildings not otherwise described in paragraph A of this rule, and class IV dams and levees not otherwise listed as high-value	Class IV: Dams 25 ft or less in height and with total storage volume of 50 acre-ft or less. Sudden failure would result in property losses restricted mainly to the dam and rural lands, and loss of human life is not probable. Class IV dams are exempt from the permit requirements of section 1521.06 of the Revised Code pursuant to paragraph (C) of rule 1501:21-19-01 of the Administrative Code.	Admin. Rules Chapt 13-1501:21-13-01. All pertinent information including any unusual circumstances shall be considered by the chief in establishing an appropriate classification for a dam. Probable future development of the area downstream from the dam that would be affected by its failure shall be considered. Completed downstream hazard mitigation such as acquisition, removal or protection of downstream property may also be considered. However, the above criteria shall in no way preclude the chief's requirement of greater safety in the interest of life, health, or property.

			property. (d) Damage or disruption to major roads including but not limited to interstate and state highways, and the only access to residential or other critical areas such as hospitals, nursing homes, or correctional facilities as determined by the chief. (e) Damage or disruption to railroads, or public utilities. (f) Damage to downstream class I, II or III dams or levees, or other dams or levees of high value.	property in paragraph A of this rule. At the request of the dam owner, the chief may exempt dams from the criterion of this paragraph if the dam owner owns the potentially affected property. (b)Damage or disruption to local roads including but not limited to roads not otherwise listed as major roads in paragraph A of this rule.		
OK	NA	High hazard: One or more habitable structures with loss of life due to dam failure likely. Excessive economic loss/property damage (extensive community, industrial or agriculture)	Significant hazard: No loss of life Potential for future development exists, habitable structures may exist in inflow design flood floodplain, but dam failure would not endanger lives that would not be endangered if structure did not exist. Appreciable economic loss/ property damage (notable agriculture, industrial or structural)	Low hazard: None (no probable future development; may be zoned to prevent future development).	Minimal economic/property loss (undeveloped to occasional structure or agriculture)	785:25-3-3. Hazard classification subject to regulation and change. (A) For dams inventoried in the National Safety of Dams program authorized under 33 USC 467, hazard classifications set forth in Phase I reports is presumed accurate. If the dam owner disagrees, he has the burden to show that hazard class should be changed. (B) At the discretion of the Board, any proposed or existing dam considered to have classification of a high hazard potential may be subject to regulation regardless of size or impounding capacity. (C) The hazard potential classification may change as the area downstream from a dam develops and the dam may be reclassified from time to time.
OR	N/A	High Hazard: This rating indicates that if the dam fails there is a strong plausibility for loss of life. The plausibility is established because of inhabited infrastructure (such as homes and business) downstream that would be inundated to such a degree see 690-020-0100(2)(d) for specific criteria that it would put the person	Significant Hazard: This rating indicates that if a dam fails, infrastructure (such as roads, power lines or other largely uninhabited buildings) would be damaged or destroyed due to inundation and flooding. The department shall endeavor to inspect this class of dams at least once every three years.	Low Hazard: This rating indicates that if the dam fails there is little plausibility for loss of life, and human infrastructure that could be affected by inundation downstream is minor or non-existent. The department shall endeavor to inspect this class of dams at least once every six years.	NA	http://arcweb.sos.state.or.us/rules/OARS_600/OAR_690/690_020.html

		who inhabits the structure in jeopardy. Any factor that puts a strong probability of people being downstream in an inundation area of a dam failure shall be considered. The department shall endeavor to inspect this class of dams on an annual basis.				
PA	NA	High Hazard: A dam so located as to endanger populated areas downstream by its failure. Category 1: Substantial loss of life. Excessive economic loss (extensive residential, commercial, agricultural and substantial public inconvenience). Failure would impact two or more habitable structures. Category 2 - High Hazard: Breach inundation area impacts one habitable structure.	Category 2 - Non High Hazard: No habitable structures are impacted (appreciable economic loss only). Category 2: Few fatalities (no rural communities or urban developments and no more than a small number of habitable structures). Appreciable economic loss (Damage to private or public property and short duration public inconvenience).	Category 3: No loss of life expected (no permanent structure for human habitation). Minimal economic loss (undeveloped or occasional structures with no significant effect on public inconvenience).	NA	Source: PA DEP, Sept. 2010
PR	NA	High Hazard - Structures for which failure would cause more than very little loss of life and serious damage to communities, industry and agriculture.	Intermediate Hazard - Structures for which failure would cause very little loss of life and significant damage to property and project operation,	Low Hazard - Structures for which failure would result in loss of the structure itself, but little or no additional damage to other property.	NA	

