STATE ENGINEER'S FOURTEENTH ANNUAL REPORT TO THE COLORADO GENERAL ASSEMBLY ON DAM SAFETY FOR F.Y. 97-98

November 1, 1998

COLORADO DIVISION OF WATER RESOURCES
OFFICE OF THE STATE ENGINEER

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INTRODUCTION

The mission of Colorado's Dam Safety Program, is to prevent loss of life and property damage, and protect the state's water supplies, from the failure of dams, within the resources available to this office. The program assures a safe environment related to the design, construction, and operation of dams and reservoirs through working with dam owners and designers to achieve compliance with state statutes. The program includes the enforcement of a comprehensive set of regulations, policies, and procedures for the construction and maintenance of dams, the safe operation of reservoirs, and emergency preparedness. The public safety is provided by restricting the storage in the reservoir to a safe level. The safe storage level is determined by the review and approval of engineered plans for the construction and repair of dams, and regular safety evaluations of existing dams and reservoirs by professional engineers.

The program is managed by the State Engineer in accordance with Title 37, Article 87, of C.R.S. (1998 Supp.), and the Livestock Water Tank Act, Title 35, Article 49, of C.R.S. (1998 Supp.), as amended. The "Rules and Regulations for Dam Safety and Dam Construction" and Standard Specifications for Livestock Water Tanks and Erosion Control Dams establish the procedures and requirements of the State Engineer in the implementation of these statutes.

PURPOSE

This report is submitted in compliance with Section 37-87-114.4, C.R.S. (1998 Supp.) concerning the dam safety activities of the State Engineer and the Colorado Division of Water Resources relating to Sections 37-87-105 to 37-87-114, C.R.S. (1998 Supp.) and the effectiveness of the program.

EFFECTIVENESS OF PROGRAM

The effectiveness of a program is usually indicated by producing a result or accomplishment. For fiscal year 1997-1998, the dam safety program achieved the majority of its goals and objectives in the design review and inspection of dams; We continue however, to experience serious incidents at dams, including two dam failures. Fortunately, no lives were lost, but significant damage occurred. However, because of a strong dam safety program, most of the incidents resulted in reduced consequences. This is attributed to the increased awareness of the dam owners to be responsible for their dams, emergency preparedness, and to the enforcement of the regulations, policies, and procedures.

At the end of the reporting period, there were 193 dams restricted from full storage due to various structural problems such as serious leakage, cracking and sliding of embankments; and inadequate spillways. The restrictions provide for the safety of the public and environment until the problems are corrected. The owners are responsible for following the restricted operating levels, and the restrictions are enforced by the Division Engineers. In the event conditions of any dam or reservoir are so unsafe as to not permit the time to issue or enforce a restriction, or a dam is threatened by a large flood, the State Engineer may immediately employ remedial measures to protect the public safety. An emergency dam repair cash fund is provided under the Colorado Water Conservation Board's construction fund per Section 37-87-122.5 (1998 Supp.)

Eleven dams experienced serious problems during the period, including two failures which released the contents of the reservoirs. One of the failures resulted in significant property damage to the public; while the other caused damage only to the owner's property. Following is a short description of the incidents:

- The Carl Smith dam, a high hazard structure near Hotchkiss in Delta County failed on May 2, 1998, apparently due to a slope stability problem at the right abutment of the dam. The resulting flood, which occurred around 7 PM on Saturday night was witnessed by a Delta County highway crew working near the bridge where LeRoux Creek crosses State Highway 92 on the outskirts of Hotchkiss. The flood caused the destruction of several diversion structures and road crossings, numerous livestock drownings, and flood damage to one house and several corrals and outbuildings. A report of the failure was published by the State Engineer, dated June 18, 1998, and is available on request.
- The Vertrees dam, a low hazard structure in southeast Pueblo County, near Dolyle, failed on May 25, 1998, apparently due to piping leakage through the foundation. Damage was confined to the owner's property.
- Big Beaver dam, aka Lake Avery, a high hazard dam near Buford in Rio Blanco County, experienced significant leakage related to the newly constructed emergency spillway. A comprehensive monitoring plan was developed and enforced in order to maintain the reservoir level for recreation. The dam is owned by the Division of Wildlife. The reservoir was drawn down in the fall, and repairs made to reduce and control the leakage.
- The Keeton Lake dam, a low hazard structure owned by the City of Fountain in El Paso County, suffered severe erosion and damage to its spillways during an extreme rainstorm and flooding on Little Fountain Creek during the week of July 2, 1997. The dam will be breached and abandoned.
- The recently constructed Alsbury dam, a significant hazard dam near Silt in Garfield County, is experiencing significant leakage which appears to be related to foundation conditions. The damsite is on the highly fractured and erosive Wasatch Formation, which may be the reason for the problem. An earth blanket was constructed in the reservoir to reduce the leakage.
- The Western Hillside dam, a high hazard structure recently constructed for the Beaver Creek ski area at Avon in Eagle County, experienced a failure of its geomembrane lining due to an accidental puncture of the lining during filling, and due to adverse settlement of the concrete inlet basin. The holes and seals were repaired and the basin reconstructed to prevent settlement.

- Regulating Reservoir dam, is a high hazard dam owned by the City of Colorado Springs. It is located adjacent to the Air Force Academy in El Paso County. The reservoir experienced excess leakage shortly after filling. The problem was related to poor backfill around the outlet tower. The fill was removed and replaced with new material and compacted properly.

- McMahon No.2 dam is a significant hazard dam on Red Dirt Creek near Kremmling in Grand County. The old outlet pipe was recently lined using a new technology with a tradename of "Ultraliner". Unfortunately the liner failed during use, probably due to poor installation.

- The Howards Lake dam is a low hazard structure on Owl Creek near Gill in Weld County. The spillway suffered severe erosion during a flood caused by extreme rainfall. The problem was apparently caused by poor construction work of a county road crew that installed the culvert for the county road which crosses the dam.

- Horseshoe No.2 dam, a significant hazard structure, and Cattail No.1 dam, a low hazard dam near Loveland in Larimer County, both experienced uncontrolled releases from their outlets due to gate malfunctions.

The sudden, unexpected failure of the Carl Smith Dam, and the number of incidents involving outlet facilities are of concern. A review of the rules and regulations, evaluation of existing dams and other procedures are scheduled for 1999. The purpose of the review is to determine if modifications to the program are required to reduce the potential for dam failures and incidents.

With the passage of the National Dam Safety Program Act (NDSP), PL 104-303, and its subsequent funding, Colorado has applied for and received a $25,162 assistance grant for fiscal 1998 – 1999, to improve the effectiveness of its program. These funds will be used to provide advanced training to the staff in the field of dam safety. Additional training will also be provided under the Technical Seminar training provisions of the Act. The grant funds will also be used to acquire emergency communication equipment, like cell phones; engineering computer programs; and cameras. Future grants may be available each year under the Act, until the year 2002, if Congress approves the allocations.

Finally, the State Auditor completed a performance audit of the dam safety program in July 1998. The State Auditor presented the audit findings to the Legislative Audit Committee on July 13, 1998. The auditor's interviews with dam owners, insurance providers, and managers of other state dam safety programs yielded positive comments about Colorado's Dam Safety Program. The auditors also found that the engineers in the branch exhibited professionalism and thoroughness in their inspections. Nevertheless, the audit made fourteen recommendations for improving the operations of the Dam Safety Program. See Appendix F for a summary of the recommendations and the State Engineer's response.

The following sections of this report cover the activities of the program during the period.

DAM SAFETY PROGRAM

Organization

The Dam Safety Program is accomplished by the State Engineer through the Dam Safety Branch and the Division Engineer's Offices. The branch is partially decentralized, with Dam Safety Engineers working under the general supervision of the Division Engineers in the several divisions throughout the state. The Dam Safety Engineers and the divisions are responsible for implementation of the Program for their area, including enforcement of reservoir level restrictions. The Principal Engineer of the Branch, who is located in Denver, has program wide responsibilities such as: communication, training, coordination, formulating the goals of the program, recommending policies for implementation of the regulations, preparing procedures for carrying out the policies, and providing technical guidelines for conduct of the work. The Principal Engineer also supervises the Design Review and Construction Inspection activities. (See Appendix A for tables and charts of the personnel and organization of the Branch.)

