Virginia Soil and Water Conservation Board
Dam Safety Technical Advisory Committee
Subcommittee on Alternative Procedures
Monday, August 28, 2006
Richmond, Virginia

Subcommittee Members Present

William G. Browning, Department of Conservation and Recreation
David Campbell, Schnabel Engineering
Duncan McGregor, Marion
Ray Scher, Caroline County
Scott P. Cahill, Watershed Services, Inc.

Facilitator

Barbara Hulburt, The McCammon Group

DCR Staff Present

David C. Dowling, Director of Policy, Planning and Budget
Christine Watlington, Policy, Planning and Budget Analyst
Michael R. Fletcher, Director of Development
Jim Robinson, Dam Safety Program Manager
David Coniff, Dam Safety Engineer

Observers Present

John Bailey, Lake of the Woods Association

Ms. Hulburt welcomed members to the meeting.

The following documents were provided for member's reference:

- Ad Hoc Dam Safety Study Committee Report to the Virginia Soil and Water Conservation Board (Attachment #1)
- Alternative Procedure for Existing Dams by Dr. Peter Rainey (Attachment #2)
- Dr. Rainey's documents with comments by David Campbell (Attachment #3)
- Reduced Design Floods – What are the Savings? (A copy is available in PDF format from DCR)

Mr. Dowling said the purpose of the meeting was to discuss the alternative procedures. He noted that this had been an issue of consideration before several groups over the last few years. The key point for the subcommittee was to have a solid discussion of pros and cons and to see if there are any ideas that the subcommittee recommends moving forward to the Full TAC.

Mr. Dowling said the committee was to look at operational improvements that would offset the need for structural components. Table 1 already exists with regard to classification and the establishment of the SDF. The TAC has already considered incremental analysis and determined it would apply to all dams when considering reductions to the required SDF.

Mr. Dowling said the Board has concerns about anything that would reduce the safety of the Dam Safety program. What the TAC presents will need to be well defined and might be the exception rather than the rule.

Ms. Hulburt noted that the first question to address was "should there be alternative procedures?"

Ms. Hulburt clarified that in the discussion of Alternative Procedures other engineering elements were not part of that discussion. She outlined the following simple example of how alternative procedures would fit into the process:

Action	Ultimate SDF
Table 1	X
Incremental Analysis	X - Y
Alternative Procedures	X - Y - Z

A member noted that the discussion relates to alternative procedures that are nonstructural. A lot are almost rewards for doing a good faith effort maintenance job. He said that is not a good reason to adjust a design or capacity structural requirement.

The member said some of these issues were addressed in the old section 130. He said that the TAC should be cautious about allowing a structural reduction based on subjective items.

A member said that operational and maintenance considerations need to be fully satisfied before reductions could be considered.

A member said there was discussion in the prior committee about programmatic decisions. Risk analysis was mentioned. No one in the prior committee favored a full-blown risk analysis.

There was a sense that risk analysis was too complex.

Another member said there are situations where alternative procedures may be appropriate such as when automated controls are in place. There is a need to reduce reliance on human judgment in emergency situations.

Ms. Hulburt said that the committee was trying to figure out what is in place now under the regulations as drafted or what would need to be in place in order to give dam owners some understanding about what is possible and what the parameters are.

A member said there should be one avenue, not three different methodologies for change in classification. It should be one analysis.

Ms. Hulburt clarified that the committee sense was to have one analysis for the classification of a dam that would take incremental analysis into account.

Mr. Dowling again noted that the alternative procedures are nonstructural and are operational in nature.

A member said the question comes back to liability. There should be systems in place to protect downstream structures. There should be an inundation zone and studies completed to know the liability.

A member asked if there was anything other than an incremental analysis to show there is not a risk for the loss of human life or some other mechanism where loss of life can be mitigated.

Ms. Hulburt clarified that the conversation related to something that is not the engineering of the dam.

A member noted that reducing the SDF does not necessarily reduce liability.

Mr. Browning said that the permitting process involved working with the owner to determine what should be allowed. The negotiations are outlined in the dam owner's certificate.

A member asked if DCR liked the fact that this was a judgment call.

Mr. Browning said those issues can be dealt with in the procedure. He said the engineering is exact, but there is always an opportunity for discussion between the regulator, the owner and the engineer.

A member said that every classification is a judgment call.

A member said that it was important to separate incremental analysis from alternative procedures.

Another member said under incremental analysis there was a judgment call regarding the loss of life. Any other method for mitigating loss is an alternative procedure.

A member said at the last TAC meeting it was noted that the incremental analysis process is hard, not changing. The alternative procedures allow soft changes to be considered in establishing the SDF. The member noted that if the Board has determined they will not accept loss of life, why should there be any consideration of alternative procedures? The member further noted that the consideration of making one exception opened the door for other exceptions.

Ms. Hulburt asked if there were specific issues to be considered.

It was noted that the TAC has already considered the EAP. The proposed EAP standard that has been incorporated into the regulations is different from the previous language. This in no longer a viable alternative procedure.

Possible mitigating factors are:

1. EAP (non starter, already required)
2. Maintenance and Performance (non starter – should already be done)
3. Site specific PMF study (already allowed)
4. Purchase of downstream properties that are a liability (already allowed)
5. Mitigation to equal the downstream flood. There is no point in making a spillway pass more water than what the downstream can take. (already allowed – incremental analysis)
6. Automated monitoring controls on the dam that would automatically notify people reliably or close roads. A methodology that ensures people have a chance to leave. (already allowed)
7. Sirens, individual alarms in homes (already allowed)

Mr. Robinson suggested an insurance policy written or paid by the owner to cover all the expenses of what is lost and replacement costs. It was noted that such an insurance policy would be very expensive and often is not obtainable. It was also noted that this does not address the protection of life, just property.

Mitigation of downstream development through comprehensive planning and prevention was suggested. Mr. Dowling said that the entire group would be seeing an agency proposal in that regard. This will be included in draft legislation proposed by the agency.

A participant noted that a guidance document explaining to dam owners SDF reduction strategies might be a useful approach as many of the previously considered reduction strategies have now been made part of the regulations.

Ms. Hulburt asked what the committee would like to take back to the TAC in terms of recommendations.

A member said that he did not see the justification for incorporating alternative procedures into the regulations. Further, he said that guidance would muddy the water.

Ms. Hulburt asked if the committee thought there would be value in a guidance document.

Mr. Dowling said that a guidance document might be helpful, but suggested that dam owner educational fact sheets would be a preferred approach once the regulations are completed.

In regards to alternative procedures, Ms. Hulburt asked if the committee felt there was a system that could be crafted to remove some of the subjectivity. She noted that dam owners who were better financed and better informed would remain in a better situation.

A member said that in his opinion, Table 1 is a decision matrix and that a further statement was not necessary.

Ms. Hulburt clarified that the committee would not recommend to the TAC specific language beyond what is already considered. There would be no additional language dealing with other considerations.

Consensus among the committee members was that there be no change or addition with regard to alternative procedures.

Ms. Hulburt also noted the committee concerns regarding education and funding.

Mr. Dowling said that certainly the committee could address the recommendation that the Department go forward with an educational document for dam owners that would articulate certain options to be considered.

Ms. Hulburt clarified that the report to the TAC would be that the subcommittee met and discussed the concept of Alternative Procedures. Based on that discussion the subcommittee came to a sense that regulatory language was not necessary or required, but that there is a strong feeling that education of dam owners with regard to this issue is very important. Further DCR should be working to create a document to share with dam owners.

These recommendations will be provided to the subcommittee for review and then forwarded to the TAC.

A member asked if the full TAC would be discussing Table 1 further.

Mr. Dowling said that DCR staff have been working on refining that portion of the regulations and will bring that back to the TAC at a future meeting.

Ms. Hulburt said that anyone with specific language recommendations should forward those to DCR staff.

The meeting adjourned at approximately 1:30 p.m.

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Attachment #1

Report of the

Ad Hoc Dam Safety Study Committee

to the

Virginia Soil and Water Conservation Board

April 30, 2005

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Motion of the
Virginia Soil and Water Conservation Board
July 15, 2004

That the Virginia Soil and Water Conservation Board establish an Ad Hoc Committee for the expressed purpose of studying the Classes of Impounding Structures, §4VAC 50-20-40 and Performance Standards Required for Impounding Structures, §4VAC 50-20-50 and the attendant Table 1 established in the 2004 Virginia Impounding Structures Regulations. The Committee membership shall be set by the Department of Conservation and Recreation with concurrence of the Board Chairman. The Committee shall complete its work by April 30, 2005.

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Executive Summary

The Ad Hoc Dam Safety Study Committee (Committee) recommends two alternatives for changes in the Virginia Impounding Structures Regulations. These result from the Committee's technical investigations and discussions of a number of possible alternatives.

The first recommended alternative, described as "Treat New & Existing Dams Alike – Formalize Current Practice", has the advantages of reinforcing existing practice (full Probable Maximum Flood [PMF] for highest hazard dams), providing a relatively simple risk classification system, protecting public safety and property regardless of whether those at risk are downstream of existing or new dams and being consistent with current USDA NRCS practices in high hazard dam rehabilitation. The key disadvantage of this alternative is that for owners of some existing dams, spillway upgrades will be needed.

The second recommended alternative is described as "Provide an Alternate Procedure for Existing Dams" which allows spillway design floods (SDF) less than the PMF in cases where there would be no significant increase in downstream hazard. The advantages of this alternative are that it is an extension of the authority already contained in Section 130, provides a way that non-structural as well as structural factors can be considered for dams that can demonstrate an outstanding record, is sensitive to the significant site specific variations among dam sites and would likely result in lowered SDF for some dams. The key disadvantages are that this approach involves more judgment and, in some cases, negotiation between dam owners, the Department of Conservation and Recreation staff and the Virginia Soil and Water Conservation (Board). It will also entail considerably more field monitoring and therefore will require a significant increase in staff time and resources.

The Committee is composed of thirteen individuals with substantial technical expertise on dams and dam safety. It was created in response to a motion adopted by the Virginia Soil and Water Conservation Board in July of 2004. The Committee met four times, reviewed numerous reports and studies about state programs and federal guidelines, heard from several groups concerned about the issues under study, heard presentations by several leading experts, and considered four possible alternatives. Two are recommended.

The Committee also expressed concern about dams being constructed at a time and location where there is little or no development downstream and without consideration of the impacts of future development. Very commonly development takes place without regard to the dam that is already in place just as the dam was built without regard for the development that would subsequently occur. This results in the dam subsequently requiring reclassification into a higher hazard category with more stringent performance requirements. In most cases this necessitates expensive upgrades to the spillway structure along with closer scrutiny of the dam, its operations, maintenance and emergency

preparedness. There is also concern for development in the upper watershed above the dam, the effect of which can more quickly concentrate runoff, increasing spillway flood passage requirements for a given storm.

