STATE OF WEST VIRGINIA

FULL PERFORMANCE EVALUATION OF THE

DIVISION OF ENVIRONMENTAL PROTECTION
Dam Safety Program

Supplemental Report on Dam Safety Program

OFFICE OF LEGISLATIVE AUDITOR
Performance Evaluation and Research Division
Building 1, Room W-314
State Capitol Complex

CHARLESTON, WEST VIRGINIA 25305
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July 2000

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July 2000

WEST VIRGINIA LEGISLATURE

Performance Evaluation and Research Division

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Antonio E. Jones, Ph.D.
Director

July 9, 2000

The Honorable Edwin J. Bowman
State Senate
129 West Circle Drive
Weirton, West Virginia 26062

The Honorable Vicki V. Douglas
House of Delegates
Building 1, Room E-213
1900 Kanawha Boulevard, East
Charleston, West Virginia 25305-0470

Dear Chairs:

Enclosed is the supplemental report to the Full Performance Evaluation of the *Division of Environmental Protection - Dam Safety Program*, which was presented at the June interim. This supplemental report will be presented to the Joint Committee on Government Operations on Sunday, July 9, 2000.

Let me know if you have any questions.

Sincerely,

John Sylvia

John Sylvia
Acting Director

JS/wsc

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Purpose for Supplemental Report on Dam Safety Program

During the June 2000 interim, the Legislative Auditor's Office issued a report to the Joint Committee on Government Operations on the Dam Safety Program within the Division of Environmental Protection (DEP). The report identified several deficiencies within the DEP relating to its administration of the Dam Safety and Control Act. During the presentation of the report and the subsequent response by OWR officials, the Joint Committee members raised several questions and concerns which the committee needed answered before the report could be accepted. The purpose of this report is to provide answers to the questions raised by the Joint Committee. Specifically, the scope of the report focuses on answering the following questions:

1. **Can deficient dams be prioritized to show which dams may be at a higher risk of failure?**

2. **What is the difference between a dam that is determined to be "high hazard" and a dam that is determined to be "deficient"?**

3. **How does a dam with an outstanding violation differ from a deficient dam?**

4. **What are the fee structures for other states?**

Question 1: Can deficient dams be prioritized to show which dams may be at a higher risk of failure?

In the previous report, the Legislative Auditor's Office recommended that the OWR consider taking more forceful measures under the law in dealing with unresponsive owner of deficient dams such as draining the dam reservoir, pursuing legal recourse to have owners correct deficiencies in dams, or performing the necessary remedial work themselves and seek reimbursement if possible from dam owners. However, two problems are inherent with the OWR complying with this recommendation. First, often the remedial work necessary to bring a dam into compliance with the Dam Safety and Control Act is an expensive venture. During the committee meeting, an OWR official estimated that the cost to bring a deficient dam into compliance with the Act approximately $500,000 per dam. Second, many dam owners often lack the necessary resources to perform the remedial work. This implies that the State would need to supply the necessary funds either in the form of a loan to dam owners or performing the work at state expense and seeking financial remuneration through legal action. Given the fact that the state may need to provide the necessary funding, then it becomes important to prioritize deficient dams to determine which dams are more likely to fail than others.

Agency personnel at the OWR analyzed each of the dams on the deficient list and prioritized them based on five factors:

1. The storm capacity for each dam;
2. The slope stability of each dam;
3. The volume of water impounded in the dam reservoir;
4. The downstream population; and,
5. Highway traffic in the inundation area.

Each dam was evaluated on each of these areas and was assigned a priority value from 0 to 10 (0 being best and 10 worst). The cumulative scores for the above five factors were then used to determine the priority ranking.

The prioritized list of deficient dams is included in Appendix A. This list is provided as a method to satisfy the initial request of the committee and should be considered as preliminary. For certain dams, the information for one or more than one of the above factors was not readily available. Therefore, where information was lacking for a given factor, the OWR assigned the factor a value of 2 (except for the factor of highway traffic which assigned a value of 0). For a complete analysis to be done, additional study and research will need to be conducted to determine what value should be used.