The Dam Safety Engineers' principal duties are to respond to emergency situations, conduct safety inspections of existing dams, review the adequacy of spillways under the rules, enforce the requirement for emergency planning, and assist dam owners in developing their Emergency Preparedness Plans (EPP), provide design review and construction inspection of repairs and alterations when necessary, and investigate complaints on the safety of dams. They also investigate the construction of dams in violation of Section 37-87-105(1) and (4), C.R.S. (1998 Supp.), and conduct training on the inspection of dams for division personnel, dam owners, interested agencies, engineers, and the public. In addition, they review and approve Livestock Watertank and Erosion Control Dam applications, and do other related work as assigned.

Interagency coordination occurs as necessary. For example, we provide the US Forest Service copies of our inspection reports and orders for repair so they can administer their use permits on national forest lands. We also coordinate the reviews of plans with the forest service for permitted dams. See page 6 for more information on the safety of federal dams.

The Design Review Engineers' principal duties are to review the plans and specifications for the construction, alteration, modification, repair, and enlargement of reservoirs or dams in accordance with Section 37-87-105, C.R.S. (1998 Supp.). This involves a comprehensive engineering review of the plans and specifications to assure that a safe design has been developed, and to inspect the construction of the dam. The engineers assist the Department of Health in the technical evaluation of tailing impoundments through a Memorandum of Understanding, participates in the state's Joint Review Process with the Department of Natural Resources, provides technical assistance to the Division Engineers' offices on dam safety, and performs other related work as assigned.

Goals and Objectives of the Program

The program concentrates on "jurisdictional" dams and reservoirs as defined in Section 37-87-105, C.R.S. (1998 Supp.), which are greater than ten feet high at the spillway; or twenty acres in surface area, or 100 acre-feet in capacity at the high water line. Particular focus is placed on

inspecting Class 1 (High Hazard) dams annually, Class 2 (Significant Hazard) dams every two years, and Class 3 (Low Hazard) dams are inspected at least every six years. Because of their non-hazardous location, Class 4 (No Hazard) dams are not inspected regularly, but observed for changes in hazard class periodically. See SAFETY INSPECTIONS AND CONSTRUCTION OBSERVATIONS, page 8 for more information.

The Dam Safety Branch identified the following goals and objectives for the Dam Safety Program for calendar years 1997 and 1998.

1. **In order to protect the public safety, the Dam Safety Branch shall determine the amount of water which is safe to impound in the several reservoirs in the state.** All of the objectives were accomplished. See page 9 for more details on the number of inspections conducted.

2. **In order to protect the public from the failure of dams, the Dam Safety Branch shall review and recommend approval of plans and specifications for the construction, modification, and repairs of dams, in accordance with the Regulations for Dam Safety and Dam Construction, September 30, 1988.** All of the objectives for this goal were also accomplished, including the Design Review Unit completing the review of plans and specifications within the 180-day limit. See page 7 for more details on the number of plans reviewed and approved.

3. **In order to improve the public safety from the failures of dams, the Dam Safety Branch shall implement the Rules and Regulations for Dam Safety and Dam Construction in a reasonable time.** A long term program for implementing some of the regulations was begun in 1991 in accordance with Goal 3. For example:

   A five-year plan was implemented for evaluating the adequacy of existing spillways beginning in 1992. All of the Class 1 dams below 7500 feet have been reviewed. The dams above 7500 feet have been postponed pending completion of an extreme precipitation study. See page 9 for more details. Class 2 dams are being reviewed as the Dam Safety Engineers have time to do them. The dam owners are notified if their spillways are deficient, and are given a reasonable time to upgrade them.

   A ten-year program was begun on 1989 to accomplish the internal inspection of outlet works. It is expected that all Class 1 and 2 dams will be inspected by 2000. Each Dam Safety Engineer has developed workplans to accomplish them.

   We have made some progress in enforcing owners requirements. These problems are related to owners responsibilities under Rule 15, and Emergency Preparedness Planning under Rule 16. However, due to the emphasis placed on site inspections by the Dam Safety Engineers and related tasks, the need to respond to unexpected developments, and limited enforcement options, the enforcement of the owners requirements has been limited.

4. **To improve the communications of the Dam Safety Branch, the Principal Engineer of the branch and the Division Engineers shall coordinate their activities closely.** Communications are maintained through the use of e-mail and sending monthly activity reports to the Divisions. The Assistant State Engineer, Jack Byers, schedules frequent meetings with the Division Engineer's offices and annual meetings with the branch.

5. **In order to improve the functions of the Branch, and to meet the public information needs, the Dam Safety Branch shall maintain a data information system.** The maintenance of the DAMS database has been very successful. See page 10 for more information about this and the NATDAM program.

6. **In order to improve the technical proficiency of the Branch, the Division of Water Resources shall provide training and professional development of the personnel.** Two technical training sessions on BOSS RiverCad and Probable Maximum Hydrology were provided during the Spring of 1998. In addition, a portion of the Division's training budget is dedicated to paying for training of one Dam Safety Engineer each year. Dam Safety Engineer Sally Lewis attended the ASDSO Dam Safety Conference in Pittsburgh, PA in September. Administrative leave is also provided for continuing education and participation on task groups and committees.

7. **In order to improve our dam safety program, and to participate in the development of national policies on dam safety, and to take advantage of the continuing education and information available, the State shall be a full voting member of the Association of State Dam Safety Officials (ASDSO).** Under Goal 7, the Principal Engineer of the branch is the designated state representative to ASDSO. He has served on task groups, committees, and the Board of Directors, and is an officer. All of the personnel in the Branch have had an opportunity to attend ASDSO conferences and technical seminars over the years. Their Associate Member dues are paid for from operating funds.

Safety of Federal Dams

Safety evaluations have been made of U.S. Bureau of Reclamation and U.S. Army Corps of Engineers dams on a cooperative basis with their safety inspections being done in accordance with the "Federal Guidelines for Dam Safety". The Branch participated in the evaluation of the safety of two Reclamation dams; The Horsetooth Dam near Fort Collins, and the Pueblo Dam near Pueblo. The Horsetooth dam is experiencing increased leakage, and the Pueblo Dam was determined to be unstable during a comprehensive analysis of its design and construction under Reclamation's Safety of Dams Program. Dam safety personnel participated in meetings with Reclamation, and copies of the investigation reports, modification decision analysis, and consulting reports were furnished to us. Arrangements are made with other federal agencies for

the safety inspection of their dams by the U.S. Bureau of Reclamation, the Corps of Engineers, their own people, or by consulting engineers. When other than State Engineer's Office personnel conduct the safety inspections, the agency submits the findings/recommendations and follow-up reports to the State Engineer. A Memorandum of Understanding has been executed with the U.S. Bureau of Reclamation relating to dam safety activities in Colorado. It provides for the exchange of safety related information of dams under each agency's jurisdiction. An MOU has also been executed with the U.S. Forest Service, Rocky Mountain Region, to provide coordination of our mutual responsibilities for dam safety. In addition, an agreement has been made with the Federal Energy Regulatory Commission, FERC, on coordinating activities and exchange of information on inspections and design review at licensed dams. The audit of the program however, has recommended that we stop making routine inspections of federal dams.

Tables of Jurisdictional Dams

See page 13 for a table showing the distribution of dams by ownership. Table 1 shows the ownership of jurisdictional dams in division by hazard class and type of owner.

APPROVAL OF PLANS AND SPECIFICATIONS FOR CONSTRUCTION OF DAMS AND RESERVOIRS

During FY 97-98, the State Engineer's Office received plans for two new dams, and fifteen plans for alteration, modification, repair, or enlargement. Four separate hydrology studies were also submitted for determination of the inflow design flood for spillway design. The estimated cost of construction for the submitted plans was $2,069,634.00. Nine thousand six hundred and seventy two dollars ($9,672.00) was collected for the examination and filing of the submitted plans.