There is a crucial need for dams and development to be considered in relation to each other. The Committee believes that the downstream potential inundation area needs to be made a matter of public record to promote greater awareness of the impacts of a dam failure on the part of the dam owner and on the part of those downstream. The Committee also believes that land use zoning needs to be adopted or adjusted to take the inundation area into account. Additionally, permit applicants for new hazard Class II and III dams should be encouraged to anticipate future development and design spillway facilities in accordance with likely future land use patterns.

Background

Concerns Leading to the Committee

Many of the nation's dams, some originally built in the 1950s and 1960s, are in need of significant maintenance and/or redesign and upgrading. As a result of their age and unusually heavy rain events, a number of dams have failed and resulted in significant downstream damage, death or injury. Due to these failures, federal and state dam safety regulations have been introduced to address public safety concerns.

The Virginia Impounding Structures Regulations introduced in 1982 and amended in 2002, address public safety concerns by classifying impounding structures by their size and hazard potential. Each classification refers to potential loss of life and economic damage anticipated downstream in the event of a dam failure. This classification does not characterize the dam's integrity or its ability to perform its intended function. Impounding structures are subject to subsequent reclassification if the hazard potential from a dam failure increases as a result of changes such as increased development in the inundation zone.

A number of parties in the state of Virginia are concerned with the requirements as they apply to existing dams. Dam owners, such as the *Lake of the Woods Association, Inc. (Association)* in Orange County, are concerned about the cost of repairing their dams to meet compliance because they perceive the risk of failure as low. Due to increased development in the inundation zone, the Association is required by the Board to increase the spillway capacity for its Class I dam in order to pass the PMF. *The Association* argues that their dam is well maintained and that their emergency management plan will alert downstream residents in the event of a dam failure. They also note some progress in diverting some downstream development. The Association argues that the regulations, as applied to their dam and to existing dams in general, are unreasonable and believe they should not be required to increase their emergency spillway capacity. They cite high cost

and disruption to the beneficial uses of the lake during upgrading as unreasonable burdens.

The *Lake of the Woods* community solicited the assistance their state Senator and Delegate to request the reevaluation of the impounding structures classifications, performance standards, and impounding structures regulations by the Virginia Soil and Water Conservation Board. In response an Ad Hoc Committee was formed to evaluate the Classes of Impounding Structures, §4VAC 50-20-40 and Performance Standards Required for Impounding Structures, §4VAC 50-20-50 and the attendant Table I of the Virginia Impounding Structures Regulations.

Ad Hoc Study Committee Formation

On July 15, 2004 the Board adopted a motion creating this Committee and asking that it report by April 30, 2005. A copy of this motion can be found inside the front cover of this report.

This Committee is not specifically about or focused on the *Association's* case. Instead this instance serves as a case study of what may be a more general and widespread concern deserving Board attention. During the course of the Committee's meetings, each agenda provided an opportunity for public comment. In addition to comments at each meeting from the *Association*, the *Augusta County Service Authority* voiced its potential concerns with the current regulations and a former board member from *Lake Caroline* spoke in favor of current practices.

In order to address these concerns, the Board's charge to the Committee is to review Section 40, Section 50, and the Impounding Structures Table I of the Virginia Impounding Structures Regulations. The Committee is to consider whether to revise these sections and to determine if the benefits of the regulations as written justify the standards for dam safety reflected in current regulations and practice.

Membership on the Committee

The Committee is composed of thirteen individuals, all of whom have technical expertise in some aspect of dams and dam safety. A roster of members is included in Appendix B.

Committee members include several local soil and water conservation board members, a number of whom own dams, former or current state and federal officials from agencies such as the Virginia Department of Emergency Management and the Federal Energy Regulatory Commission, two representatives from local governmental water supply/service authority agencies who are dam owners, a civil engineering professor from Virginia Tech, farmers, consulting engineers, a policy consultant, and the retired director of Virginia's Dam Safety Program. Four members are or were employees of NRCS, the

agency under whose programs many of the dams in Virginia were constructed. The Committee is chaired by the chair of the Board.

The Institute for Environmental Negotiation from the University of Virginia was retained to facilitate the Committee process. The current director of the Virginia Dam Safety & Floodplain Management Program and other staff from DCR participated in meetings as resources to the Committee.

The Committee Process

The Committee established five ground rules by which to conduct their meetings and guide their deliberations. The Committee agreed to the following:

- disseminate information in advance of meeting
- seek to learn the concerns of dam owners
- learn from the experience and practice of others dealing with dam safety - such as other state regulators
- devote a portion of each agenda to public input, and
- seek consensus insofar as possible in arriving at recommendations.

The Committee agreed that for consensus to be achieved every Committee member need not stand behind every section with equal enthusiasm; however each member would ideally be willing to support the report as a whole.

The Committee also expressed their intent to conduct their investigations with an open mind and to consider a number of options/alternatives in arriving at their final recommendations.

The Committee held four day-long meetings in Richmond, with each meeting having a focused agenda.

- November 9, 2004 - Committee organization, identify data/information needs
- January 19, 2005 - Presentations and discussion of requested information
- February 16, 2005 - Presentations/discussion, assessing four options/alternatives
- March 23, 2005 - Review draft report, determine final recommendations

Appendix C contains a list of reports and materials assembled for the Committee as well as a list of experts who made presentations to the group. Also listed are information items submitted by the public.

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Upon the completion of the Committee meetings, a report of recommendations is to be submitted to the Board by April 30, 2005. The Board will review the recommendations, and determine whether amendments to the regulations are appropriate. If amendments are needed, there are several processes through which these changes might be promulgated depending on the nature of the changes proposed. A general description of the process for amending regulations can be found at http://www.townhall.virginia.gov/dpbpages/apaintro.cfm.

Dams and Dam Safety

National Perspective

The Association of State Dam Safety Officials website http://www.damsafety.org/ contains a number of key facts about dams and dam safety in the US (Dam Safety 101).

- Dams provide flood control, water supply for drinking, irrigation for farming, recreational areas, and clean renewable energy through hydropower.
- Millions of people throughout the US depend on dams to bring them the benefits above.
- While most infrastructure facilities are owned by public entities, the majority of dams in the US, (56%) according to the 2004 National Inventory of Dams, are privately owned.
- Dam failures can be devastating for dam owners, to the dam's intended purpose, and especially, for downstream populations and property.
- A string of significant failures in the 1970's raised state and federal awareness for the first time.
- Today, every state but Alabama has a dam safety regulatory program. A total of 92,316 dams nationally are under state regulation as of December 2004.
- Dam failures are most likely to happen because of:
    - Overtopping caused by water spilling over the top of the dam
    - Structural failure of materials used in dam construction
    - Cracking caused by the settling of the dam
    - Inadequate maintenance and upkeep

- Piping – where seepage forms cavities when the outlet pipe is not properly bonded with surrounding soil or poor compaction allows water to flow through soils in the embankment.

- Dams are innately hazardous structures – concerns are loss of human life, economic loss due to property damage, lifeline disruption and environmental damage.
- High hazard is a term used by most state and federal dam safety programs – high hazard reflects the dam's potential for doing damage downstream should it fail.
- Dams must be maintained, occasionally upgraded or rehabilitated to keep them safe.
- The lack of funding for dam upgrade has become a serious national problem, especially for those private owners where the dam does not generate revenues.
- Many state dam safety programs are under-resourced for carrying out their laws.
- The average number of dam inspectors per state is eight, meaning that each inspector would have to oversee the safety of about 250 existing dams plus overseeing new construction. The inspection staff in Virginia currently is numbered at 5.
- The Model State Dam Safety Program recommends that ten state regulators are necessary per 250 dams to responsibly carry out the regulatory mandate.
- Only 33% of high hazard dams nationally have Emergency Action Plans.
- Lack of public awareness about downstream public safety and economic loss among ordinary citizens, developers, zoning officials is a widespread problem.

Dams in Virginia

Dams (impounding structures) are regulated in Virginia if they are either 25 feet or greater in height and impound 15 acre-feet or greater, or are 6 feet or greater in height but impound 50 acre-feet or more, unless exempted by statute. The following impoundment structures are exempt by statute: (a) dams licensed by the State Corporation Commission that are subject to a safety inspection program; (b) dams owned or licensed by the United States government; (c) dams constructed, maintained, or operated primarily for agricultural purposes which are less than 25 feet in height or which create a maximum impoundment capacity smaller than 100 acre-feet; (d) water or silt retaining dams approved pursuant to 45.1-222 or 45.1-225.1 of the Code of Virginia; or (e) obstructions in a canal used to raise or lower water.

The Virginia Dam Safety Act was first established in 1982 and then amended in July 2002 to include additional dams. The Act seeks to provide for the proper and safe design, construction, operation, and maintenance of impounding structures to reduce the risks and hazards associated with dam failures and to protect public safety. Although no

impounding structure might ever be completely failsafe due to natural and human-induced influences, the Dam Safety Act is designed to minimize catastrophic events associated with dam failures.

Like those in most other states, dams are classified in Virginia into several categories based on size and hazard potential. The four hazard potential classes are summarized below.