Question 2: **What is the difference between a dam that is determined to be "high hazard" and a dam that is determined to be "deficient"?**

This question is in response to an article which was circulated at the meeting and was published in the Charleston Gazette on July 6, 2000. The article indicated that West Virginia currently has 248 *"high hazard"* dams. The article was based on information contained in a recent report issued by the Federal Emergency Management Agency (FEMA). The FEMA report shows that West Virginia has the 10th highest number of high hazard dams in the country, and the 3rd highest percentage (46%) of its dams that are high hazards.[1]

The term *"high hazard"* actually means *"high hazard potential"* and is an industry specific term. This term refers to the hazard classification assigned to a dam. According to CSR §47-34-2.23, the term hazard classification means:

> *a classification rating assigned to a structure based upon engineering evaluations and judgements for predicting the danger to human life, property, and environment should a failure of the structure occur.*

Dams can be classified as either high hazard, significant hazard, or low hazard. Each hazard classification is defined as follows:

- High hazard dams - are those dams located where failure may cause loss of human life or major damage to dwellings, commercial or industrial buildings, main railroads, important public utilities, or where a high risk highway may be affected or damaged. This classification must be used if failure may result in the loss of human life.

- Significant Hazard Dams - are those dams located where failure may cause minor damage to dwellings, commercial or industrial buildings, important public utilities, main railroads, or cause major damage to unoccupied buildings, or where a low risk highway may be affected or damaged. The potential for loss of human life resulting from failure of a significant hazard dam must be unlikely.

- Low Hazard Dams - are those dams located in rural or agricultural areas where failure may cause minor damage to nonresidential and normally unoccupied buildings, or rural or agricultural land. Failure of a Class 3 dam would cause only a loss of the dam itself and a loss of property use, such as use of related roads, with little additional damage to adjacent property. The potential for loss of human life resulting from failure of a dam must be unlikely.

Furthermore, according to the Association of State Dam Safety Officials (ASDSO), ***"the hazard***

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[1] *California has the highest percentage of its dams that are high hazard at 75%, followed by Pennsylvania with 55%.*

potential classification of a dam does not reflect in any way on the current condition of the dam and its appurtenant structures (e.g. safety, structural integrity, flood routing capacity)."

Conversely, the term *"deficient"* deals entirely with the current condition of the dam. According to the OWR, a dam is considered to be deficient and is placed on the list of deficient dams by the OWR when the dam meets one of three criteria:

1.) The National Dam Inspection Program (NDIP) conducted during the late 70's and early 80's cited the dam as a high hazard potential, unsafe structure;

2.) The National Dam Inspection Program (NDIP) conducted during the late 70's and early 80's cited the dam as a high hazard potential, structure in need of additional investigation;

3.) Dam safety determined the dam to be deficient due to hydrological, hydraulic, or structural problems.

Question 3: How does a dam with an outstanding violation differ from a deficient dam?

The previous report discusses a list of 42 deficient dams. Page 16 of the previous report indicates that there are 63 dams with outstanding violations. While all deficient dams except those owned by the state have outstanding violations, not all dams with outstanding violations are deficient. According to the OWR, the term "*deficient*" is a condition of a dam resulting from a design, construction, or maintenance problem that if left uncorrected could eventually lead to dam failure. The term violation refers to an action by a dam owner which may or may not lead to a deficiency if left uncorrected.

If a dam owner does not apply for a Certificate of Approval (COA) prior to beginning construction of the dam, then the owner has committed a violation. If the dam in question is built to improper standards, then the dam owner is guilty of a violation and the dam itself is deficient. However, if the dam owner designs and constructs the dam to the proper standards but fails to apply for a COA, or if the dam owner neglects the maintenance of a dam, then the owner is guilty of a violation.

Question 4: What are the fee structures for other states?

As was previously stated, many dam owners do not have the necessary funds to affect repairs on dams. According to the Dam Safety Control Act, the Dam Safety Fund can be used to pay for emergency remedial action. The Dam Safety Fund receives revenues from certificate application fees, annual registration fees, interest and surcharges, interest on investments, and any other money designated by the Division. However, many dam owners do not pay the annual registration fee. Currently, the OWR charges an application fee of $300. However, many dam owners have never applied for a Certificate and have therefore, not paid the application fee. For these reasons, the amount of money currently in the Dam Safety Fund is insufficient to affect repairs to even a single deficient dam given that the cost of repairs would average $500,000. On July 1, 1993, the Dam Safety Fund had a balance of $856.22. Between July 1, 1993 and July 1, 1998, the OWR collected a total of nearly $21,500 in application and annual registration fees, and a total of $1,500 in interest was earned. On July 1, 1998, the Dam Safety Fund had a balance of $17,096.92.