Twenty-three sets of plans and specifications for construction, and seven hydrology studies were approved by the State Engineer during FY 97-98. In addition, three special plans were approved, two for monitoring plans, and one an alteration to a non-jurisdictional dam. (See Appendix B for lists of dams which were approved.) In order to expedite the approval of repair plans for dams, the Dam Safety Engineers may review them and perform the construction inspections. This enables the owners to repair their dams sooner by shortening the review time.

Upon completion of construction, the owner's engineer submits copies of the "AS-CONSTRUCTED" plans showing any changes made during construction. These plans are reviewed by the engineer who monitored the construction for completeness before being accepted for filing. The superseded plans are disposed of and the "AS-CONSTRUCTED" plans serve as the public record as required by the statutes.

Section 37-87-114.5., C.R.S., (1998 Supp.) exempts certain structures from the State Engineer's approval. They are, structures not designed or operated for the purpose of storing water, mill tailing impoundments permitted under Article 32 or Article 33 of Title 34, C.R.S. (Minerals or Coal Mines), uranium mill tailing and liquid impoundment structures permitted under Article 11 of Title 25, C.R.S., siltation structures permitted under Article 33 of Title 34, C.R.S. (Coal Mines), and structures which only store water below the natural surface of the ground.

In order to prevent administrative problems as a result of the construction of small dams which do not fall under the jurisdiction of the State Engineer's review and approval, Section 37-87-125, C.R.S. (1998 Supp.) requires that a Notice of Intent to Construct a Nonjurisdictional Water Impoundment Structure must be submitted to the State Engineer prior to beginning construction.

SAFETY INSPECTIONS AND CONSTRUCTION OBSERVATIONS

Scope

The statutes specify that a safety inspection include the review of previous inspection reports and drawings, site inspection of the dam, spillways, outlet facilities, seepage control and measurement system, and permanent monument or monitoring installations. Construction inspections also need to be maintained at a high level. Construction inspections are important because we must assure that the approved plans are being followed and to assure changed conditions during construction does not jeopardize the safety of the design. The site visit is preceded by a review of the file and history of performance, coordination with the owner, division staff, and other interested parties so they may take part in the inspection.

The safety inspection must also include an evaluation of the adequacy of the spillway to pass the appropriate sized flood for the dam's size and hazard class, to make an evaluation of the dam's hazard classification and whether it has changed, and to assess the adequacy of the Emergency Preparedness Plan for the dam. The internal inspection of the outlet works and evaluation of instrumentation has also been added to the workload as required by the regulations. The hydrologic evaluation of spillways has been postponed above 7500 foot elevation, pending the completion of a study of extreme precipitation by the State Engineer and the Water Conservation Board.

The findings of the inspection are documented on a report form which rates the conditions observed of the several components of the dam and reservoir. The overall conditions are rated as satisfactory, conditionally satisfactory, or unsatisfactory (unsafe) for full storage, and a recommendation is made for the safe storage level by the Dam Safety Engineer. An order is prepared for the State Engineer's signature, restricting storage in the reservoir until the problem is fixed. The report also identifies the several repair and maintenance items which the owner should take care of, and any engineering and monitoring requirements necessary to assure the safety of the dam. A copy of the ENGINEERS INSPECTION REPORT is in Appendix D.

Procedures have been implemented to begin reporting incidents, and the findings of safety inspections where orders have been issued to make modifications for safety reasons, to the Center for the Performance of Dams at Stanford University, Palo Alto, California. This is a new national program that has been developed by the Association of State Dam Safety Officials and the Federal Emergency Management Agency for accumulating data for the improvement of design and safety evaluations of dams nationwide. Dam incident reports were submitted for eleven (11) dams during the period.

Orders to repair or maintain the dam usually require the reinspection of the dam in order to verify that the work has been done in a workmanlike manner. Re-inspections also occur to assure follow-up of the State Engineer's orders or as requested by the owner. If the safety inspection finds that the overall conditions are unsafe, an order is written by the State Engineer restricting the storage in the reservoir to a safe storage level. If the findings are conditionally satisfactory, full storage is recommended contingent upon appropriate monitoring being provided by the owner. Restriction letters are accompanied by orders to rehabilitate the dam to make it safe for full storage or to breach the dam. In the event the owner fails to comply with an order to make the dam safe, a breach order is issued to remove the hazard created by the dam and reservoir.

Scheduling

The Dam Safety Engineers collectively conduct about 700 to 800 safety inspections each year. Jurisdictional dams identified for inspection in accordance with the policies of the State Engineer are assigned to the Dam Safety Engineers in each Division. The number of inspections required to be scheduled is related to the number of dams in each division and their hazard class. Included in these numbers has been the annual inspection of all Class 1 dams, one-half of the Class 2 hazard dams, and about one-sixth of the Class 3 hazard dams. Inspection of federal dams are integrated with these schedules. Subsequent follow-up and problem solving results in additional inspections each year.

In order to track potential problems which could develop at Class 3 dams, the Dam Safety Engineers assign dams to be observed to the Division's Water Commissioners, and they file a report. The report is reviewed, and then furnished to the owner for their information, and to implement any recommendations for repair and maintenance. A copy of the WATER COMMISSIONER DAM OBSERVATION REPORT form is in Appendix C.

Number of Inspections

During FY 97-98, a total of 648 safety inspections and 56 construction inspections were conducted for a total of 704. In addition, 113 follow-up inspections were made. The safety inspections included 255 Class 1 (High) hazard dams, 192 Class 2 (Significant) hazard dams, 192 Class 3 (Low) hazard dams, and nine inspections of Class 4 (No Hazard) dams (includes Federal dams which are inspected at 3 year intervals and which we participated.) For inspections of federally owned dams in which we don't participate, we receive and review their reports and findings. The objective of inspecting all High hazard dams on an annual basis, Significant hazard on a bi-annual basis, and Low hazard dams on a six-year basis is an inspection year objective versus a fiscal year objective. This objective was attained for 1997 with the assistance of engineers in some of the Divisions, and is expected to be achieved for 1998.

DAM SAFETY PROJECTS

Extreme Precipitation Study

The State Engineer and the Colorado Water Conservation Board (CWCB) continued the process during the period to study extreme precipitation in the mountainous areas of Colorado. See Proposal for Evaluating Extreme Precipitation for the Mountainous Areas of Colorado in Appendix E. A volunteer committee of meteorologists, hydrologists, engineers, federal and state agencies, and private entities prepared the proposal. The Department of Atmospheric Science, CSU (State Climatologist) was engaged for doing Phase I of the study, which is the collection and verification of data. A workshop was held to provide a forum for professionals in the field to determine which modeling technology should be used during Phase II of the plan. The Phase I report was completed in May 1997, and it contains a list of recommended extreme storms that will be used for modeling research, and can be used for site specific analysis of extreme events for project studies. The Colorado Water Conservation Board, CWCB, approved $300,000 for doing the Phase II study. They also approved the use of $100,000 for updating the 100-year frequency atlas for Colorado. The National Weather Service, NOAA, will be requested to update the atlas. The request for proposals for the Phase II study will be solicited in September 1998.

Emergency Preparedness Plans

Emergency preparedness for incidents at dams that jeopardize the public safety, including the failure of dams, has become an integral part of dam safety programs. All the federal dam owning/regulating agencies, and most states require that plans be formulated in order to detect incidents at dams, give adequate warning, and maintain preparedness, for the eventual failure or misoperation of dams. Colorado has been actively involved in this area since 1981, ultimately requiring that Emergency Preparedness Plans, EPPs, be prepared for High and Significant hazard dams as part of the regulations for dam safety adopted in September 1988. As a result of increased effort, at the end of the period of this report, June 30, 1997, emergency plans have been prepared for 98% of the High Hazard dams of record statewide. Much work is still needed however, to update, maintain, and exercise the plans annually.