- Class I - probable loss of life and excessive economic loss downstream
- Class II - possible loss of life and appreciable economic loss downstream
- Class III - no loss of life expected and minimal economic loss downstream
- Class IV - no economic loss to others and no loss of life expected

Dams in Virginia (by regulatory definition)

November 2004 Inventory

Hazard Potential Classification	Certificate Type	Owner Type						
		Private	SWC District	Local Government	State	Public Utility	Not Identified	Total
I	Regular	17	15	32	9	2	0	75
	Conditional	5	10	16	1	2	0	34
	Other	9	0	5	1	0	2	17
	Total	31	25	53	11	4	2	126
II	Regular	51	11	28	10	7	4	111
	Conditional	17	4	4	0	0	0	25
	Other	98	0	8	1	0	26	133
	Total	166	15	40	11	7	30	269
III	Regular	107	62	14	21	7	12	223
	Conditional	11	1	1	1	0	1	15
	Other	576	1	17	18	0	93	705
	Total	694	64	32	40	7	106	943
IV	Total	21	0	3	1	0	0	25
Total All Dams		912	104	128	63	18	138	1363

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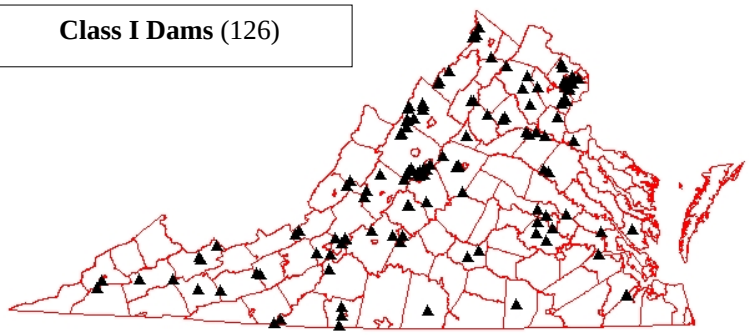
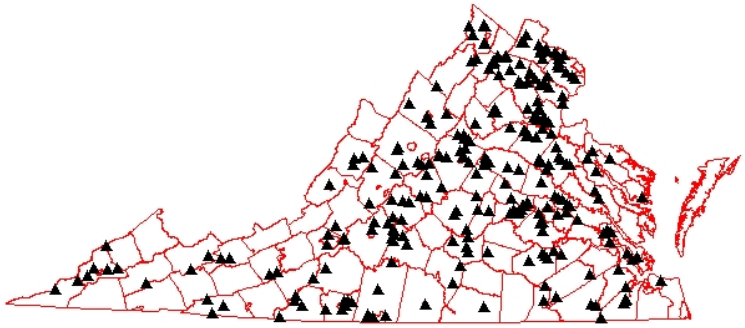
Many of the dams built in Virginia were initially classified as Class III structures. Because of their rural location, there was limited downstream potential impact. Since that time, development has taken place in many of these once rural areas triggering reclassification to a higher level due to the increased hazard potential to homes, roads or other infrastructure located in the potential inundation zone of the dam. Evaluation of the classifications of most of the "new definition" (2002) dams has not been completed, so many of the dams presently inventoried as Class III may actually be Class I or Class II.

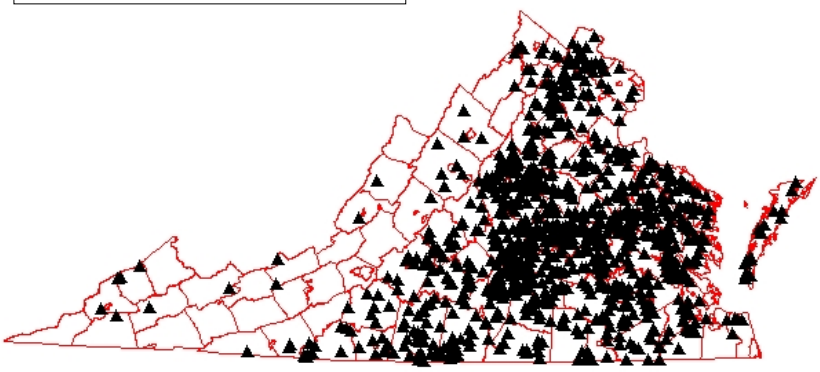
Class I Dams (126)



Class II Dams (269)



Class III & **IV Dams** (968)



To date, DCR's database contains approximately 1600 dams, many of which await full inventory and investigation to ensure compliance with the current regulations. The table above reflects only those dams that are currently in the database. The maps above indicate that dams can be found in all parts of the state.

The primary focus of this Committee is on the performance and construction standards for Class I, High Hazard, dams shown on the top map.

Among the 126 Class I dams, the primary issues are associated with the 109 dams built prior to the 1982 adoption of dam safety regulations in Virginia.

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Of the 109 dams built before 1982, 73 are required to be designed to the full PMF standards – the others may meet a lesser standard based on their small size and/or less than significant incremental downstream damage potential. DCR's database indicates that 38 of these 73 dams are currently achieving the full PMF standard. An almost equal number have not yet been brought into compliance.

Dam Failure in Virginia in 2004

The DCR Dam Safety Database does not have a historical record of dam breaches and failures in Virginia prior to 2004. The table that follows covers 2004, and largely reflects the results of one dominant storm, Tropical Storm Gaston. Given the area impacted by Gaston, many of these breaches and failures indicated on the chart occurred in Chesterfield, Hanover, and Henrico counties between late August and early September.

Roughly half of these dams do not currently have Operation and Maintenance Certificates or Permits as indicated by the third column from the right. Amendments to the state regulations in July 2002 require staff to evaluate these dams and determine their status. Approximately twenty of these dams can be addressed each year with available staff resources.

The table below indicates each dam's location, date reported, condition, regulatory status, class and height. No tabulation of economic loss or loss of life is available to supplement this table.

Virginia Dams Breached or Damaged in 2004

Name of Dam	County	Date Reported	Condition	VA Regulated	Class	Size
Cherrydale Dam	Hanover	8/31/2004	Damaged	Y	3	15
Regional Basin L-5	Hanover	8/31/2004	Damaged	N		
Regional Basin L-4	Hanover	8/31/2004	Damaged	N		
Colonial Forest Dam	Hanover	8/31/2004	Damaged	Y	2	23
Gaines Mill Dam	Hanover	8/31/2004	Damaged	Y	1	15
Beaties Millpond Dam	Hanover	8/31/2004	Damaged	Y	2	16
Westheaven Lake Dam	Hanover	8/31/2004	Damaged	Y	3	13
Lake Overton	Henrico	8/31/2004	Damaged	Y	1	<6
Gillie Dam	Henrico	8/31/2004	Damaged	Y	2	28
Swift Creek Lake Dam	Chesterfield	8/31/2004	Damaged	Y	2	31
Falling Creek Dam	Chesterfield	8/31/2004	Damaged	Y	1	34
Pebblebrook Dam	Hanover	9/1/2004	Damaged	Y	3	21
Talleys Millpond Dam	Hanover	9/2/2004	Damaged	Y	3	15
Hartford Lake Dam	Hanover	9/2/2004	Damaged	Y	3	34
Brookshire Pond	Hanover	9/2/2004	Damaged	N		
Altee Lakes Estate	Hanover	9/2/2004	Damaged	N		
Edward Tally Pond	Hanover	9/3/2004	Damaged	N		
George Rice Pond	Hanover	9/3/2004	Damaged	N		
Cady Lake	Hanover	9/7/2004	Damaged	Y	3	<6
Mill Pond Dam	Henrico	9/9/2004	Damaged	N		
Staples Mill Pond Dam	Henrico	9/9/2004	Damaged	N		
Upper Powhatan Dam	Powhatan	6/17/2004	Breached	Y	3	20
Lower Powhatan Dam	Powhatan	6/17/2004	Breached	Y	3	19
Essex Mill Dam	Essex	7/26/2004	Breached	Y	3	14
Pebble Creek	Hanover	8/31/2004	Breached	N		
Dabney Lake	Hanover	8/31/2004	Breached	N		
Lake Idylwild	Hanover	8/31/2004	Breached	Y	2	14
Waldens Dam	Hanover	8/31/2004	Breached	Y	3	24
Carter Dam	Hanover	8/31/2004	Breached	Y	2	24
301 Landfill Pond	Hanover	8/31/2004	Breached	N		
Carter Home Pond	Hanover	8/31/2004	Breached	N		
Broaddus Dam	Hanover	8/31/2004	Breached	N		
Hanover Hills	Hanover	8/31/2004	Breached	N		
Smith Mill Pond	Hanover	8/31/2004	Breached	N		
New Castle Pond	Hanover	8/31/2004	Breached	N		
Morrisons Pond	Hanover	8/31/2004	Breached	N		
Summerhill Rd Pond	Hanover	8/31/2004	Breached	N		
Carrie Halls Ponds	Hanover	8/31/2004	Breached	N		
Vickie Holstein	Hanover	8/31/2004	Breached	N		
Boscher Ponds (3)	Hanover	8/31/2004	Breached	N		
Al Young	Hanover	8/31/2004	Breached	N		
Sandy Valley Rd Pond	Hanover	8/31/2004	Breached	N		
Rainer Dam	Hanover	9/1/2004	Breached	Y	2	18
Rotherham Drive Pond	Hanover	9/1/2004	Breached	N		
Rose Hill Pond	Hanover	9/1/2004	Breached	N		
Griggs Dam	Henrico	9/1/2004	Breached	Y	3	18
Medrums Dam	Hanover	9/2/2004	Breached	Y	3	20
Parsleys Mill Dam	Hanover	9/2/2004	Breached	Y	3	13
Highpoint Farms Area	Hanover	9/2/2004	Breached	N		

Probable Maximum Flood (PMF)

The charge to the Committee includes examining Table I (see below) and the standards for spillway design, the "Spillway Design Flood" (SDF). Upgrading dams to meet these spillway standards is a primary issue of concern to dam owners as well as government officials, safety personnel, and those living or owning property downstream. The standard for Large and Medium Class I and Large Class II dams is the Probable Maximum Flood (PMF). Smaller dams and dams with a lesser hazard potential and classification are required to meet lesser standards and may qualify for consideration under Section 130 B. for a reduced SDF. The following two definitions as well as Table I are taken from the Virginia regulations.

"The spillway design flood (SDF) represents the largest flood that need be considered in the evaluation of the performance for a given project. The impounding structure shall perform so as to safely pass the appropriate SDF. Where a range of SDF is indicated, the magnitude that most closely relates to the involved risk should be selected."

"PMF: Probable maximum flood. This means the flood that might be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is derived from the current probable maximum precipitation (PMP) available from the National Weather Service, NOAA. "

TABLE I – Impounding Structure Regulations

Class of Dam	Hazard Potential If Impounding Structure Fails	SIZE CLASSIFICATION Maximum Capacity (Ac-Ft)	Height(Ft)	Spillway Design Flood (SDF)
I	Probable Loss of Life; Excessive Economic Loss	Large ≥ 50,000 Medium ≥ 1,000 & < 50,000 Small ≥ 50 & < 1,000	≥ 100 ≥ 40 & < 100 ≥ 25 & < 40	PMF PMF 1/2 PMF to PMF
II	Possible Loss of Life; Appreciable Economic Loss	Large ≥ 50,000 Medium ≥ 1,000 & < 50,000 Small ≥ 50 & < 1,000	≥ 100 ≥ 40 & < 100 ≥ 25 & < 40	PMF 1/2 PMF to PMF 100-YR to 1/2 PMF
III	No Loss of Life Expected; Minimal Economic Loss	Large ≥ 50,000 Medium ≥ 1,000 & < 50,000 Small ≥ 50 & < 1,000	≥ 100 ≥ 40 & < 100 ≥ 25 & < 40	1/2 PMF to PMF 100-YR to 1/2 PMF 50-YR[d] to 100-YR

IV	No Loss of Life Expected; No Economic Loss to Others	≥ 50 (nonagricultural) ≥ 100 (agricultural)	≥ 25 (both)	50-YR to 100-YR

The history of the PMF dates from its early discussion in 1939 to the 1950's and 1960's when it was in agency use for high hazard dams. Various federal agencies and scientific organizations studied the concept during the 1970's and 1980's. In 1979, in a report entitled "Federal Guidelines for Dam Safety", the PMF was broadly formalized as the design standard for dams where failure could cause significant hazard to life or major property damage. These factors, potential for loss of life and property damage, are the basis for Virginia's current regulations. In the mid-1980's, several study groups addressed the justification for using an extreme event, the PMF, as the basis for dam design.