RI	NA	High hazard: Failure or mis-operation results in a probable loss of human life.	Significant hazard: Failure or mis-operation results in no probable loss of human life but can cause major economic loss, disruption of lifeline facilities or impact other concerns detrimental to the public's health, safety or welfare.	Low hazard: Failure or mis-operation results in no probable loss of human life and low economic losses.	NA	In regulations effected December 2007, each dam has a hazard classification of high, significant or low, which is a determination made by the Director relating to the following probable consequences of failure or misoperation of the dam:
SC	NA	Class I - High Hazard: Dams located where failure will likely cause loss of life or serious damage	Class II - Significant Hazard: Dams located where failure will not likely cause loss of life but may damage property.	Class III - Low Hazard: Dams located where failure may cause minimal property damage	NA	
SD	NA	Category 1: Potential loss of life;	Category 2: No loss of life expected: Extensive economic loss potential (community or industry)	Category 3: No loss of life expected: minimal economic loss potential (undeveloped to occasional structures)	NA	http://legis.state.sd.us/rules/DisplayRule.aspx?Rule=74:02:08:05
TN	NA	Category 1: Failure would probably result in any of the following: loss of human life; excessive economic loss due to damage of downstream properties; excessive economic loss, public hazard, or public inconvenience due to loss of impoundment and/or damage to roads or any public or private utilities.	Category 2: Failure may damage downstream private or public property, but such damage would be relatively minor and within the general financial capabilities of the dam owner. Public hazard or inconvenience due to loss of roads or any public or private utilities would be minor and of short duration. Chances of loss of life would be possible but remote.	Category 3: Failure may damage uninhabitable structures or land but such damage would probably be confined to the dam owner's property. No loss of human life would be expected.	NA	Regulations state that dams will be re-evaluated for hazard potential every 5 years (1200-5-7-.05).
TX	NA	A dam in the high-hazard potential category has: (A) loss of life expected (seven or more lives or three or more habitable structures in the breach inundation area downstream of the	A dam in the significant-hazard potential category has: (A) loss of human life possible (one to six lives or one or two habitable structures in the breach inundation area downstream of the dam); or (B) appreciable economic loss, located primarily in rural areas where	A dam in the low-hazard potential category has: (A) no loss of human life expected (no permanent habitable structures in the breach inundation area downstream of the dam); and (B) minimal economic loss (located	NA	Definitions provided by TX Program, 9/3/2010.

		dam); or (B) excessive economic loss, located primarily in or near urban areas where failure would be expected to cause extensive damage to: (i) public facilities; (ii) agricultural, industrial, or commercial facilities; (iii) public utilities, including the design purpose of the utility; (iv) main highways as defined in §299.2(33); or (v) railroads used as a major transportation system.	failure may cause: (i) damage to isolated homes; (ii) damage to secondary highways as defined in §299.2(58); (iii) damage to minor railroads; or (iv) interruption of service or use of public utilities, including the design purpose of the utility.	primarily in rural areas where failure may damage occasional farm buildings, limited agricultural improvements, and minor highways as defined in §299.2(38) of this title (relating to Definitions)).		
UT	NA	High hazard: Failure has a high probability of causing loss of human life or extensive economic loss, including damage to critical public utilities.	Moderate hazard. Failure has a low probability of causing loss of human life, but would cause appreciable property damage, including damage to public utilities. Subcategories: Over 20 ac-ft: (Approval process requires formal plans) Under 20 ac-ft: (Approval process requires application procedure.)	Low hazard: Failure would cause minimal threat to human life, and economic losses would be minor or limited to damage sustained by the owner of the structure. Subcategories: Over 20 ac-ft and failure would damage property not held by the owner: (Approval process requires formal plans) Over 20 ac-ft with failure consequences limited to property held by the owner. (Approval process requires application procedure.) Under 20 ac ft. (Approval process requires application procedure.)	Low hazard (No formal plans required). Subcategories: NA	The State Engineer has the final authority in assigning hazard ratings.
VT	N	Class 1/High Hazard	Class 2/Significant Hazard	Class 3/Low Hazard	NA	The department classifies dams according to the potential loss resulting from failure, and uses

		Dams are those, the failure of which could result in more than a few deaths and excessive economic loss.	Dams, are those, the failure of which could result in a few deaths and appreciable economic loss.	Dams are those, the failure of which is not expected to result in either loss of life or any economic loss.		the Downstream Hazard Classification system recommended by the US Army Corps of Engineers.
VA	NA	High Hazard Potential is defined where an impounding structure failure will cause probable loss of life or serious economic damage. "Probable loss of life" means that impacts will occur that are likely to cause a loss of human life, including but not limited to impacts to residences, businesses, other occupied structures, or major roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, major roadways, railroads, personal property, and agricultural interests. "Major roadways" include, but are not limited to, interstates, primary highways, high-volume urban streets, or other high-volume roadways.	Significant Hazard Potential is defined where an impounding structure failure may cause the loss of life or appreciable economic damage. "May cause loss of life" means that impacts will occur that could cause a loss of human life, including but not limited to impacts to facilities that are frequently utilized by humans other than residences, businesses, or other occupied structures, or to secondary roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, secondary roadways, railroads, personal property, and agricultural interests. "Secondary roadways" include, but are not limited to, secondary highways, low-volume urban streets, service roads, or other low-volume roadways.	Low Hazard Potential is defined where an impounding structure failure would result in no expected loss of life and would cause no more than minimal economic damage. "No expected loss of life" means no loss of human life is anticipated.		4VAC50-20-40. Hazard potential classifications of impounding structures (2008) www.dcr.virginia.gov/documents/dsfinregs092608.pdf The hazard potential classification shall be proposed by the owner and shall be subject to approval by the board. To support the appropriate hazard classification, dam break analysis shall be conducted by the owner's engineer. Present and planned land-use for which a development plan has been officially approved by the locality in the dam break inundation zones downstream from the impounding structure shall be considered in determining the classification. Impounding structures shall be subject to reclassification by the board as necessary.
WA	High-hazard/ Class	High-hazard/ Class 1b:	High-hazard/ Class 1c:	Significant-hazard/	Low-hazard/ Class 3:	Downstream hazard classification reflects current conditions of development in downstream