The Dam Safety Engineers in the Divisions continue to assist dam owners in the preparation of their EPPs. Approximately 92 percent of the Significant hazard dams have plans on file. The others who do not have a plan, have been notified of the requirement to prepare them. This will continue to be enforced during the following year of inspections.

Dam Safety Database Management System

The dams database (DAMS) is maintained on a personal computer system (PC) using dBASE IV as the data management program. While the main database is kept on a PC in Denver, the several dam safety engineers maintain the data for their Divisions on their PCs. The main database in Denver is updated from the several Divisions on a periodic basis. The Dam Safety Branch's capability to maintain the database was enhanced by the receipt of computer hardware for the Denver office and the Division offices, from the Association of State Dam Safety Officials (ASDSO), for our participation in the US Army Corps of Engineers National Inventory of Dams

Program (NATDAM). The addition of e-mail and Internet Services has improved our ability to maintain and share our databases materially. The Y2K problem is being addressed by the Division's Information Services Branch to assure we maintain our databases into the next millenium. All of the computers in the Division of Water Resources are Y2K compliant. The databases will be on Hydrobase by March 1999, which will be compliant.

Publications

As a service to dam owners, the Dam Safety Branch makes available, at no charge, a brochure on the construction and operation of dams in Colorado (June, 1994). It contains general information on requirements for approval of plans, water rights, financing, liability, insurance, Emergency Preparedness Plans, statutes, publications, and Division Engineer and Water Court addresses. A "Dam Safety Manual" is also available at a reasonable cost that instructs dam owners on the safety inspection of their dams. Guidelines for preparing EPPs and a Project Review Guide for submitting plans for approval also are provided at no cost.

ASSOCIATION OF STATE DAM SAFETY OFFICIALS

All of the engineers in the Dam Safety Branch are members of the Association of State Dam Safety Officials (ASDSO) and actively participate in its programs. The purpose of ASDSO is to provide a forum for the exchange of ideas and experiences on dam safety issues, foster interstate cooperation, provide information and assistance to dam safety programs, provide representation of state interests before Congress and Federal agencies for dam safety, and to improve efficiency and effectiveness of state dam safety programs. Alan Pearson, Principal Engineer of the Dam Safety Branch is a member of the Board of Directors, and is serving as Past - President of the Association. Alan also is a member of the Peer Review Committee. The Peer Review Program provides member states with an opportunity to have their dam safety programs reviewed to see if they are accomplishing their objectives, and to receive recommendations for improving their programs.

The branch executed an MOA with the Association for updating the National Inventory of Dams for 1998. We will be receiving $1700.00 for fiscal year 1998/99 upon completion of the update. The funds will be used for training and covering the costs to participate in planning for future updates with the US Army Corps of Engineers.

USE OF APPROPRIATED FUNDS

Dam safety personal service expenditures for the FY 97-98 were $865,179.00. Total operating and travel expenditures were approximately $25,000.00. Whenever possible, the members of the Dam Safety Branch are provided training to keep them up to date on current technology and methods being used by professionals in the area of dam safety. During the period, two special training seminars were provided to the branch; one on the BOSS RiverCad program (including acquisition of the software) and the other on Probable Maximum Hydrologic analysis. The total cost for this training was $8000.00.

Several members of the Branch also attended conferences and meetings of the Association of State Dam Safety Officials, participated in University courses on hydrology, and computer related courses. Funds for these are partially provided from a training fund made up of 2 percent of each Sections/Divisions operating budget, and managed by a training officer and committee. $ 8,300.00 was expended from this fund for training of personnel in the branch for FY 1998 (included about $4000.00 of the above). Training is also paid for with operating funds from the Division Engineer's and the Dam Safety Branch's budgets when available.

RECEIPTS GENERATED FOR COSTS OF FILING PLANS

Fees collected by the State Engineer and deposited in the General Fund for dam safety amounted to $9,672.00 for filing plans and specifications during the period.

ENFORCEMENT ORDERS AND PROCEEDINGS

No enforcement orders were issued during the period.

LEGISLATION

No legislation affecting dam safety was enacted during the period.

TABLE 1

DISTRIBUTION OF DAMS BY IRRIGATION DIVISION/CLASS

HAZARD RATING	DIVISION	NONFEDERAL	FEDERAL	TOTAL
Class 1	1	118	14	132
Class 2	1	132	9	141
Class 3	1	418	11	429
Class 4	1	32	9	41
Class 1	2	35	6	41
Class 2	2	50	3	53
Class 3	2	115	12	127
Class 4	2	95	4	99
Class 1	3	9	1	10
Class 2	3	14	0	14
Class 3	3	28	4	32
Class 4	3	15	0	15
Class 1	4	28	10	38
Class 2	4	37	0	37
Class 3	4	145	8	153
Class 4	4	4	3	7
Class 1	5	23	16	39
Class 2	5	41	1	42
Class 3	5	112	15	127
Class 4	5	13	0	13
Class 1	6	12	0	12
Class 2	6	13	0	13
Class 3	6	106	9	115
Class 4	6	9	0	9
Class 1	7	10	4	14
Class 2	7	20	1	21
Class 3	7	38	1	39
Class 4	7	5	0	5
TOTALS		**1677**	**141**	**1818**

Class 1 - Loss of human life is expected in the event of failure of the dam, while the reservoir is at the high water line.

Class 2 - Significant damage to improved property is expected in the event of failure of the dam while the reservoir is at the high water line, but no loss of life is expected.

Class 3 - Loss of human life is not expected, and damage to improved property is expected to be small in the event of failure of the dam while the reservoir is at the high water line.

Class 4 - Loss of human life is not expected, and damage will occur only to the dam owner's property in the event of failure of the dam while the reservoir is at the high water line.

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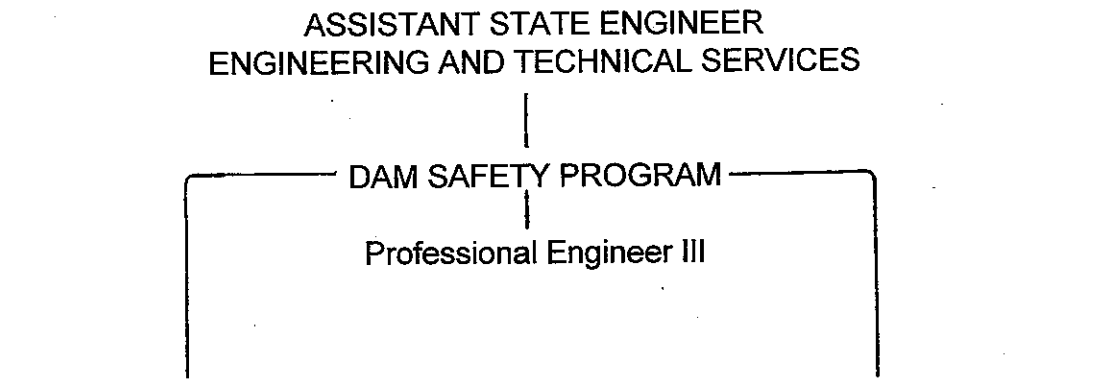
APPENDIX A