In 1985, the National Research Council concluded that safely passing the PMF was justified, but in some cases compromise could be tolerated. In 1986, in a report entitled "Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams" it was concluded that loss of life or extensive property damage justified PMF but suggested that agencies could develop additional specific criteria. More recently, in 1998, in "New Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams" it was concluded that less than the full PMF could be allowed as the basis for assessing dam performance if this resulted in acceptable incremental consequences in terms of downstream hazards to life and property.

Virginia's current regulations contain a provision (Section 130 B.) for this type of incremental consideration where dam failure would not significantly increase the downstream hazard and there would be no significant difference in the flood hazard with or without dam breach. On this incremental basis, the Keeton's Run dam built in 1970, the smaller of the two dams owned by the *Association* was issued a certificate based on less than the full PMF. That organization's larger dam, however, is required to meet the full PMF. The floodplain below the larger dam has a flood depth of 20 feet during the PMF. If the dam would fail during this PMF storm event, there is an additional 27 feet of water for a total depth of 47 feet. In this case it is the dam failure which greatly increases the hazard potential downstream.

The PMP (probable maximum precipitation), the rainfall related value upon which the PMF is based, is seldom observed in any individual's experience, leaving some to question if actual rainfalls ever approach the PMP. In a presentation to the Committee it was pointed out that the Mid-Atlantic area in particular is a target for PMP events, and recent occurrences of extreme rain events have approached the PMP. For example, the Mid-Atlantic region has experienced three of the five most intense twelve-hour storms in the United States. One of these storms occurred in Smethport, Pennsylvania in 1942, and the other two occurred in Nelson County Virginia in 1969 and in Madison County

Virginia in 1995. In Smethport, the PMP was exceeded by nineteen percent, while the two extreme rainfall events in Virginia approached eighty-one and eighty-six percent of the PMP for areas less than ten square miles, respectively.

Similarly, some argue that the probable maximum flood has never been witnessed and question whether floods actually approach the PMF. A figure was presented to the Committee of floods in the Northern Appalachian area of Pennsylvania which indicates that extreme flood events have occurred in the last century that approach within 20-30% of a PMF envelope curve. In the Central Appalachian region where Virginia is located, however the PMF curve is very close to the envelope line representing the most severe observed (historical) floods on record for the area.

It has been acknowledged that the PMF has been recognized as a standard of practice since 1970 and earlier. Questions remain because the PMF is only an estimate, as are other estimates that are regularly relied upon to gauge risk, and its accuracy depends on other factors, such as the accuracy of the PMP upon which it is based and conditions such as the pre-existing extent of saturation in the watershed.

Committee Analysis/Findings/Recommendations

The Issue of Dams and Downstream Development

The Committee as a whole agrees that awareness of the impact of downstream development on the selection of SDF is crucial. The owner of each dam proposes its classification which must then be approved by the Director of the Department of Conservation and Recreation. The regulations go on to state that dams are subject to reclassification as necessary. This means that if the downstream land use or other changes occur, a dam is subject to being reclassified. To upgrade a dam to meet a higher classification can be a very significant change and, depending on the dam's size and physical condition may result in a very costly modification on the part of the owner. Spillway upgrading costs can be highly variable and will depend upon a number of site specific circumstances. Upgrading a dam can cost anywhere from a few thousand dollars to several tens of thousands or even several million dollars.

This presents a very real and potentially recurring problem for owners of dams, since downstream land use is normally not within the control of the owner of the dam. In fact, in some instances, downstream land use has probably intensified because of the dam and its effect in decreasing the frequency and depth of downstream flooding, thus encouraging a more intensive land use or even residential development.

This is not an infrequent problem and has occurred with numerous dams throughout the Commonwealth. For example, a dam can be built today within acceptable standards as a CLASS III based on the current land use and no significant threat to lives or major

property in event of a possible failure. If, sometime in the future, the land use changes to become more intensive, such as a housing development or a highway, then that potential threat to human life can change significantly and result in the dam being reclassified based on the more intensive land use even though the dam had previously been acceptable as a CLASS III and the owner did nothing to contribute to the more intense land use. Nevertheless, because of the potential risk that a dam presents, it is the owner who is held responsible for upgrading the dam to the higher standards.

In many communities there is no map or discussion included within the local government's comprehensive plan to alert citizens, land owners or government officials to the presence of a dam and to point out the ways that such structures and downstream development can impact each other. When a dam owner builds a dam at less than the full PMF, he/she needs to be aware that they are setting themselves up to bear the full cost of any needed upgrades to the facility at a future date.

As mentioned earlier, it should also be noted that development of land upstream of a dam could cause significant increases in the inflow characteristics and peak discharges that prevailed at the time a dam was initially designed. This increase may well change the previous capacity requirement for the emergency spillway and require that the spillway be expanded.

Discussion of the Committee's Potential Recommendation Alternatives

Prior to discussing four potential recommendation alternatives, individual Committee members offered several overall observations or opinions.

One Committee member expressed concern that a strictly PMP/PMF criterion, for both new and existing dams, is a one-size fits all approach. He asked whether the Committee should seek a middle ground through balancing the incorporation of increased spillway capacity, consideration of the Emergency Action Plan, and a reduction in downstream development.

Another Committee member stated that a risk-based alternative would be useful, but is very difficult to apply beyond establishing an agenda that identifies those dams most critically out of compliance. He also commented that the regulations of other states are not relevant to Virginia because of the different environmental situations and other circumstances surrounding any state's approach. It is necessary, he believes, to establish recommendations within the context of Virginia.

There was a discussion of the amount of added risk that is fair to place on the general public to protect dam owners from expense. A Committee member stated that it seems unfair for the general public to be subjected to greater risk for the benefit of dam owners. Dam owners benefit from their investments in impoundments. They must, in turn, invest sufficiently to ensure that the general public is not subjected to unwarranted risk as a

result of their impoundment. He related a seminal decision from English Common Law that found that dam owners are "harnessing nature", an inherently dangerous act, and it is their duty to take extraordinary care to protect public safety.

One Committee member observed that the general public is frequently not cognizant of the presence of dams. He also stated that, in his view, it is necessary for the Committee to include in its review Sections 130 and 140 of the current Impounding Structures Regulations which address dams built prior to and after July 1, 1982.

* * * *

Next the Committee presents and discusses four alternatives that it might potentially recommend to the Board. Following this, in Appendix A, is a series of questions asked by the Board and the Committee's responses.

Alternative 1: Treat New and Existing Dams Alike – Formalize Current Practices

a) Description: This Alternative would maintain those aspects of current practice that require both new and existing dams to meet the spillway design flood standard contained in Table 1 of the regulations. This is not a true "do nothing" or "no change" alternative with respect to the current regulations for several reasons.

First, Section 50 of the regulations states that Table 1 applies to new dams ("For new impounding structures, the spillway[s] capacity shall perform at a minimum to safely pass the appropriate spillway design flood as determined in Table I"). Alternative 1 would require that this regulatory language be changed to refer to all dams.

Second, Sections 130 and 140 of the regulations refer to existing dams constructed either before July 1, 1982 (section 130) or having a construction permit issued after July 1, 1982 (section 140). Alternative 1 would change the regulations to drop this date distinction and simply refer to all dams.

Third, Sections 130 A. and 140, as they currently exist, would be repealed. The provisions of 130B. would be applicable to all existing dams. This would have the effect of affirming the current practice of requiring those existing dams that don't qualify for a reduced spillway design flood based on an incremental analysis to meet the requirements of Table I.

b) Discussion:

Committee members outlined the various pluses and minuses of Alternative 1. The benefits of Alternative 1 are that it:

- requires minimal change in established procedures
- establishes a high level of public safety
- does not draw an arbitrary distinction between existing dams of different ages
- provides some latitude for any existing dam under appropriate circumstances
- does not differentiate between new and existing dams with regard to public safety
- potentially reduces liability from dam breach damages and deaths
- has clear criteria
- offers predictability and ease of program management
- recognizes that a dam's classification may need to change in the future as development takes place

Committee members then outlined deficiencies associated with the current regulations. It was observed that:

- the current regulations are difficult to interpret - words such as "significantly" and "reasonable" as well as the threshold at which "probable" becomes "possible" are not defined
- several possible types of failure are not differentiated - some failures could be due to operation and maintenance issues while others are related to extreme storms - actions taken to address these considerations would be different
- Medium and Large Class I dams are required to meet the same PMF standard in spite of their different size

While not necessarily a detriment, it was noted that under current practices a limited amount of change in downstream land use (i.e. one home in the inundation zone is considered to be the threshold for potential loss of life) can significantly alter the classification of the dam, which causes the dam owner to incur significant costs

Suggestions for improving the current regulations included defining and clarifying the wording of the regulations, finding a way to limit downstream land use through the use of local planning controls, designing dams to the full PMF so that they would be compatible with land use that could occur in the future, and developing a way to estimate the trade-off associated with preventing downstream development versus upgrading the dam after the development has occurred. It was also noted that it is necessary to update the Impounding Structures Table I to be in complete compliance with several new 2002 requirements. Furthermore, the Table I regulations appear to focus primarily on extreme flood events, rather than sunny day breaks. It was also suggested that scarce agency resources should have a primary focus on dam owners with major compliance issues in

order to ensure that their impounding structures come into compliance and that the public safety is protected. Finally, a program that would assist dam owners through state grants and loans was suggested.

c) Recommendation: Alternative 1 is one of the two scenarios recommended by the Committee for consideration by the Board. See the Overall Conclusions and Recommendations section that follows.

Alternative 2: Provide an Alternate Procedure for Existing Dams

a) Description: In Alternative 2, a differentiation is made between new and existing dams. As in Alternative 1, existing dams would be defined as any dam in operation or for which there were valid permits. Section 130 A's provisions[1] for operation and maintenance certificates for existing dams would be emphasized and extended and included in Sections 40 and 50 as a guideline. It should be noted that dams that qualified for a reduced spillway capacity under Section 130 B's allowance for incremental damage assessment analysis would be expected to explore that possibility before proceeding with the process described below.

Alternative 2 would require that the default spillway design flood for both new and existing dams would be as specified in Table I. However, for existing dams, there would also be an alternate procedure available. A SDF less than the PMF could be allowed in cases where there would be no unreasonable hazard to life and property.