Another factor which influences the amount of funds available in the Dam Safety Fund is the application fee and the annual renewal fee rates. West Virginia uses a flat fee for both the application fee and the annual registration fee. According to OWR rules, the application fee is set at $300 and the annual registration fee ranges from $50 to $100 depending on the hazard class of the dam. This fee is not standard among states. Many states charge an application fee but no annual registration fee. Some states charge no fees at all. However, for those states that do charge a fee, there are four fee structures that seem more prevalent than others:

- A flat application fee;
- An application fee representing a percentage of the construction costs;
- An application fee representing a flat fee plus an additional amount per foot in height; or,
- An application fee representing a flat fee plus an additional amount per water volume stored.

As was previously mentioned, West Virginia uses the flat fee method. One example of a state which uses a percentage of construction costs is North Carolina. For example, in the previous report, the estimate received by DNR to bring the Teter Creek Dam into compliance with the Act, was $1,457,422. This action would require the filing of an application for modification. In West Virginia, this would be accompanied by an application fee of $300. In North Carolina, the application fee would be $200, plus a percentage of the construction costs. This means that the total application fee in North Carolina would be $7,309.11.

California and Pennsylvania are the only two states that have a higher percentage of their dams classified as high hazard than West Virginia. California charges owners an application fee that is based on a percentage of the dam's construction costs, and Pennsylvania charges owners an application fee of $3,000. California charges an annual fee of $150 plus $16 per foot in height of the dam. Pennsylvania does not charge an annual fee.

APPENDIX A

Agency Analysis

Office of Water Resources
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Charleston, WV 25311
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West Virginia 2000 CELEBRATION

West Virginia Division of Environmental Protection

Cecil H. Underwood
Governor

Michael C. Castle
Director

June 27, 2000

Mr. John Sylvia
West Virginia Legislature
Performance Evaluation and Research Division
1900 Kanawha Boulevard East
Charleston WV 25305-0610

Re: June 13 Request for Additional Analysis

Dear Mr. Sylvia:

Thank you for your June 13, 2000, letter asking for additional analysis as requested by the Joint Committee on Government Operations.

The attached responses are offered to answer the Committee's questions. If you need clarification of the responses, please contact me at 558-0320.

Sincerely,

OFFICE OF WATER RESOURCES

Brian R. Long, Assistant Chief
Dam Safety Section

Enclosure

Cc: Allyn Turner, Chief

"To use all available resources to protect and restore West Virginia's environment in concert with the needs of present and future generations."

DEP West Virginia Division of Environmental Protection

ADDITIONAL ANALYSIS REQUEST

INTRODUCTION

The WV Division of Environmental Protection (DEP), Office of Water Resources (OWR), Dam Safety Program offers the following answers to a request for additional analysis from the Joint Committee on Government Operations as summarized in a June 13, 2000, letter from the Performance Evaluation and Research Division.

QUESTION 1: The Committee would like to have a better understanding of the deficiencies of dams on the deficient list. This can be accomplished by re-ordering the deficient dam list. Priority should be provided to dams that present the highest risk of failure due to structural deficiencies, and by the magnitude of the loss [of life] that might occur should the dam fail. The list should also include the name of owners and a brief description of the deficiencies.

ANSWER:

The list of deficient dams is presented below in priority order according to our study results. To prioritize the dams, the study addressed the following factors:

- storm capacity of the dam – percent of design storm handled by the dam;
- factor of safety – structural deficiencies;
- reservoir volume – magnitude of loss;
- downstream population – magnitude of loss; and
- highway traffic – magnitude of loss.

A numeric score was assigned to each dam for each factor. The scores ranged from 10 (worst score) to 0 (best score). The cumulative score for the above factors was used to list the dams in priority order.

NOTE: The reader is cautioned that the information presented in the table contains many variables. An explanation of the variables and underlying assumptions are discussed following the table.