DAM SAFETY BRANCH



DIVISION ENGINEERS OFFICES

DIVISION 1
4 - Professional Engineer II

DIVISION 2
2 - Professional Engineer II

DIVISION 3-7
Professional Engineer II

DIVISION 4
Professional Engineer II

DIVISION 5
Professional Engineer II

DIVISION 6
Professional Engineer II

DESIGN REVIEW AND CONSTRUCTION INSPECTION UNIT

1 - Professional Engineer II

APPENDIX A

PERSONNEL
DAM SAFETY BRANCH

TITLE	NAME	AREA OF RESPONSIBILITY
	Denver Office	
Professional Engineer III	Alan Pearson	Principal Engineer, Dam Safety Program
Professional Engineer II	Mark Haynes	Design Review/Const. Inspection
	Resident, Division Offices	
Professional Engineer II	Dennis Miller	Dam Safety Engineer, Division 1
Professional Engineer II	Michael Cola	Dam Safety Engineer, Division 1
Professional Engineer II	James Dubler	Dam Safety Engineer, Division 1
Professional Engineer II	Gregory Hammer	Dam Safety Engineer, Division 1
Professional Engineer II	Michael Graber	Dam Safety Engineer, Division 2
Professional Engineer II	Garrett Jackson	Dam Safety Engineer, Division 2[1]
Professional Engineer II	Frank Kugel	Dam Safety Engineer, Divs. 3&7
Professional Engineer II	James Norfleet	Dam Safety Engineer, Division 4
Professional Engineer II	John Blair	Dam Safety Engineer, Division 5
Professional Engineer II	Sally Lewis	Dam Safety Engineer, Division 6[2]

appA98.per

[1] One-half time Field Engineer, one-half time Design Review Engineer
[2] One-half time Field Engineer, one-half time Asst. Division Engineer

APPENDIX B

APPROVED PLANS AND SPECIFICATIONS FOR ALTERATIONS
ENLARGEMENTS, OR REPAIRS OF EXISTING DAMS

NAME	DAMID	C-NO(1)	DATE	USE
WOODLAND PARK	080416	C-1121A	08/07/97	WATER SUPPLY
MASON	120106	C-0234A	08/25/97	WATER SUPPLY
LEFT HAND VALLEY	050210	C-0635A	08/25/97	IRRIGATION
UTE CREEK	510131	C-1438B	08/25/97	INDUSTRY
D.O.E. ROCKY FLATS B-5	025626	C-1545B	08/25/97	FLOOD CONTROL
ROLLING HILLS NO.18	070315	C-1768A	08/25/97	RECREATION
HARRIS BROTHERS AND BOONE #2	290103	C-0478A	10/15/97	IRRIGATION
MAGIC MOUNTAIN #1	070214	C-0861B	11/13/97	INDUSTRY
HORSESHOE LAKE	160112	C-0997A	11/24/97	WATER SUPPLY
PAWNEE POND NO.1	010705	C-1548A	12/03/97	INDUSTRY
BIG BEAVER	430103	C-1122C	01/07/98	RECREATION
STANDLEY LAKE	020326	C-1070G	02/02/98	IRRIGATION
MEADOW CREEK	510118	Letter	03/04/98	WATER SUPPLY
EAST LAKE #3	020124	Letter	03/04/98	IRRIGATION
PASTORIUS	300126	C-1454A	04/02/98	IRRIGATION
CLEAR LAKE	070117	C-0820C	04/29/98	UTILITY
CARMODY	090110	Letter	05/13/98	RECREATION
EAGLE PARK RESERVOIR	370103	C-1106D	06/26/98	INDUSTRY

[1] Filing system for approved plans (C-1471D). Letter at end of number denotes revision/additions to previously approved plans.

APPROVED PLANS AND SPECIFICATIONS FOR NEW DAMS
OR OLD DAMS NOT PREVIOUSLY APPROVED

NAME	DAMID	C-NO(2)	DATE	USE
TWIN LAKE NO. 1	400526	C-1767	07/24/97	IRRIGATION
ROLLING HILLS NO.18	070315	C-1768	08/25/97	RECREATION
WADLEY NO. 2	020338	C-1769	09/03/97	IRRIGATION
CHENEY	420112	C-1770	10/15/97	IRRIGATION
ROOTS	72____	C-1764	11/04/97	RECREATION
PRIEST	600127	C-1774	12/03/97	AUGMENTATION
THOMAS	380138	C-1776	03/26/98	IRRIGATION
TWIN LAKES	030314	C-1777	06/03/98	WATER SUPPLY

[2] Filing system for approved plans (C-1760). Assigned to plans for new dams and alterations repairs to existing dams that weren't previously approved.

APPENDIX C

WATER COMMISSIONER • DAM OBSERVATION REPORT • OFFICE OF THE STATE ENGINEER

M NAME_____ W. DIV.____ W. DIST.____ DATE OF INSPECTION__/__/__

M ID_____ FILE NO. C-_____ FOREST I.D._____ DATE OF LAST INSPECTION__/__/__

VNER NAME_____ OWNER PHONE_____

DDRESS_____ ZIP CODE_____

NTACT NAME_____ CONTACT PHONE_____

ASS____ CAPACITY____AF SURFACE AREA____AC. HEIGHT____FT. CREST LENGTH____FT CREST WIDTH____FT.

RRENT RESTRICTION ☐ (NO) ☐ (YES) LEVEL____ EPP ON FILE ☐ (NO) ☐ (YES) SPWY WIDTH____FT. FBD.____FT. Z____

ELD ONDITIONS BSERVED

WATER LEVEL: BELOW DAM CREST____FT., BELOW SPILLWAY____FT., GAGE ROD READING____

GROUND MOISTURE CONDITION: DRY____ WET____ SNOWCOVER____ OTHER____

DIRECTIONS: MARK AN X FOR CONDITIONS FOUND AND UNDERLINE WORDS THAT APPLY.

	Conditions Observed			
	GOOD	ACCEPTABLE	POOR	
PROBLEMS NOTED: ☐ (0) NONE ☐ (1) RIPRAP - MISSING, SPARSE, DISPLACED, WEATHERED ☐ (2) WAVE EROSION-WITH SCARPS ☐ (3) CRACKS-WITH DISPLACEMENT ☐ (4) SINKHOLE ☐ (5) APPEARS TOO STEEP ☐ (6) DEPRESSIONS OR BULGES ☐ (7) SLIDES ☐ (8) CONCRETE FACING-HOLES, CRACKS, DISPLACED, UNDERMINED ☐ (9) OTHER____				UPSTREAM SLOPE
PROBLEMS NOTED: ☐ (10) NONE ☐ (11) RUTS OR PUDDLES ☐ (12) EROSION ☐ (13) CRACKS - WITH DISPLACEMENT ☐ (14) SINKHOLES ☐ (15) NOT WIDE ENOUGH ☐ (16) LOW AREA ☐ (17) MISALIGNMENT ☐ (18) IMPROPER SURFACE DRAINAGE ☐ (19) OTHER____				CREST
PROBLEMS NOTED: ☐ (20) NONE ☐ (21) LIVESTOCK DAMAGE ☐ (22) EROSION OR GULLIES ☐ (23) CRACKS - WITH DISPLACEMENT ☐ (24) SINKHOLE ☐ (25) APPEARS TOO STEEP ☐ (26) DEPRESSION OR BULGES ☐ (27) SLIDE ☐ (28) SOFT AREAS ☐ (29) OTHER____				DOWNSTREAM SLOPE
PROBLEMS NOTED: ☐ (30) NONE ☐ (31) SATURATED EMBANKMENT AREA ☐ (32) SEEPAGE EXITS ON EMBANKMENT ☐ (33) SEEPAGE EXITS AT POINT SOURCE ☐ (34) SEEPAGE AREA AT TOE ☐ (35) FLOW ADJACENT TO OUTLET ☐ (36) SEEPAGE INCREASED/MUDDY **DRAIN OUTFALLS SEEN** __No __Yes ☐ (37) FLOW INCREASED/MUDDY ☐ (38) DRAIN DRY/OBSTRUCTED ☐ (39) OTHER____				SEEPAGE
PROBLEMS NOTED: ☐ (40) NONE ☐ (41) NO OUTLET FOUND ☐ (42) POOR OPERATING ACCESS ☐ (43) INOPERABLE ☐ (44)UPSTREAM OR DOWNSTREAM STRUCTURE DETERIORATED ☐ (45) OUTLET NOT OPERATED DURING INSPECTION **INTERIOR INSPECTED** ☐ (120) NO ☐ (121) YES ☐ (46) CONDUIT DETERIORATED OR COLLAPSED ☐ (47) JOINTS DISPLACED ☐ (48) VALVE LEAKAGE ☐ (49) OTHER____				OUTLET
PROBLEMS NOTED: ☐ (50) NONE ☐ (51) NO EMERGENCY SPILLWAY FOUND ☐ (52) EROSION-WITH BACKCUTTING ☐ (53) CRACK - WITH DISPLACEMENT ☐ (54) APPEARS TO BE STRUCTURALLY INADEQUATE ☐ (55) APPEARS TOO SMALL ☐ (56) INADEQUATE FREEBOARD ☐ (57) FLOW OBSTRUCTED ☐ (58) CONCRETE DETERIORATED/UNDERMINED ☐ (59) OTHER____				SPILLWAY
PROBLEMS NOTED: ☐ (60) NONE ☐ (61) ACCESS ROAD NEEDS MAINTENANCE ☐ (62) CATTLE DAMAGE ☐ (63) BRUSH ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☐ (64) TREES ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☐ (65) RODENT ACTIVITY ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☐ (66) DETERIORATED CONCRETE-FACING, OUTLET, SPILLWAY ☐ (67) GATE AND OPERATING MECHANISM NEED MAINTENANCE ☐ (68) OTHER____				MAINTENANCE