[1]Section 130 A. Many existing impoundment structures were designed and constructed prior to the enactment of the Dam Safety Act, and may not satisfy current criteria for new construction. The board may issue an operation and maintenance certificate for such structures provided that:

1. Section 130 A. Many existing impoundment structures were designed and constructed prior to the enactment of the Dam Safety Act, and may not satisfy current criteria for new construction. The board may issue an operation and maintenance certificate for such structures provided that:

1. Operation and maintenance is determined by the director to be satisfactory and up to date;

2. Annual owner's inspection reports have been filed with and are considered satisfactory by the director;

3. The applicant proves in accordance with the current design procedures and references of 4VAC50-20-320 to the satisfaction of the board that the impounding structure as designed, constructed, operated and maintained does not pose an unreasonable hazard to life and property; and

4. The owner satisfies all special requirements imposed by the board.

When considering spillway capacity for existing dams that are in a size and hazard classification currently requiring passage of a full PMF, the SDF would be presented as a range from ½ PMF to PMF for existing dams (statutory bounds). The selection of SDF would default to the full PMF, but could be considered for downward adjustment based upon the owner's historic compliance with regard to all other dam safety requirements and taking into account meaningful site specific factors, such as:

- maximum depth and duration of overtopping
- robustness of the dam's construction
- potential structural/operational changes
- number and type of structures and transportation corridors in the inundation zone
- number of people at risk
- flood wave travel time to impact areas
- simplicity or complexity of evacuation provisions
- existence of a well coordinated and regularly exercised Emergency Action Plan
- public education program
- flood recurrence and frequency data for relevant nearby streams
- likelihood of prior flooding from other nearby streams or rivers affecting the inundation zone
- other possible site-specific factors relating to the level of risk, potential impacts of a failure and mitigating circumstances

This listing is not intended to be comprehensive, but rather to be indicative of the types of information and analysis that may be required for this process.

The owner, engineer and regulator would need to meet to discuss and define how site-specific conditions relate to the justification of an assigned SDF in an attempt to reach consensus on adjustment downward from the default PMF basis. In no case would the spillway design flood be reduced to less than ½ of the PMF (except as is considered acceptable based on 4VAC50-20-130, B). Also, it will need to be recognized that, like all other regulated dams, an agreed upon SDF would be open to review and adjustment at a later time based on evolving conditions, especially those factors that were drawn upon to reach the initial decision to reduce an SDF to less than the PMF. The six-year cycle for O&M Certificates required for Class I and Class II dams would likely establish a minimum time-frame for reconsideration. As a way of reducing the need for repeated complex analyses, there may be merit in deferring future reconsideration of the SDF basis to the second O&M Certificate period following negotiated acceptance of a reduced SDF.

Those owners that wish to engage in the process will initially need to have proved themselves by addressing operations, maintenance, inspections, emergency action planning, and non-spillway upgrading issues in a diligent and timely manner. They will also have to provide compelling arguments regarding mitigating circumstances justifying an SDF reduction. Therefore, the process would be supportive of educated and responsive dam owners.

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No less important, this approach would require a significant increase in dam safety staffing and credentials to provide for in-depth reviews of documents and analyses presented to justify a reduction in the SDF, to accommodate proactive involvement by dam safety regulators in negotiating and adjudicating SDF considerations (requiring significant qualitative judgments relating to risks and impacts), and to support periodic reviews of justifying conditions to assess the need for updating a negotiated SDF basis.

The rationale for allowing this alternative process only for existing dams is that new dams have no "track record" of operation and maintenance to evaluate. This allows existing dam owners to demonstrate their ability to be diligent custodians by presenting evidence of years of successful management and operation.

b) Discussion:
Committee members then outlined the benefits and deficiencies of Alternative 2.

Benefits from this Alternative include that it:

- allows for a qualitative risk assessment that examines site specific factors and weighs them based on experience and professional engineering judgment
- is not a formula or one size fits all approach
- does not require a questionable cost/benefit analysis

- appears to be consistent with the authority already contained in Sections 130 but adds specificity that would be helpful in applying these Sections
- it retains the full PMF as the default with the burden of proof falling on the dam owner
- the expense and added time required of an owner for this alternate process would act as a deterrent to its abuse

Detriments identified with Alternative 2 include that it:

- would require staffing levels and credentialing for review that are well beyond that currently available
- requires further efforts to assign priorities or weights to the factors in order to reduce subjectivity
- necessitates an initial meeting with dam safety program staff to scope out which site specific factors are significant for each project
- provides less certainty than current practices for the dam owner and regulator
- is less straightforward and requires more time to administer than current practices

It was suggested that if Alternative 2 is adopted that further work be undertaken to develop the list of structural and non-structural factors to be considered in reducing spillway capacity below full PMF. A subcommittee of dam safety program staff and several members of this Committee who are familiar with these discussions might provide a suitable approach.

c) Recommendation: Alternative 2 is one of the two Alternatives recommended by the Committee for consideration by the Board. See the Overall Conclusions and Recommendations section that follows.

Alternative 3: Reduced Percentage of PMF

a) Description: The idea embedded in this Alternative is that older dams, due to the cost and practical issues with upgrading an existing dam, would not be required to undergo the expense and possible disruption of full compliance with current standards but rather would be required to achieve some percentage of full compliance. No specific reduced percentage of PMF has been proposed as part of this Alternative, just the concept of a reduction. Some, for example, might consider ½ PMF to be too small, while others might believe that full PMF is too drastic. A reduced percentage of PMF would be an attempt to reconfigure standards in order to achieve consensus or in some sense to “share the pain”.

b) Discussion: Benefits of a reduction from a full PMF include that it could be based on best policy judgment and that it would be less costly to dam owners. Detriments of this alternative are the lack of technical rationale for a reduction from a full PMF. The concern is that this alternative could be based more on a political decision than on technical analysis. It was also noted that a reduction from a full PMF could potentially reduce public safety and could lead to uneven standards of protection because the same fractional part of the PMF has widely different return periods depending on location and climatology.

c) Recommendation: Alternative 3 is not recommended by the Committee. See the Overall Conclusions and Recommendations section that follows.

Alternative 4: Risk-based Approach

a) Description: This alternative would involve a much more detailed risk-based assessment than current regulations which include a more general risk-based classification. One possibility would be a system similar to that developed by the Bureau of Reclamation in which up to 1000 points are awarded based on a wide range of considerations. Included would be an assessment of the quality of the dam's emergency action plan, the quality of its maintenance and the extent of downstream development. While no details have been proposed for this Alternative, such an approach would be highly site and dam specific.

b) Discussion: All of the risk-based analyses currently employed by federal agencies are used to establish priorities for allocation of resources, and are not used to establish design standards. One state, Washington, is known to use a Risk-based approach as its design standard. The discussion of the risk-based approach generated many question amongst the Committee such as how would issues such as the potential loss of life, the Emergency Action Plan, and the maintenance of the dam be addressed in the risk-based approach? This would be new territory with few guideposts. Furthermore, it was mentioned that the risk-based approach essentially appears to be an elaborate cost-benefit analysis. If this approach were to go forward the Board should explore a simplified version of the risk-based analysis, which includes a cost benefit analysis. Finally, several Committee members pointed out that the risk-based approach is partly based on operational factors, rather than structural, and would require increased enforcement and incentive tools.

Potential benefits of Alternative 4 are that it may minimize risk and costs associated with site-specific factors, and it takes into account the history of the dam, soils, and other conditions rather than assume that one size fits all. It was also noted that the risk-based approach could potentially create less risk than the full PMF, assuming that the dam owners engage in exemplary emergency management plans and continuous monitoring. To apply a risk-based approach, diligent ownership is necessary. The incentive for this

approach is if the owners perform better maintenance, the expenditures for structural upgrades will be significantly less. Finally, the risk-based approach is beneficial because it allows the development of an analytical framework in which a variety of factors can be analyzed.

On the other hand, the risk-based approach requires increased supervision of operation and maintenance, the emergency action plan, and inspections, as well as increases the costs to the owners and the regulators for this monitoring. Furthermore, there are no widely accepted design criteria on which to base a risk-based approach, and there is no currently accepted practice for risk-based approach design criteria. Nationally, the currently accepted design criteria are PMP/PMF. Therefore, the risk-based approach would require breaking new ground. The risk-based approach is highly complex, contains numerous uncertainties, and is data intensive, thus breaking new ground at this juncture is difficult. It seems clear that such an approach can not be proposed with confidence without full investigation of it applicability to dams in Virginia. In addition to the difficulties associated with breaking new ground, the risk-based approach is difficult because it is based on the premise that not all dam owners perform maintenance at the necessary level. In the state of Washington, development of their risk-based system required almost a decade, benefited from a staff member holding a PhD specializing in risk-based approaches, responded to a state having a range of climates from rainforest to desert, and depended on the state having first to process large amounts of data with which to estimate the magnitude-frequency relationship of extreme events.. (A paper [Johnson] describing the Washington approach is listed in Appendix C).

After discussing the benefits and deficiencies, the Committee was asked what could be done to improve this option. A continuous, twenty-four hour monitor would increase the effectiveness of the Emergency Action Plan. It was also suggested it is necessary to ensure that the many varied professional groups (engineering, legal, policy, etc) would be willing to stand behind a dam constructed under the risk-based approach design standards. Full disclosure of risks and requirements to avoid or manage them must be presented to the dam owners in order to remove the liability from the engineers and to educate the owners about their responsibilities. If there was no loss of life issue and the engineer has communicated a thorough description of potential deficiencies and liabilities to the dam owners, it was anticipated that the engineering profession would adapt to submitting spillway modification designs on a risk-based approach.

c) Recommendation: Alternative 4 is not recommended by the Committee. See the Overall Conclusions and Recommendations section that follows.

Overall Conclusions and Recommendations

Eleven members were in attendance at the final Committee meeting. To test for consensus about the four alternatives which had been considered and discussed, members

were given three response categories from which to choose. They could express strong agreement with each alternative ("clearly the best way to go"), agreement with each alternative ("would be willing to support this approach"), or disagreement ("cannot support this approach"). The results of this testing for consensus are as follows.

Committee Positions on the Four Alternatives

Alternative	Strong Agreement	Agreement	Disagreement
1 – Treat New & Existing Dams Alike	3	8	0
2 – Alternate Procedure for Existing Dams[2]	5	6	0
3 – Reduced % of PMF	0	8	3
4 – Risk-based Approach	0	1	10

There were two alternatives, 1 and 2 for which there was Committee consensus. On these two alternatives, all eleven members were in agreement and willing to support them. No Committee members were in disagreement with either Alternative 1 or 2.