WV DEFICIENT DAMS LIST IN PRIORITY ORDER

Name of Dam	ID	Percent PMP Score (a)	Factor of Safety Score (b)	Reservoir Volume Score (c)	Downstream Population Score (d)	Highway Traffic Score (e)	**Cumulative Score (a)+(b)+(c)+(d)+(e)**
Thomas Dam	09307	10	10	7	4	1	**32**
Teter Creek Dam	00101	3	8	8	10	0*	**29**
Rock Lake Dam	04917	9	6	6	5	0*	**26**
Upper Salem Dam	03301	5	2	9	6	1	**23**
Deegan Lake Dam	03322	10	6	5	1	0*	**22**
Charles Fork Dam	08705	1	4	10	6	1	**22**
Lake Washington Dam	07906	2*	8	9	2	1	**22**
Lake of Eden Dam	01102	3**	10	1	4	3	**21**
Lynch Lake Dam	06116	9	8	2	1	1	**21**
Hurricane WS Dam	07909	4	10	3	4		**21**
Asbury Lake Dam	09905	10	2	2	5	1	**20**
Old Bramwell Dam	05524	2*	10	2	6	0*	**20**
Flat Top Lake Dam	08101	5	0	10	4	1	**20**
Hinkle Lake Dam	03328	9	0	2	6	2	**19**
Poffenbarger # 1 Dam	03904	9	0	2	3	5	**19**
Burch Run Dam	05101	2*	8	6	2	0*	**18**
Lake Trotter Dam	08704	2*	10	3	2*	1	**18**
B & O Dam	07715	2*	6	4	5	0*	**17**
New Bramwell Dam	05501	8	1	2	6	0*	**17**
Lake Floyd Dam	03319	8	0	6	2	1	**17**
Berwind Lake Dam	04702	7	0	8	2	0*	**17**
Cacapon Res Dam	06502	1	10	4	2*	0*	**17**
Bear Rock # 2 Dam	06902	2*	8	5	2*	0*	**17**
Hatfield Lake Dam	01105	9	0	2	4	1	**16**
Sleepy Hollow Dam	00303	2*	2*	2*	10	0*	**16**
Bluewell # 2 Dam	05520	8	0	5	2	1	**16**
Lough Lake Dam	06115	2*	10	2	1	1	**16**
Scott Lake Dam	08304	3	6	3	3	1	**16**
Moncove Lake Dam	06301	1	2	10	2*	0*	**15**
Maple Lake Dam	03327	7	0	5	2	0*	**14**
Bluewell # 1 Dam	05519	8	0	5	1	0*	**14**
Long Branch Dam	08903	3	2	7	2	0*	**14**
Lower Salem Dam	03314	5	1	7	1	0*	**14**
Tennants Farm Dam	10703	10	0	2	1	0*	**13**
Old Keyser Dam	05722	2*	2*	3	4	0*	**11**
Sun Valley Dam	08904	6	0	3	2	0*	**11**
Cherry Lake Dam	02903	2*	2*	2*	3	1	**10**
Bear Rock # 1 Dam	06901	2*	2	3	2*	0*	**9**
Lees Fishing Dam	04301	1**	4	1	2	1	**9**
Cacapon Park Dam	06503	2*	2*	2*	2*	0*	**8**
Bear Rock # 3 Dam	06903	2*	2*	2	2*	0*	**8**
Poffenbarger #2 Dam	03916	5	0	1	1	0*	**7**