See Guidelines on Back of this Sheet

DIRECTIONS: ENTER PROBLEM NUMBER ( ) THEN LOCATION DIMENSIONS, DEGREE, ETC.

LOCATION OF PROBLEMS & COMMENTS:____

MAINTENANCE – MINOR REPAIR – MONITORING — ACTION REQUIRED OF OWNER TO IMPROVE THE SAFETY OF THE DAM.

- ☐ (80) PROVIDE ADDITIONAL RIPRAP:____
- ☐ (81) LUBRICATE AND OPERATE OUTLET GATES THROUGH FULL CYCLE:____
- ☐ (82) CLEAR TREES AND/OR BRUSH FROM:____
- ☐ (83) INITIATE RODENT CONTROL PROGRAM AND PROPERLY BACKFILL EXISTING HOLES:____
- ☐ (84) GRADE CREST TO A UNIFORM ELEVATION WITH DRAINAGE TO THE UPSTREAM SLOPE:____
- ☐ (85) PROVIDE SURFACE DRAINAGE FOR:____
- ☐ (86) MONITOR:____
- ☐ (88) OTHER:____
- ☐ (89) OTHER:____

DAM REQUIRES INSPECTION BY A FIELD ENGINEER ☐ ☐ **FIELD DIMENSIONS SHOWN ON BACK**

OBSERVATION BY WATER COMMISSIONER **DATE**

6 JTS

APPENDIX D

ENGINEERS INSPECTION REPORT

OFFICE OF THE STATE ENGINEER-DIVISION OF WATER RESOURCES - DAM SAFETY BRANCH
1313 Sherman Street, Room 818, Denver, CO 80203, (303) 866-3581

DAM NAME _____ W. DIV. _____ W. DIST. _____ DATE OF INSPECTION ___/___/___

DAM ID _____ FILE NO. C- _____ FOREST I.D. _____ DATE OF LAST INSPECTION ___/___/___

OWNER NAME _____ OWNER PHONE _____

ADDRESS _____ ZIP CODE _____

CONTACT NAME _____ CONTACT PHONE _____

CLASS _____ CAPACITY _____ AF SURFACE AREA _____ AC. HEIGHT _____ FT. CREST LENGTH _____ FT CREST WIDTH _____ FT.

CURRENT RESTRICTION ☐ (NO) ☐ (YES) LEVEL _____ EPP ON FILE ☐ (NO) ☐ (YES) SPWY WIDTH _____ FT. FBD. _____ FT. Z _____

INSPECTION PARTY REPRESENTING _____ _____ _____

DIRECTIONS: MARK AN X FOR CONDITIONS FOUND **AND** UNDERLINE WORDS THAT APPLY. GIVE LOCATION AND EXTENT WITH NUMBER REFERENCE I.E. (25) ALL ALONG SLOPE, OR SHOW IT ON SKETCH.

FIELD CONDITIONS OBSERVED

WATER LEVEL - BELOW DAM CREST _____ FT., BELOW SPILLWAY _____ FT., GAGE ROD _____

GROUND MOISTURE CONDITION: DRY _____ WET _____ SNOWCOVER _____ OTHER _____

Conditions Observed	GOOD	ACCEPTABLE	POOR

UPSTREAM SLOPE

PROBLEMS NOTED: ☐ (0) NONE ☐ (1) RIPRAP - MISSING, SPARSE, DISPLACED, WEATHERED ☐ (2) WAVE EROSION-WITH SCARPS
☐ (3) CRACKS-WITH DISPLACEMENT ☐ (4) SINKHOLE ☐ (5) APPEARS TOO STEEP ☐ (6) DEPRESSIONS OR BULGES ☐ (7) SLIDES
☐ (8) CONCRETE FACING-HOLES, CRACKS, DISPLACED, UNDERMINED ☐ (9) OTHER _____
Comments: _____

CREST

PROBLEMS NOTED: ☐ (10) NONE ☐ (11) RUTS OR PUDDLES ☐ (12) EROSION ☐ (13) CRACKS - WITH DISPLACEMENT ☐ (14) SINKHOLES
☐ (15) NOT WIDE ENOUGH ☐ (16) LOW AREA ☐ (17) MISALIGNMENT ☐ (18) INADEQUATE SURFACE DRAINAGE
☐ (19) OTHER _____
Comments: _____

DOWNSTREAM SLOPE

PROBLEMS NOTED: ☐ (20) NONE ☐ (21) LIVESTOCK DAMAGE ☐ (22) EROSION OR GULLIES ☐ (23) CRACKS - WITH DISPLACEMENT ☐ (24) SINKHOLE
☐ (25) APPEARS TOO STEEP ☐ (26) DEPRESSION OR BULGES ☐ (27) SLIDE ☐ (28) SOFT AREAS ☐ (29) OTHER _____
Comments: _____

SEEPAGE

PROBLEMS NOTED: ☐ (30) NONE ☐ (31) SATURATED EMBANKMENT AREA ☐ (32) SEEPAGE EXITS ON EMBANKMENT
☐ (33) SEEPAGE EXITS AT POINT SOURCE ☐ (34) SEEPAGE AREA AT TOE ☐ (35) FLOW ADJACENT TO OUTLET ☐ (36) SEEPAGE INCREASED/MUDDY
DRAIN OUTFALLS SEEN ___No ___Yes ☐ (37) FLOW INCREASED/MUDDY ☐ (38) DRAIN DRY/OBSTRUCTED
☐ (39) OTHER _____ Show location of drains on sketch and indicate amount and quality of discharge.
Comments: _____

OUTLET

PROBLEMS NOTED: ☐ (40) NONE ☐ (41) NO OUTLET FOUND ☐ (42) POOR OPERATING ACCESS ☐ (43) INOPERABLE
☐ (44)UPSTREAM OR DOWNSTREAM STRUCTURE DETERIORATED ☐ (45) OUTLET NOT OPERATED DURING INSPECTION
INTERIOR INSPECTED ☐ (120) NO ☐ (121) YES ☐ (46) CONDUIT DETERIORATED OR COLLAPSED ☐ (47) JOINTS DISPLACED ☐ (48) VALVE LEAKAGE
☐ (49) OTHER _____
Comments: _____

SPILLWAY

PROBLEMS NOTED: ☐ (50) NONE ☐ (51) NO EMERGENCY SPILLWAY FOUND ☐ (52) EROSION-WITH BACKCUTTING ☐ (53) CRACK - WITH DISPLACEMENT
☐ (54) APPEARS TO BE STRUCTURALLY INADEQUATE ☐ (55) APPEARS TOO SMALL ☐ (56) INADEQUATE FREEBOARD ☐ (57) FLOW OBSTRUCTED
☐ (58) CONCRETE DETERIORATED/UNDERMINED ☐ (59) OTHER _____
Comments: _____

See Guidelines on Back of this Sheet

DC185a-85

GUIDELINES FOR DETERMINING CONDITIONS

CONDITIONS OBSERVED - APPLIES TO UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, OUTLET, SPILLWAY

GOOD	ACCEPTABLE	POOR
In general, this part of the structure has a near new appearance, and conditions observed in this area do not appear to threaten the safety of the dam.	Although general cross-section is maintained, surfaces may be irregular, eroded, rutted, spalled; or otherwise not in new condition. Conditions in this area do not currently appear to threaten the safety of the dam.	Conditions observed in this area appear to threaten the safety of the dam.