The strength of the consensus on these two Alternatives varied somewhat. Alternative 2, Provide an Alternate Procedure for Existing Dams, had slightly more strong supporters than Alternative 1, Treat New and Existing Dams Alike.

The key strengths of Alternative #1 are that it formalizes existing practice (full PMF for the highest hazard dams), provides a relatively simple risk classification system, is protective of public safety and property regardless of whether they are downstream of existing or new dams and is consistent with current USDA NRCS practices in high hazard dam rehabilitation. The key disadvantage of this scenario is that for owners of some existing dams, additional spillway upgrades will be needed.

[2] A variation on Alternative 2 was also tested for consensus. This variation would allow the alternate procedure for new as well as existing dams. The results of the poll on this variation were 0,10,1.

The key strengths of Alternative #2 are that it is an extension of the authority already contained in section 130, provides a way that non-structural as well as structural factors can be considered for dams that can demonstrate an outstanding record, is sensitive to significant variations among dam sites and could result in lowered structural upgrade costs for dam owners. The key disadvantages are that this approach involves more judgment and potential negotiation between dam owners, the staff and the Board and careful monitoring and therefore imposes significantly greater demand for staff time and resources.

Alternative 3, the reduction of the spillway design standard by some set percentage, received no strong agreement but did achieve the agreement of eight members. Three members disagreed with this approach. The key strength of this Alternative is that it would reduce the costs of spillway upgrades for dam owners. The key disadvantages would be that any set percentage reduction would be to some degree an arbitrary compromise and would be less protective than the current standards.

Alternative 4, a more elaborate risk-based approach, was not supported by ten of the eleven members of the Committee. One member found this approach acceptable. The key advantages of such an approach would be that it takes into account multiple factors and assigns weights based on their importance. The key disadvantage of Alternative 4 is that its development would be complex and require both data and staff resources which are not currently available. An established model for this approach does not currently exist.

In addition to these four Alternatives the Committee also recommends that efforts be made to increase the degree to which dam safety is recognized and considered by the public and local officials as they make land use and development decisions. Although not part of the specific charge by the Board to this Committee, the Committee believes that misunderstanding and lack of awareness on the part of the public and local officials of the potential impact of future land use changes on the classification of a dam lies at the heart of the problem that brought this Committee together and recommends that some positive action be taken by the Board to initiate steps to foster more complete communication connecting the classification of each dam with the land use downstream that affects its classification.

As a minimum, the Committee believes that the downstream potential inundation area needs to be made a matter of public record so that this information is available to land owners and policy makers. All dam owners need to know that their dam is subject to evolving design standards tied to downstream development. The Committee also believes that land use zoning needs to be adopted or adjusted to take the inundation area into account.

Appendix A

Questions from the Virginia Soil and Water Conservation Board

On March 17, 2005, the Board addressed thirteen questions to the Committee for discussion at its final meeting and for inclusion in its report. Those questions and the Committee's responses are provided below.

1. Is the PMF the best view of reality?

The Probable Maximum Flood or PMF is "the flood that might be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region. The PMF is derived from the current Probable Maximum Precipitation (PMP) available from the National Weather Service, NOAA."

The PMF concept was created because of the desire to define an extreme event, an event which has almost no chance of occurring, upon which to base the design of high hazard dams and other critical infrastructure in order to protect downstream lives and property. Part of the rationale for use of the PMP to derive the PMF as the design standard is that there simply is not sufficient historical data upon which to base a reliable estimate for a PMP storm at a specific location that is not expected to be exceeded. Attempts at defining limiting floods over the early years of dam design were found to be deficient because invariably, a storm larger than any previously recorded would occur. For this reason, engineers gradually abandoned use of historical data for very large storms and developed the concept of estimating the extreme floods based upon meteorological data taking into account numerous factors including the historical patterns of large storms and the ability of the atmosphere to hold and deliver large quantities of moisture. The PMF became the standard for design of high hazard dams whose failure consequences were considered unacceptable.

The history of PMF dates from its early discussions in 1939 to the 1950's and 1960's when it was in agency use for high hazard dams. Various federal agencies and scientific organizations studied the concept during the 1970's and 1980's. In a 1979 report entitled "Federal Guidelines for Dam Safety", PMF was broadly formalized as the design standard for dams where failure could cause significant hazard to life or major property damage.

The PMP, the weather related value upon which PMF is based is seldom observed in any individual's experience, leaving many to question if actual rainfalls ever approach the PMP. The Mid-Atlantic area, however, in particular is a target for PMP events, and recent occurrences of extreme rain events have approached the PMP. For example, the Mid-Atlantic region has experienced three of the most five intense twelve-hour storms in the United States. One of these storms occurred in Smethport, Pennsylvania in 1942, and the other two occurred in Nelson County Virginia in 1969 and in Madison County Virginia in 1995. In Smethport, the PMP was exceeded by nineteen percent, while two rainfall events in Virginia approached eighty-one and eighty-six percent of the PMP, respectively for areas less than ten square miles.

The PMF is a" best available estimate" that the engineering community regularly relies upon and improves over time. The PMF is the outcome of analytical processes using a combination of well defined and estimated physical data that represent application of best available technology. Levels of estimation many times vary based on the criticality of the outcome and some margin of variation can be accommodated by parameter selection.

2. What level of loss of life and/or property is acceptable for Virginia to require a full PMF?

The Committee believes that its value is as a technical body and that a determination about acceptable loss of life or property damage is a matter for those in elected or appointed policy positions. The approach taken in Virginia's current regulations is consistent with that recommended in the Bureau of Reclamations Publication 11 and FEMA Publication 33.

3. Are other states enforcing full PMF?

It is the experience and belief of the Committee that more states use the PMF standard as recommended in the federal guidelines for their highest hazard dams than use a lesser standard. Some states do, however, use a reduced percentage of PMF for existing dams.

A percentage reduction in PMF was one of the options considered by the Committee but not recommended. The key strength of this approach is that it reduces the costs of spillway upgrades for dam owners. The key disadvantages are that any set percentage reduction may be an arbitrary compromise and is less protective to residents and property owner downstream of existing dams.

In Section 130 B. of its regulations, Virginia does allow for using less than the full PMF when it can be shown that if dam failure did occur it would not add significantly to the hazard beyond that which would result from the breach flood wave just prior to failure. On this incremental basis, the Keeton's Run dam built in 1970, the smaller of the two dams owned by the Lake of the Woods Association was issued a certification based on a reduced spillway design flood. That Associations larger dam, however, is required to meet the full PMF under current practices and current conditions.

The USDA NRCS, in responding to a question about its practices when dealing with dam rehabilitation in Virginia, has indicated that it would not approve any design at less than PMF for high hazard structures.

4. If we allow for less than full PMF, will the professional engineering community put their seal on it?

Under appropriate circumstances and justifications it is known that professional engineers do put their seal on projects designed for less than the full PMF. The example above, where Section 130 allows incremental analysis as the justification for less than the full PMF, illustrates one set of circumstances where a project was designed and sealed by a professional engineer. Another situation is that of less hazardous dams, Classes II, III and IV, where loss of life is less likely and economic loss is reduced. If a high hazard dam that did not qualify under incremental analysis were designed based on less than full PMF and the reduction of hazards downstream depended on non-structural operation and management behaviors on the part of the owner, professional engineers would likely want to make certain that they fully inform the owner that a reduced design standard is a choice and that risks and responsibilities for that choice rest with the owner.

5. Should our Class I dams continue to require PMF engineering design or are there circumstances under which less than full PMF would be sufficient? What are those?

Table I of the Virginia regulations does allow small Class I dams, those less than 40 feet high and less than 1,000 acre feet, of maximum storage capacity to be designed within the range of ½ to full PMF. Medium and small Class II dams are currently allowed at less than full PMF as are all sizes of Class III and Class IV dams. Size, height and hazard potential are all factors upon which a requirement or reduction can be based. Incremental analysis as discussed above is a circumstance where a reduction from a full PMF may be justified.

6. In what situations might a Risk-based or % of PMF be applicable?

The Committee's Alternative 3, the reduction of the spillway design standard by some set percentage, received no strong agreement but did achieve the agreement of eight

members. Three members disagreed with this approach. The concern is that there exists no strong technical rationale supporting any particular reduction. A reduction would be a choice that ideally would attempt to balance perceptions of public safety, allocations of resources, and governmental reach. The key strength of this Alternative is that it would reduce the costs of spillway upgrades for dam owners. The key disadvantages would be that any set percentage reduction may be an arbitrary compromise and would be less protective than the current standards.

Alternative 4, a more elaborate Risk-based approach, was not supported by ten of the eleven members of the Committee. One member found this approach acceptable. The key advantages of such an approach would be that it takes into account multiple factors and assigns weights based on their importance. The key disadvantage of Scenario 4 is that its development would be complex and require both data and staff resources which are not currently available.

Scenario #2, one of the two Alternatives recommended by the Committee, does offer a vehicle for defining circumstances where a case by case assessment could result in a reduction of the PMF for certain existing dams. The key strengths of Alternative #2 are that it is an extension of the authority already contained in Section 130, provides a way that non-structural as well as structural factors can be considered for dams that can demonstrate an outstanding record, is sensitive to significant variations among dam sites and could result in lowered structural upgrade costs for dam owners. The key disadvantages are that this approach involves considerable judgment and potential negotiation between dam owners, the staff and the Board as well as careful monitoring and therefore requires greater staff time and resources. Committee members emphasized that sufficient resources are a necessary part of any decision to implement this type of approach.

7. Has any state adopted a risk-based standard? What is their experience?

The state of Washington is unusual, if not unique, in adopting a fairly sophisticated risk-based approach. Development of their risk-based system required almost a decade, benefited from a staff member holding a PhD specializing in Risk-based approaches, and depended on the state having data with which to estimate the magnitude-frequency relationship of extreme events. (A paper [Johnson] describing the Washington approach is listed in Appendix C). The climate and physical setting in Washington and Virginia are very different such that a simple borrowing of the Washington model for Virginia would not be valid.

8. What enforcement tools do states with risk-based approaches have? What additional operational requirements would the dam owners be willing to accept? What added enforcement authorities would DCR and the Soil and Water Board need?

A state of Washington type risk-based approach is a different way to regulate the design of a dam but then, compliance may not be any different than other approaches in terms of authority. If non-structural and operational factors became the basis for a reduction in the PMF, then the Emergency Action Plan and other parameters would become key. Greater attention would need to go into enforcing those operational controls. The Committee did not know of any authorities that the Board would lack but staff resources, enforcement authorities and time would become crucial.

9. What other states have modified their requirements? What has been their experience and is most applicable to Virginia?