* no information

** based on 100 year storm

OWNERS OF DEFICIENT DAMS

Name of Dam	ID	Owner
Thomas Dam	09307	City of Thomas
Teter Creek Dam	00101	WVDNR Wildlife Resources
Rock Lake Dam	04917	Rock Lake Club, Inc.
Upper Salem Dam	03301	City of Salem
Deegan Lake Dam	03322	City of Bridgeport
Charles Fork Dam	08705	City of Spencer
Lake Washington Dam	07906	Forest Lake Club, Inc.
Lake of Eden Dam	01102	William T. Workman
Lynch Lake Dam	06116	Elza Hunt
Hurricane WS Dam	07909	City of Hurricane
Asbury Lake Dam	09905	Garry Harper
Old Bramwell Dam	05524	City of Bramwell
Flat Top Lake Dam	08101	Flat Top Lake Association, Inc.
Hinkle Lake Dam	03328	City of Bridgeport
Poffenbarger # 1 Dam	03904	Martha Poffenbarger
Burch Run Dam	05101	WVDNR Wildlife Resources
Lake Trotter Dam	08704	City of Spencer
B & O Dam	07715	City of Newburg
New Bramwell Dam	05501	City of Bramwell
Lake Floyd Dam	03319	Lake Floyd Club
Berwind Lake Dam	04702	WVDNR Wildlife Resources
Cacapon Res Dam	06502	WVDNR Parks & Recreation
Bear Rock # 2 Dam	06902	WVDNR Wildlife Resources
Hatfield Lake Dam	01105	Raymond G. Cyrus
Sleepy Hollow Dam	00303	Sleepy Hollow Lot Owners Association
Bluewell # 2 Dam	05520	Bluewell Public Service District
Lough Lake Dam	06115	Robert Lough
Scott Lake Dam	08304	Scott Lake Corporation
Moncove Lake Dam	06301	WVDNR Parks & Recreation
Maple Lake Dam	03327	Maple Lake Club
Bluewell # 1 Dam	05519	Bluewell Public Service District
Long Branch Dam	08903	WVDNR Parks & Recreation
Lower Salem Dam	03314	City of Salem
Tennants Farm Dam	10703	Tim Moore
Old Keyser Dam	05722	City of Keyser
Sun Valley Dam	08904	Unknown
Cherry Lake Dam	02903	Paul Settle
Bear Rock # 1 Dam	06901	WVDNR Wildlife Resources
Lees Fishing Dam	04301	Oren Johnston
Cacapon Park Dam	06503	WVDNR Parks & Recreation
Bear Rock # 3 Dam	06903	WVDNR Wildlife Resources
Poffenbarger #2 Dam	03916	Martha Poffenbarger

FACTORS AND ASSUMPTIONS USED TO DEVELOP PRIORITY LIST

NOTE: Despite our best efforts and research, Dam Safety could not document all of the listed factors for all of the dams. Where information was lacking for a given factor, Dam Safety assigned that factor a value of "2." A score of "2" is above the minimum, but not high enough to give priority to a dam with little information. This problem may only be resolved through a more complete study to document the factors as further discussed at the end of the answer to Question 1.

Storm Capacity of the Dam - Percent PMP Storm Score - Column (a)

The National Dam Inspection Program (NDIP) reports conducted by the US Army Corps of Engineers from 1978 – 1982 were utilized as the best existing source of information regarding a dam's capacity to handle storms. The NDIP studied watershed runoff characteristics and spillway capacity of dams, however, the NDIP generally used storms less than those required by current regulations.

Current regulation requirements begin at the national standard of 100 percent Probable Maximum Precipitation (PMP – 27.5 inches of rain in six hours). The NDIP used 80 percent of the PMP (22 inches of rain in six hours) and, in some cases, the 100 year storm (4.5 inches of rain in six hours). As a result, the NDIP information is not accurate for current requirements, but was the best information available.

For the purposes of this prioritization, we calculated the ratio of peak inflow (flow into the reservoir) versus the maximum capacity of the spillways (flow out of the reservoir) to produce a percentage of storm water handling capability. The percentage of capability was then assigned a numeric score based upon ranges of values (see Table 1) to allow comparison. Higher numbers denote greater deficiency than lower numbers.

TABLE 1 – Percent of PMP Score for Column (a)

Percent of PMP	Numeric Score
0 – 5	10 (more deficient)
6 – 10	9
11 – 15	8
16 – 20	7
21 – 25	6
26 – 30	5
31 – 40	4
41 – 50	3
51 – 60	2
>60	1 (less deficient)
No Information	2

Slope Stability – Factor of Safety Score – Column (b)

The National Dam Inspection Program (NDIP) assumed conservative embankment strength parameters without benefit of subsurface investigation or laboratory documentation to calculate a slope stability factor of safety. The NDIP factor of safety value was assigned a numeric score based upon ranges of values (see Table 2) to allow comparison. Higher numbers denote greater deficiency than lower numbers.