	1a: -PAR*: More than 300 -Economic loss: Extreme. More than 100 inhabited structures. Highly developed, densely populated suburban or urban area with associated industry, property, transportation and community life line features.	-PAR*: 31-300 -Economic loss: Extreme. 11 to 100 inhabited structures. Medium density suburban or urban area with associated industry, property and transportation features. -Environmental damages: Severe water quality degradation potential from reservoir contents and long term effects on aquatic and human life.	-PAR*: 7-30 -Economic loss: Major. 3 to 10 inhabited structures. Low density suburban area with some industry and work sites. Primary highways and rail lines.	Class 2: -PAR*: 1-6 -Economic loss: Appreciable. 1 or 2 inhabited structures. Notable agriculture or work sites. Secondary highway and/or rail lines. -Environmental damages: Limited water quality degradation from reservoir contents and only short term consequences.	-PAR*: 0 -Economic loss: Minimal. No inhabited structures. Limited agricultural development. Environmental damages: No deleterious materials in reservoir contents.	areas. The most serious potential consequences of failure of PAR, economic loss, and environmental damages are used to establish hazard classification. **PAR = Population at Risk*
WV	NA	Class 1 (High Hazard): Dams located where failure may cause loss of human life or major damage to dwellings, commercial or industrial buildings, main railroads, important public utilities, or where a high risk highway may be affected or damaged. This classification must be used if failure may result in the loss of human life.	Class 2 (Significant Hazard): Dams located where failure may cause minor damage to dwellings, commercial or industrial buildings, important public utilities, main railroads, or cause major damage to unoccupied buildings, or where a low risk highway may be affected or damaged. The potential for loss of human life resulting from failure of a Class 2 dam must be unlikely.	Class 3 (Low Hazard): Dams located in rural or agricultural areas where failure may cause minor damage to nonresidential and normally unoccupied buildings, or rural or agricultural land. Failure of a Class 3 dam would cause only a loss of the dam itself and a loss of property use, such as use of related roads, with little additional damage to adjacent property. The potential for loss of human life resulting from failure of a Class 3 dam must be unlikely. An impoundment exceeding 40 ft in height or 400 acre-ft storage volume shall not be classified as a Class 3 dam. A waste disposal dam, the failure of which may cause significant harm to the	Class 4 (Negligible Hazard): Dams where failure is expected to have no potential for loss of human life, no potential for property damage and no potential for significant harm to the environment. Examples: dams across rivers, failure of which under any conditions will not flood areas above normal streambank elevations; dams located in the reservoir of another dam which, under any conditions, can contain water released by failure of the Class 4 dam; and dams in series where the toe of the Class 4 dam(s) is in close proximity to the reservoir of a dam which can contain failure of the Class 4 dam(s) under any condition. In considering a request for a Class 4 designation, the director may require written	

				environment, shall not be classified as a Class 3 dam.	concurrence from the owner(s) of downstream dams that may be affected by failure of the Class 4 dam. Approval is vested in the director, and will be based on engineering evaluation of the dam(s) and downstream areas in question.	
WI	N/A	High hazard: A high hazard rating shall be assigned to those dams that have existing development in the hydraulic shadow that will be inundated to a depth greater than 2 feet or do not have land use controls in place to restrict future development in the hydraulic shadow. This rating must be assigned if loss of human life during failure or mis-operation of the dam is probable.	Significant hazard: A significant hazard rating shall be assigned to those dams that have no existing development in the hydraulic shadow that would be inundated to a depth greater than 2 feet and have land use controls in place to restrict future development in the hydraulic shadow. Potential for loss of life during failure must be unlikely. Failure or mis-operation of the dam would result in no probable loss of human life but can cause economic loss, environmental damage, or disruption of lifeline facilities.	Low hazard: A low hazard rating shall be assigned to those dams that have no development unrelated to allowable open space use in the hydraulic shadow where the failure or mis-operation of the dam would result in no probable loss of human life, low economic losses (losses are principally limited to the owners property), low environmental damage, no significant disruption of lifeline facilities, and have land use controls in place to restrict future developments in the hydraulic shadow.	N/A	Source: Page 63 of Dam Design and Construction
WY	NA	High hazard dams would, in case of failure of the dam, likely cause loss of life.	Significant hazard dams would, in case of failure, likely cause significant property damage, but no loss of life.	Failure of a low hazard dam would likely cause only minimal property damage.	NA	http://wyohomelandsecurity.state.wy.us/Library/mitigation_plan/Chap4_Dam_Safety.pdf

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