There is no one source upon which to base a response. The Association of State Dam Safety Officials (ASDSO), *Summary of State Laws and Regulations on Dam Safety*, July 2000 does not get into sufficient detail to explain how the different state programs are operating. A past President of ASDSO spoke to the Committee about his organization and programs in his home state of New Jersey but did not have first hand knowledge of states beyond his own. Materials submitted by the *Lake of the Woods Association* during one of the public comment periods identified approximately ten state programs that had less than full PMF spillway requirements. Their investigation was based on internet research and in some cases follow-up phone calls. Perhaps the most relevant states would be those in the Mid-Atlantic region if the Board were interested in asking staff to explore this question further.

10. Funding assistance – what states have done it well?

Three states were suggested by the Committee as having strong programs. These have been contacted and yielded the following information.

Georgia - contact, Ed Fiegle

- No funding for private dam owners.
- Some funding for public dams with water supply and public water systems through a state revolving fund.
- State funds are earmarked to rehabilitate dams built under the PL-566 program (2 dams have been upgraded/repaired).
- State Soil and Water Conservation Commission gets a small amount of funding for normal operation and maintenance work on PL-566 dams.

New Jersey - from John Moyle's presentation to the Ad Hoc Committee

1992 Dam Restoration and Inland Water Projects Loan Program

- Revolving loan program initially funded at $15 million

The "Dam, Lake, Stream, Flood Control, Water Resources, and Wastewater Treatment Project Bond Act of 2003"

- $95 Million for loans to local government unit (municipal and county) dam owners and owners of private dams for the purpose of bringing their dams into compliance with current dam safety standards.
- $15 Million to finance the costs of dam restoration and repair projects for State owned dams.
- $15 Million for loans to owners of lakes or streams to finance the costs of lake dredging and restoration projects, or stream cleaning or desnagging projects.
- $25 Million to finance the costs of State flood control projects.
- $45 Million for loans to finance the costs of water resources projects or to make improvements to water supply facilities and wastewater treatment system projects. Water resource projects include any work related to transferring water between public water systems during a state of water emergency, to plan, design or construct interconnections of existing water supplies or to extend water supplies to areas with contaminated ground water supplies.
- $5 Million to the New Jersey Environmental Infrastructure Trust for establishing reserves and providing loan guarantees for water resources and wastewater treatment projects.

Additional 18 dams rehabilitated through special budget appropriations for high hazard dams and flood damaged dams.

- FY'00, $9.5 million
- FY'01, $10 million
- FY'03, $500,000

Pennsylvania -contact, Mike Conway

- Approximately $50 million available through a low interest loan to community water
- Supply companies.
- Funding received through legislative budget process to rehabilitate state owned dams.
- Funding available to remove old power generating dams and dams on canals.

11. Could we require (for an alternative approach of any kind) that the dam owner have a written binding agreement from the locality to address in perpetuity downstream development, easements, etc?

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Since the classification of a dam is based on downstream development, a dam owner could potentially purchase a perpetual conservation easement over the inundation zone and use this as a basis for retaining a lower classification than would be the case if development were allowed to occur. The owner would need to compare and weigh the costs of obtaining the easement against the potential cost of a reclassification and structural upgrade in the future.

One Committee member spoke of a soil and water conservation district in Virginia that does have an easement over the inundation zone but then experienced a problem when the local building official approved construction not knowing that the easement existed.

This same desire for downstream land use control is being explored at the federal level. The "Draft" National Watershed Manual (NWSM-1-26-05) contains the following language (page 67):

Prior to construction of "high" hazard dams, the State Conservationist will verify that the Sponsoring Local Organization (SLO) has prepared a current Emergency Action Plan (See NEM 210-520.27 and 180-V-NOMM). For inventory-size dams (as defined in NEM, Section 210-520.21) with a hazard class of "low" or "significant", the State Conservationist will verify that the SLO has certified that adequate controls on future development within the breach inundation area (as defined in 210-520.28) are in force. The controls must limit development within the breach inundation area such that the hazard class does not increase during the evaluated project life.

12. Is new upstream development with increased runoff a concern parallel to the concern for new downstream development? Neither may have been taken into account at the time a dam was designed.

Development of land upstream of a dam can cause significant increases in the inflow characteristics and peak discharges that prevailed at the time a dam was initially designed. This could at some point necessitate re-determination of the PMF. On the other hand additional dams upstream could also reduce the PMF. It is considered prudent engineering practice to perform flood inflow hydrologic analyses that include anticipated future land use conditions both up and down stream.

13. What would be the ramifications of changing the regulatory requirements for those who have already upgraded their facilities or for those in the pipeline preparing to do so?

This is the situation whenever regulations are changed. Those who had recently complied with the more stringent regulations could feel that they spent money they did not have to spend. Those who come after the regulatory change experience the benefits of the cost

savings. Some applicants might decide to go ahead and design for the full PMF, especially for new dams, as a way of avoiding future upgrade requirements.

Appendix B: Membership Roster

Virginia Soil and Water Conservation Board
Ad Hoc Study Committee Membership
Updated 11-09-04

Name/Address	Telephone Numbers	E-mail Address	Affiliation
David L. Moyer 4277 Old River Trail Powhatan, VA 23139	804-598-4481 B: 804-598-4451	kelonafarm@aol.com	Virginia Soil & Water Conservation Board Chairman, Farmer, SWCD Director
Charles E. Horn Sr. 1142 Freemason Run Road Mt. Solon, VA 22843	540-350-2351	deltasprings@eaglenet.us	Farmer, SWCD Director
Mathew J. Lyons, P. E. 1606 Santa Rosa Road, Suite 209 Richmond, VA 23229-5014	B: 804-287-1653	mathew.lyons@va.usda.gov	State Conservation Engineer, USDA, Natural Resources Conservation Service
Joseph S. Haugh, P. E. 10257 Henderson Hall Road Mechanicsville, VA 23116	804-550-3325	joeandterry@prodigy.net	Retired, USDA Soil Conservation Service; Department of Conservation & Recreation, Dam Safety Director
Donald L. Wells, P. E. 8036 Dunwoody Road Mechanicsville, VA 23111	804-746-0148	dwells1943@aol.com	Retired, Department of Conservation & Recreation, Deputy Director; Hanover-Caroline SWCD Director
John W. Peterson, P. E. 9304 Lundy Court Burke, VA 22015-3431	703-455-6886/4387 Cell: 703-505-1782	jwpeterson@cox.net	President/CEO KEMPS Consultants, Inc.
David B. Campbell, P.E. 510 E. Gay Street West Chester, PA 19382	B: 610- 696-6066 Cell: 610-656-4422	davec@schnabel-eng.com	Director of Dam Engineering Schnabel Engineering
Daniel J. Mahoney 283 Mackintosh Drive Glen Burnie, MD 21061	B: 202-502-6743	daniel.mahoney@ferc.gov	Deputy Director Division of Dam Safety & Inspections Federal Energy Regulatory Commission
David F. Kibler, P.E. Professor 200 Patton Hall Virginia Tech Blacksburg, VA 24061-0105	B: 540-231-8309	kiblerdf@vt.edu	Department of Civil & Environmental Engineering Virginia Tech
David S. Rosenthal, CLM 6040 Waterworks Road Norfolk, Virginia 23502	B: (757) 441-5774 ext. 253	david.rosenthal@norfolk.gov	Reservoir Manager City of Norfolk
Paul W. Demm 10501 Trade Court Richmond, VA 23236-3713	B: 804-674-2423	paul.demm@vdem.virginia.gov	Virginia Department of Emergency Management
L. Lynn Clements, P.E.	(434) 985-7811	lclements@rapidan.org	Director of Projects

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Name/Address	Telephone Numbers	E-mail Address	Affiliation
P.O. Box 148 Ruckersville, VA 22968			Rapidan Service Authority
Warren M. Lee, P.E. 2300 Lakeview Parkway Locust Grove, VA 22508	(540) 972-6873	wandblee@adelphia.net	Associate SWCD Director

DCR Support Staff

Name/Address	Telephone Numbers	E-mail Address	Affiliation
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David Dowling 203 Governor Street, Suite 302 Richmond, VA 23219	804-786-2291	david.dowling@dcr.virginia.gov	Policy, Planning and Budget Director
Michael Fletcher 203 Governor Street, Suite 302 Richmond, VA 23219	804-786-8445	michael.fletcher@dcr.virginia.gov	Director of Development

Facilitators

Name/Address	Telephone Numbers	E-mail Address	Affiliation
A. Bruce Dotson Campbell Hall P.O. Box 400122 Charlottesville, VA 22904-4122	434-924-6459	dotson@virginia.edu	Associate Dean for Academics, Urban And Environmental Planning, University of Virginia
E. Franklin Dukes, Ph.D. 164 Rugby Road Charlottesville, VA 22903	434-924-2041	ed7k@virginia.edu	Director, The Institute for Environmental Negotiation, University of Virginia
Jessica Lynn Ryan 164 Rugby Road Charlottesville, VA 22903	434-924-1970	jlr9h@virginia.edu	Graduate Associate, The Institute for Environmental Negotiation, University of Virginia

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Appendix C: List of Materials and Presentations

Informational Handouts

Association of State Dam Safety Officials (ASDSO), *Summary of State Laws and Regulations on Dam Safety*, July 2000.

Binder, Denis. *Legal Liability for Dam Failures*. 2002.

City of Norfolk, Department of Utilities and Water Resources. *Map of Virginia Regulatory Definition Dams*. January 2005.

Department of Conservation and Recreation. *Virginia Dams Breached or Damaged in 2004*. February 2005.

FEMA, *Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners*, October 1998. Reprinted April 2004.

FEMA, *Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams*, October 1998. Reprinted January 2004.

FEMA, *Selecting and Accommodating Inflow Design Floods for Dams*, April 2004.

FEMA, *The National Dam Safety Program Fiscal Years 2000-2001, December 2001*

FEMA, *Availability of Dam Insurance*, 1999.

FEMA, *Model State Dam Safety Program*, March 1998.

FEMA, Federal Guidelines for Dam Safety, April 2004, publication 93.

Graham, Wayne J. Bureau of Reclamation. *A Procedure for Estimating Loss of Life Caused by Dam Failure*, Denver: September 1999.

Harrison, John. *PMPs Never Happen – Or Do They?*

Harrison, John and Greg Paxson. *Ballpark PMFs.*

Johnson, Doug, Washington State Dam Safety Supervisor. *Risk is not a Four Letter Word: Ten Years of Success Using a Risk-Based Dam Safety Approach in Washington.*

Paxton, Greg and John Harrison, Schnabel Engineering. Reduced Design Floods: What are the Savings?

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Peterson, J.W. *Rehabilitating Aging Earthen Dams: Recent United States Experience.*

U.S. Bureau of Reclamation, *Risk-based Profiling System*, Denver: February 2000.