TABLE 2 – Factor of Safety Score for Column (b)

Factor of Safety	Numeric Score
< 1.0	10 (more deficient)
1.0 – 1.1	8
1.11 – 1.2	6
1.21 – 1.3	4
1.31 – 1.4	2
1.41 – 1.49	1 (less deficient)
≥ 1.5	0
No Information	2

Reservoir Volume Score – Column (c)

A dam break analysis was not attempted for this prioritization. Effects from a potential dam break were estimated using three factors. The first factor used was the maximum water storage volume of the reservoir to show the raw amount of water that could be released by dam failure. The reservoir volume was assigned a numeric score based upon ranges of values (see Table 3) to allow comparison. Higher numbers represent more damage potential than lower numbers.

TABLE 3 – Reservoir Volume for Column (c)

Max Reservoir in Acre-Feet	Numeric Score
> 700	10 (more potential damage)
601 – 700	9
501 – 600	8
401 – 500	7
301 – 400	6
201 – 300	5
101 – 200	4
51 – 100	3
26 – 50	2
15 – 25	1 (less potential damage)
No Information	2

Downstream Population Score – Column (d)

The second factor related to potential for loss of life was an estimation of the number of people living downstream in the inundation area. Dam Safety counted the number of houses within one mile downstream from the dam at the dam crest elevation or below using available USGS maps last updated in the mid-1970's. We then assumed two person occupancy per house and assigned a numeric score based upon the total number of people living below the dam (see Table 4) to allow comparison. Higher numbers represent higher loss of life potential than lower numbers.

TABLE 4 – Downstream Population for Column (e)

Estimated Number of People	Numeric Score
> 80	10 (higher loss of life potential)
71 – 80	9
61 – 70	8
51 – 60	7
41 – 50	6
31 – 40	5
21 – 30	4
11 – 20	3
6 – 10	2
< 5	1 (lesser loss of life potential)
No Information	2

Highway Traffic Score – Column (f)

The third factor related to potential for loss of life was the possible presence of highways downstream. A score was assigned to downstream highways based upon the West Virginia Division of Highways (WVDOH) Traffic Count Maps completed in 1993 using ranges of people per unit time (see Table 5). Higher numbers represent higher loss of life potential than lower numbers.

TABLE 5 – Highway Traffic Score for Column (f)

Traffic Count (Number of Vehicles per Day)	Numeric Score
>40,000	5 (higher loss of life potential)
20,000 – 40,0000	4
10,000 – 20,000	3
5,000 – 10,000	2
< 5,000	1 (lesser loss of life potential)
No Information	0

NOTE: Factors Necessary for Complete Study

The factors listed above were utilized to provide an answer to the Committee's question within the time frame provided. By necessity, many additional contributing factors were not included in the study. Given sufficient time and resources, the additional factors listed below should be included in a complete study of deficient dam priority.

Hydrology/Hydraulics Deficiencies: Historically, dams were designed using the 100 year storm criteria (currently 4.5 inches of rain in six hours). Following the Buffalo Creek Disaster, the Dam Safety program adopted the national standard known as the Probable Maximum Precipitation (PMP – currently 27.5 inches of rain in six hours) as determined by the National Weather Service. The PMP is the design standard for the Corps of Engineers, Bureau of Reclamation, Mine Safety and Health Administration, and other federal dam safety agencies. In addition, the PMP standard is a requirement of other state dam safety programs with very few exceptions. The difference between the 100 year storm many older dams were designed to meet and the current PMP requirement results in insufficient spillway capacity, storm water storage, or a combination of both. Upgrading dams to current safety standards protects life and property downstream.

> Hydrology/Hydraulics Evaluation: A complete and accurate method of prioritization would involve in-depth studies of the watershed above and below the dam as well as the potential effects of a failure under both sunny day and storm conditions. The study should begin with a complete hydrology evaluation of the watershed upstream from the dam and calculation of the amount of storm runoff based upon land use and slopes of the land. The resulting runoff is prorated based on the time duration of the storm and added to the water normally in the reservoir, thus raising the water level of the lake. The rising water level (storm water storage) is balanced against flow from the spillways (outflow hydraulics) to calculate the maximum amount of storm water the dam can safely handle without overtopping the crest of the embankment (flood routing).