CONDITIONS OBSERVED - APPLIES TO SEEPAGE

GOOD	ACCEPTABLE	POOR
No evidence of uncontrolled seepage. No unexplained increase in flows from designed drains. All seepage is clear. Seepage conditions do not appear to threaten the safety of the dam.	Some seepage exists at areas other than the drain outfalls, or other designed drains. No unexplained increase in seepage. All seepage is clear. Seepage conditions observed do not currently appear to threaten the safety of the dam.	Seepage conditions observed appear to threaten the safety of the dam. Examples: 1) Designed drain or seepage flows have increased without increase in reservoir level. 2) Drain or seepage flows contain sediment, i.e., muddy water or particles in jar samples. 3) Widespread seepage, concentrated seepage or ponding appears to threaten the safet of the dam.

CONDITIONS OBSERVED - APPLIES TO MONITORING

GOOD	ACCEPTABLE	POOR
Monitoring includes movement surveys and leakage measurements for all dams, and piezometer readings for Class I dams. Instrumentation is in reliable, working condition. A plan for monitoring the instrumentation and analyzing results by the owner's **engineer** is in effect. Periodic inspections by owner's engineer.	Monitoring includes movement surveys and leakage measurements for Class I & II dams; leakage measurements for Class III dams. Instrumentation is in serviceable condition. A plan for monitoring instrumentation is in effect by **owner**. Periodic inspections by owner or representative. OR, NO MONITORING REQUIRED.	All instrumentation and monitoring described under "ACCEPTABLE" here for each class of dam, are not provided, or required periodic readings are not being made, or unexplained changes in readings are not reacted to by th owner.

CONDITIONS OBSERVED - APPLIES TO MAINTENANCE AND REPAIR

GOOD	ACCEPTABLE	POOR
Dam appears to receive effective on-going maintenance and repair, and only a few minor items may need to be addressed.	Dam appears to receive maintenance, but some maintenance items need to be addressed. No major repairs are required.	Dam does not appear to receive adequate maintenance. One or more items needing maintenance or repair has begun to threaten the safety of the dam.

OVERALL CONDITIONS

SATISFACTORY	CONDITIONALLY SATISFACTORY	UNSATISFACTORY
The safety inspection indicates no conditions that appear to threaten the safety of the dam, and the dam is expected to perform satisfactorily under all design loading conditions. Most of the required monitoring is being performed.	The safety inspection indicates symptoms of *possible* structural distress (seepage, evidence of minor displacements, etc.), which, if conditions worsen, *could* lead to the failure of the dam. Essential monitoring, inspection, and maintenance must be performed as a requirement for continued full or reduced storage in the reservoir.	The safety inspection indicates *definite* signs of structural distress (excessive seepage, cracks, slides, sinkholes, severe deterioration etc.), which *could* lead to the failure of the dam if the reservoir is used to full capacity. The dam is judged unsafe for full storage of water.

SAFE STORAGE LEVEL

FULL STORAGE	CONDITIONAL FULL STORAGE	RESTRICTION
Dam may be used to full capacity with no conditions attached.	Dam may be used to full storage if certain monitoring, maintenance, or operational conditions are met.	Dam may not be used to full capacity, but must be operated at some reduced level in the interest of public safety.

CLASSIFICATION OF DAMS

CLASS I	CLASS II	CLASS III
Class I - Loss of human life is expected in the event of failure of the dam, while the reservoir is at the high water line.	Class II - Significant damage to improved property is expected in the event of failure of the dam while the reservoir is at the high water line, but no loss of human life is expected.	Class III - Loss of human life is not expecte and damage to improved property is expect to be small, in the event of failure of the da while the reservoir is at high water line.

DAM NAME: _____ DAM I.D.: _____ DATE ___/___/___

MONITORING

EXISTING INSTRUMENTATION FOUND ☐ (110) NONE ☐ (111) GAGE ROD ☐ (112) PIEZOMETERS ☐ (113) SEEPAGE WEIRS/FLUMES
☐ (114) SURVEY MONUMENTS ☐ (115) OTHER _____
MONITORING OF INSTRUMENTATION: ☐ (116) NO ☐ (117) YES PERIODIC INSPECTIONS BY: ☐ (118) OWNER ☐ (119) ENGINEER
Comments: _____

GOOD ☐ ACCEPTABLE ☐ POOR ☐ **MONITORING**

MAINTENANCE AND REPAIR

PROBLEMS NOTED: ☐ (60) NONE ☐ (61) ACCESS ROAD NEEDS MAINTENANCE ☐ (62) CATTLE DAMAGE
☐ (63) BRUSH ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☐ (64) TREES ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE
☐ (65) RODENT ACTIVITY ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☐ (66) DETERIORATED CONCRETE-FACING, OUTLET, SPILLWAY
☐ (67) GATE AND OPERATING MECHANISM NEED MAINTENANCE ☐ (68) OTHER _____
Comments: _____

GOOD ☐ ACCEPTABLE ☐ POOR ☐ **MAINTENANCE AND REPAIRS**

OVERALL CONDITIONS

REMARKS: _____

Based on this Safety Inspection and recent file review, the overall condition is determined to be:

☐ 71 SATISFACTORY ☐ 72 CONDITIONALLY SATISFACTORY ☐ 73 UNSATISFACTORY

OVERALL CONDITIONS

The State Engineer, by providing this dam safety inspection report, does not assume responsibility for any unsafe condition of the subject dam. The sole responsibility for the safety of this dam rests with the reservoir owner or operator, who should take every step necessary to prevent damages caused by leakage or overflow of waters from the reservoir or floods resulting from a failure of the dam.

ITEMS REQUIRING ACTION BY OWNER TO IMPROVE THE SAFETY OF THE DAM

MAINTENANCE - MINOR REPAIR - MONITORING

☐ (80) PROVIDE ADDITIONAL RIPRAP: _____
☐ (81) LUBRICATE AND OPERATE OUTLET GATES THROUGH FULL CYCLE: _____
☐ (82) CLEAR TREES AND/OR BRUSH FROM: _____
☐ (83) INITIATE RODENT CONTROL PROGRAM AND PROPERLY BACKFILL EXISTING HOLES: _____
☐ (84) GRADE CREST TO A UNIFORM ELEVATION WITH DRAINAGE TO THE UPSTREAM SLOPE: _____
☐ (85) PROVIDE SURFACE DRAINAGE FOR: _____
☐ (86) MONITOR: _____
☐ (87) DEVELOP AND SUBMIT AN EMERGENCY PREPAREDNESS PLAN. _____
☐ (88) OTHER: _____
☐ (89) OTHER: _____

ENGINEERING - EMPLOY AN ENGINEER EXPERIENCED IN DESIGN AND CONSTRUCTION OF DAMS TO: (Plans & Specification must be approved by State Engineer prior to construction.)