Presentations

Hayes, Donald. United States Geological Survey. *"Flooding in Virginia." January 2005.*

Kibler, David. Virginia Tech. *"History and Current Status of the PMF as the Inflow Design Flood for Dams." February 2005.*

Moyle, John. New Jersey Dam Safety Program. *"ASDSO and the New Jersey Dam Safety Program." January 2005.*

Sammler, Bill. NOAA's National Weather Service. *"Weather Info for Dam Owners: Precipitation, Forecasts, Rainfall, Monitoring, Precipitation, Frequency Data." January 2005.*

Sheesley, Diana. Dam Safety and Floodplain Management Program, DCR. *"Dam Safety Ad Hoc Committee: Virginia Impounding Structure Regulations, Classes of Impounding Structures, Performance Standards, and Table 1."* November 2004.

Information Provided by the Public

Graham, Wayne J. *Should Dams Be Modified for the Probable Maximum Flood?* Journal Of the American Water Resources Association, October 2000.

Lake of the Woods Association, Inc. *Proposed Changes to Virginia Impounding Structures Regulations (Dam Safety)*, February 2005.

Lave, Lester, Resendiz-Carrillo, Daniel, and Francis C. McMichael. *Safety Goals for High-Hazard Dams: Are Dams Too Safe?* Water Resources Research, July 1990.

Monroe, William, Augusta County Service Authority, "Talking Points for Ad Hoc Committee Meeting 2/16/05".

National Research Council, *Safety of Dams: Flood and Earthquake Criteria*, Washington D.C.: 1985.

Scher, Ray "Public Comment on Reclassification of Earthen Dams", presented to VSWCB on March 17, 2005 and Ad Hoc Committee on March 23, 2005.

Weinert, Don. "Recommendations by Lake of the Woods Association, Inc." January

2005.

Attachment #2

Alternative Procedure for Existing Dams

by Peter G. Rainey

The Ad Hoc Dam Safety Study Committee stated, “The advantages of this alternative are..it..provides a way that non-structural as well as structural factors can be considered for dams that can demonstrate an outstanding record, is sensitive to the significant site specific variations among dam sites and would likely result in lowered SDF for some dams.”

Reading the Ad Hoc group report and the follow on sub-committee report left me with the impression that there is a presumed need for an alternative process for existing dams, but the need is not articulated.

Before TAC members start to structure the regulation for the alternative procedure, we should discuss and reach consensus on the need for and purpose of the Alternative Procedure.

I think there is a very good reason to need an alternative procedure and that is: *it is very difficult to find an upgrade design that causes no harm and is fiscally realistic*.

The purpose of the procedure is –
to provide the dam owner the right to propose an Alteration that is less than the "appropriate" SDF along with "alternatives" which the dam owner considers to improve dam safety, and the VSWCB should have the right to approve an unconditional permit, if they so choose.

The Ad Hoc Dam Safety Study Committee recognized that consideration of site specific variations was important. To date, the Discussion Draft regulations have removed consideration of “peculiarities and local conditions for each impounding structure”, see lines 235-237.

Existing dams present constraints due to topography, upstream and downstream development, and other site specific issues that restrict the ability to increase spillway capacity without possibly causing harm to persons and property upstream and/or downstream.

- For a fixed dam height, increasing spillway size will result in greater downstream flooding at the dam’s current SDF. That is, the amount of flooding downstream, for a much more likely storm event, will be significantly increased with commensurate increase in damage.

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- One of the lesser costly ways to increase SDF is to raise the height of the dam. Of course this has limits and usually applies to a rise of a few feet. However, the real estate around an existing dam may have structures built in consideration of a known dam height, and raising that height will possibly cause flooding of those structures with resulting risk of loss of life and property damage.
- The alteration event itself is not without risk.

It is time to talk about the elephant in the room. Upgrading to 1 PMF can be very expensive.

Economic concerns that need to be considered include:

- Very high marginal cost – somewhat smaller SDF for a lot less money
- Better use of the money – alarms, monitor devices, etc that reduce risk of failure or subsequent loss
- Maximum fiscal capacity of the dam owner – everyone has their limit
- Severe financial loss due to lowering/dewatering of the reservoir – whether loss of drinking water, recreation or stormwater management, potentially a billion dollar liability

I do not propose a set of explicit fiscal procedures. I do propose that implicit in the alternative procedure is the recognition that the intent is a qualitative cost-risk trade-off.

Summary

It is my opinion that the Alterative Procedure should apply to Alteration permits (4VAC50-20-80) where the alteration achieves less than the applicable SDF. The dam engineer should have calculated the applicable SDF per 4VAC50-20-50 and 54. The dam owner should explain the reason(s) for requesting less than the applicable SDF and the proposed alternative method(s) for achieving dam safety. The list of factors to consider can be very large. The Ad Hoc Dam Safety Study Committee report has an extensive discussion of these factors. Whatever is agreed to be included in the list of factors, I believe the principle factors should “include but not be limited to”

- An effective Emergency Action Plan has to be the cornerstone of an alternative procedure which calls for adequate warning to get people out of harms way long before a dam may break.
- Maintenance and performance history, especially performance in extreme storm events
- Significant site specific characteristics and mitigating circumstances
- Proposed alternative investment in dam safety methods and procedures

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Attachment #3 [COMMENTS FROM DAVID CAMPBELL IN BLUE]

Alternative Procedure for Existing Dams

by Peter G. Rainey

The Ad Hoc Dam Safety Study Committee stated, “The advantages of this alternative are..it..provides a way that non-structural as well as structural factors can be considered for dams that can demonstrate an outstanding record, is sensitive to the significant site specific variations among dam sites and would likely result in lowered SDF for some dams.”

Reading the Ad Hoc group report and the follow on sub-committee report left me with the impression that there is a presumed need for an alternative process for existing dams, but the need is not articulated.

This alternative was drafted by Dave Campbell in response to Ad Hoc Committee discussion related to risk assessment. A number of committee members saw merit in risk assessment but also recognized that risk assessment was costly and time consuming to the owner, required considerable manpower and expertise of dam safety regulators, and reached a stall point whenever loss of life considerations needed to be addressed. The Alternative Procedure was written as a straw man document to present for committee discussion an option that would be less costly of resources and time for both the owner and regulator while providing a mechanism to provide relief to owners where loss of life concerns can reliably be mitigated.

Before TAC members start to structure the regulation for the alternative procedure, we should discuss and reach consensus on the need for and purpose of the Alternative Procedure. As was its original purpose. A total of four alternatives were developed. Members were asked if they 1) supported, 2)could live with, or 3) objected to each of the four. At least one committee member objected to Alternatives 3 and 4. Alternatives 1 and 2 were moved to the Board for further consideration because no one objected to them.

I think there is a very good reason to need an alternative procedure and that is: *it is very difficult to find an upgrade design that causes no harm and is fiscally realistic*. DC1 - It is the responsibility of the design professional to address upgrading in a manner that is protective of existing uses and existing facilities.

Comment [DC1]: It is the responsibility of the design professional to address upgrading in a manner that is protective of existing uses and existing facilities.

The purpose of the procedure is –
to provide the dam owner the right to propose an Alteration that is less than the "appropriate" SDF along with "alternatives" which the dam owner considers to improve dam safety, and the VSWCB should have the right to approve an unconditional permit, if they so choose. DC2 - How about “prescriptive”?

Comment [DC2]: How about “prescriptive”?

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The Ad Hoc Dam Safety Study Committee recognized that consideration of site specific variations was important. To date, the Discussion Draft regulations have removed consideration of "peculiarities and local conditions for each impounding structure", see lines 235-237.

Existing dams present constraints due to topography, upstream and downstream development, and other site specific issues that restrict the ability to increase spillway capacity without possibly causing harm to persons and property upstream and/or downstream.

- For a fixed dam height, increasing spillway size will result in greater downstream flooding at the dam's current SDF. That is, the amount of flooding downstream, for a much more likely storm event, will be significantly increased with commensurate increase in damage. This "may" be a design issue of concern and can be mitigated by a number of design approaches. Where a large increase in spillway capacity instigates problem flooding of developed areas, many engineering consultants (including Schnabel) will modify the design approach to prevent increased flooding.
- One of the lesser costly ways to increase SDF is to raise the height of the dam. Of course this has limits and usually applies to a rise of a few feet. However, the real estate around an existing dam may have structures built in consideration of a known dam height, and raising that height will possibly cause flooding of those structures with resulting risk of loss of life and property damage. DC3 - Increased reservoir area flooding is 'still water' that, with limited exceptions, rises at a nominal rate, so the risk of drowning is many orders of magnitude less likely than from flowing water. Structure flooding outside of the existing flood pool for a raised dam would also occur only under an extreme flood condition.
- The alteration event itself is not without risk. DC4 – Nor is attendance at our committee meetings.

Comment [DC3]: Increased reservoir area flooding is 'still water' that, with limited exceptions, rises at a nominal rate, so the risk of drowning is many orders of magnitude less likely than from flowing water. Structure flooding outside of the existing flood pool for a raised dam would also would occur only under an extreme flood condition.

Comment [DC4]: Nor is attendance at our committee meetings.

It is time to talk about the elephant in the room. Upgrading to 1 PMF can be very expensive.

Economic concerns that need to be considered include:

- Very high marginal cost – somewhat smaller SDF for a lot less money
- Better use of the money – alarms, monitor devices, etc that reduce risk of failure or subsequent loss
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I do not propose a set of explicit fiscal procedures. I do propose that implicit in the alternative procedure is the recognition that the intent is a qualitative cost-risk trade-off.

Summary

It is my opinion that the Alterative Procedure should apply to Alteration permits (4VAC50-20-80) where the alteration achieves less than the applicable SDF. The dam engineer should have calculated the applicable SDF per 4VAC50-20-50 and 54. The dam owner should explain the reason(s) for requesting less than the applicable SDF and the proposed alternative method(s) for achieving dam safety. The list of factors to consider can be very large. The Ad Hoc Dam Safety Study Committee report has an extensive discussion of these factors. Whatever is agreed to be included in the list of factors, I believe the principle factors should "include but not be limited to"

- An effective Emergency Action Plan has to be the cornerstone of an alternative procedure which calls for adequate warning to get people out of harms way long before a dam may break.
- Maintenance and performance history, especially performance in extreme storm events
- Significant site specific characteristics and mitigating circumstances DC5 – The Ad Hoc write-up considers these to be precursors to consideration under Alternative Procedure 2.
- Proposed alternative investment in dam safety methods and procedures

Comment [DC5]: The Ad Hoc write-up considers these to be precursors to consideration under Alternative Procedure 2.

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