Stability Deficiencies: Earth dams are always constructed with sloping embankments. Designers frequently use the minimum materials necessary to accomplish the design intent. When an embankment does not have sufficient thickness to provide protection against internal seepage of water, the dam may become structurally unstable. Steep embankment slopes contribute to instability. To correct slope stability deficiencies, a dam owner often must regrade the existing embankment to a more stable slope or construct a buttress to prop up the dam. The buttress reduces the slope of the embankment, thus making it more stable. Internal drains at the bottom of the buttress keep the internal water table low and the embankment slope dry. Stability of embankments can be evaluated using the following sequential steps:

> Documentation Search. Any existing plans for the dam should be researched to determine the configuration of the dam, internal drain structures, and construction record that may provide information regarding slope stability.

Field Work. An on-site drilling program to determine the geology, soils, and internal material strength of the dam should be conducted to determine as-built conditions of the foundation of the dam and embankment materials. The subsurface investigation should be followed by laboratory analysis to document the composition and strength of the materials found by drilling. Drill holes in the dam should be used for installation of water wells that may provide information regarding the internal water table of the embankment.

Analysis. The subsurface conditions, internal water table, configuration of internal materials and the strength of materials should be utilized as input to a slope stability analysis. The analysis determines the stability of the dam embankment. For concrete dams, a similar analysis should show the probability of the dam structure sliding off the foundation or falling on its face during high reservoir conditions.

Analysis of Downstream Damage Potential: The slope stability analysis, hydrology/hydraulics information and survey of the downstream stream area below the dam are combined in a dam break analysis to determine the potential impacts to human life and property if the dam were to fail. Complex calculations result in flow depth and water velocity at points of interest downstream sufficient to show potential impacts to life and property downstream.

Time/Cost Required: The sequential steps as outlined above can easily cost $20,000 per dam, or more depending on site specific characteristics. The time frame allowed to prioritize the deficient dams list was from June 13 to June 27. As a result, OWR Dam Safety had neither time nor budget to conduct a complete study.

QUESTION 2: The Committee needs to understand the difference between the terms "deficient" and "high hazard."

ANSWER:

A first understanding of the term "high hazard" is helpful in subsequent understanding of the term "deficient." Correctly stated as "*High Hazard Potential*," the term refers to the amount and kind of damage that may be caused by a dam failure. High hazard potential means that loss of human life and major property damage will occur if the dam fails. For example, Summersville Dam is high hazard potential and always will be due to the loss of life and property damage that would occur if the dam were to fail. The condition of the dam (whether it has deficiencies) is an entirely separate concept from hazard potential. West Virginia is listed as having 248 high hazard potential dams in a recent report issued by the Federal Emergency Management Agency (FEMA). The FEMA list documents the number of high hazard potential dams, not to the condition of the dams.

The term "*deficient*" and measures to determine deficiencies are discussed in detail as part of the answer to Question 1. The term refers to the condition of a dam. If a dam is deficient, it is more likely to fail and cause loss of human life and property damage if it is a high hazard potential structure. Dam Safety placed dams on the deficient list if they met one of the following three criteria:

1) The National Dam Inspection Program (NDIP) cited the dam as a high hazard potential, unsafe structure.
2) The National Dam Inspection Program (NDIP) cited the dam as a high hazard potential, structure in need of additional investigation.
3) Dam Safety determined the dam to be deficient due to hydrological, hydraulic, or structural problems.

QUESTION 3: Would you also indicate what the difference is between a "*deficiency*" and a "*violation*?" What are examples of violations that do not necessarily indicate a deficiency?

ANSWER: A deficiency is a condition of a dam resulting from a design, construction, or maintenance problem that, left uncorrected, could lead to failure of the dam after a long period of neglect or due to heavy rainfall.

One type of violation is an action of the dam owner that may cause a deficiency. For example, a dam may have an adequately designed and constructed emergency spillway channel. However, if the dam owner fills the spillway channel with material that blocks the design water flow through the channel, then the owner has committed a violation. Such a violation indicates a deficiency of the dam that did not previously exist.

Another type of violation is an unlawful action by the dam owner or another party. The owner may cause a violation that does not indicate a deficiency of the dam, if he fails to comply with provisions of the Dam Control and Safety Act, the Dam Safety Regulations, Notice, Order, or terms of a Certificate of Approval.