☐ (90) PREPARE PLANS AND SPECIFICATIONS FOR THE REHABILITATION OF THE DAM: _____
☐ (91) PREPARE AS-BUILT DRAWINGS OF: _____
☐ (92) PERFORM A GEOTECHNICAL INVESTIGATION TO EVALUATE THE STABILITY OF THE DAM: _____
☐ (93) PERFORM A HYDROLOGIC STUDY TO DETERMINE REQUIRED SPILLWAY SIZE: _____
☐ (94) PREPARE PLANS AND SPECIFICATIONS FOR AN ADEQUATE SPILLWAY: _____
☐ (95) SET UP A MONITORING SYSTEM INCLUDING WORK SHEETS, REDUCED DATA AND GRAPHED RESULTS: _____
☐ (96) PERFORM AN INTERNAL INSPECTION OF THE OUTLET: _____
☐ (97) OTHER: _____
☐ (98) OTHER: _____
☐ (99) OTHER: _____

SAFE STORAGE LEVEL RECOMMENDED AS A RESULT OF THIS INSPECTION

☐ (101) FULL STORAGE
☐ (102) CONDITIONAL FULL STORAGE
☐ (103) RECOMMENDED RESTRICTION → RESTRICTED LEVEL OFFICIAL ORDER TO FOLLOW

_____ FT. BELOW DAMS CREST
_____ FT. BELOW SPILLWAY CREST
_____ FT. GAGE HEIGHT
_____ NO STORAGE-MAINTAIN OUTLET FULLY OPEN
_____ _____

REASON FOR RESTRICTION: _____

ACTIONS REQUIRED FOR CONDITIONAL FULL STORAGE OR CONTINUED STORAGE AT THE RESTRICTED LEVEL: _____

Engineer's Signature _____ INSPECTED BY

Owner's Signature _____ OWNER/OWNER'S REPRESENTATIVE DATE: ___/___/___

APPENDIX E

PROPOSAL FOR EVALUATING EXTREME PRECIPITATION FOR THE MOUNTAINOUS AREAS OF COLORADO

INTRODUCTION

The state engineer's Regulations for Dam Safety and Dam Construction require that spillways for dams be adequate to handle floods based upon Probable Maximum Precipitation (PMP). PMP is the theoretically greatest depth of precipitation for a given duration, that is physically possible over a drainage basin at any specific time of year. This is essentially a no risk standard that is in accord with the national standards for dam safety, and Colorado case law, where failure of a dam could be catastrophic to the public health and welfare.

PROBLEM

The sources of extreme rainfall (PMP)[1] data for the mountainous areas of Colorado are presently the National Weather Service.[2] Recent studies by the US Geological Survey (Jarrett-Costa), reveal a difference in quantity between the level of flooding predicted by the weather service publications, and runoff observations for areas above 7500 feet in Colorado. Also, studies presently being done (December 1993) by the Denver Water Board for their Williams Fork Dam appear to support that the extreme rainfall for this basin is significantly less than predicted by the weather service. Another study, of the Grizzly Creek watershed near Aspen (1992), provided a conservative reduction of about 20 % in the PMP in relation to the weather service.

PROPOSAL

Because of these apparent differences, and the significant cost associated with designing/constructing spillways to handle floods caused by extreme precipitation (EP), the state engineer is proposing that the Colorado Water Conservation Board fund a study of the extreme precipitation problem in the mountainous areas of Colorado.

# of dams affected.	**81 Class I, 69 Class II**	**Total = 150**
# of owners affected.	**81**	
Volume of storage affected.	**3,379,000 Acre Feet**	

According to a thesis by David Chagnon, Colorado State University, Department of Atmospheric Science (1986), the total economic effect of estimating EP magnitude ranges from $10 -$16 Million per inch of change in rainfall, for about 150 dams in the area affected by HMR 55A. (1996 costs at 3% inflation for 10 years are $13.5 - $22 Million per inch of change in rainfall.) A 20% reduction in estimates of about 3 inches (conservative analysis) could result in a total savings of $40 - $60 million dollars (1996 dollars).

---

[1]Hydrometeorological Reports No. 55A (June 1988) for areas east of the continental divide; and No. 49 (1984) for areas west of the divide.

[2]US Department of Commerce, National Oceanic and Atmosphere Administration (NOAA)

PLAN

This proposal was developed by a volunteer committee of meteorologists, hydrologists, and engineers from universities, consulting firms, dam owners, and state and federal agencies. The proposal contains the following components, which will be executed in three phases:

Phase I	1.	Data collection (Extreme precipitation data/studies).
	2.	Development of EP Database (Verification)
	3.	Modeling Workshops (Forum for professionals in field to reach consensus on which technology would be applicable for predicting an EP atmosphere in the mountains of Colorado.)
Phase II	4.	Research/Development of "Model/s" for use.
Phase III	5.	Creation of data for isohyetal maps and depth-duration data of EP. Correlation of data with hydrologic records (Including paleo-hydrologic.).
	6.	Peer review and endorsement by other agencies.
	7.	Documentation, development of the procedures for use by practitioners.

Phase I is expected to be accomplished in about one-years time. The State Climatologist's Office (SCO) will do the inventory, and develop the EP database. The SCO will also organize and conduct a workshop on modeling of EP at Colorado State University. Additional workshops may be organized for other components. The estimated cost of these Phase I components are $50,000 - $75,000 for the inventory, and $20,000 - $25,000 for the workshops (primarily for reimbursement of travel expenses of participants). Total cost estimate is $70,000 - $100,000.

The research/development component of Phase II is necessary to understand the physical mechanisms of extreme precipitation with elevation, and to develop a modeling program for analyzing/defining extreme precipitation. (The scope of this component is expected to be defined by the workshops.) The time period could be from 3 to 5 years as presently estimated. The cost shall also be defined by the workshops. After the EP analyses and modeling program are developed, the EP data will be produced and correlated with historic records for verification during Phase III. The generated EP data can then be used to develop (after peer review) procedures for use by practitioners. Geographical Information Systems (GIS) technology is available to do this. The time period for this is estimated to be 1 - 2 years. The cost will be defined by the scope of the project and requests for proposals from the industry.

Total estimated time for completion of all phases is 5 to 8 years. The benefits expected from this proposal are:

Significant reduced costs for the design of new dams, and for upgrading spillways at existing dams, to the standards contained in the regulations.

Increased conservation pools in reservoirs.

Increased head available for power generation.

RECOMMENDATION LOCATOR

Rec. No.	Page No.	Recommendation Summary	Agency Addressed	Agency Response	Implementation Date
1	20	The Division of Water Resources should change DWR policy to accept Bureau of Reclamation and Army Corps of Engineers-performed routine safety inspection reports and reallocate the general fund resources used to perform routine coinspections to higher-value/priority Dam Safety Program engineering activities.	Division of Water Resources	Agree	1999
2	21	The Division of Water Resources should develop guidelines requiring Dam Safety Program staff to determine risk, show cause and seek prior management approval to participate in each optional coinspection of a federal dam and related activities.	Division of Water Resources	Agree	1999
3	24	The Division of Water Resources should reduce general fund resources used to perform redundant routine safety inspections of Federal Energy Regulatory Commission-licensed dams by changing DWR policy to accept FERC safety inspection reports.	Division of Water Resources	Agree	1999
4	28	The Division of Water Resources should reduce general fund resources used to perform routine safety inspections of federally owned and operated dams by requiring that federal agencies operate a dam safety program at federal expense, provide the program with staff and provide the DWR with safety inspection reports in lieu of DSP inspection reports.	Division of Water Resources	Agree	2000
5	31	The Division of Water Resources should stop using general fund resources to provide dam safety evaluation services on federally owned, operated, and licensed dams and save or reallocate those general fund resources to higher-value/priority Dam Safety Program engineering activities.	Division of Water Resources	Agree	1999

RECOMMENDATION LOCATOR

Rec. No.	Page No.	Recommendation Summary	Agency Addressed	Agency Response	Implementation Date
6	33	The Division of Water Resources should record and report in its *Dam Safety Program Annual Report*, the general fund cost and time Dam Safety Program staff spend on federal dams either by recommending an amendment to C.R.S. 37-87-114.4 or through State Engineer's rules and regulations.	Division of Water Resources	Agree	1999
7	35	The Division of Water Resources should work with the Denver Water Board to develop a routine dam safety inspection report acceptable to both agencies or obtain DWB inspection reports and use them in lieu of Dam Safety Program performed routine safety inspections.	Division of Water Resources	Agree	1999
8	36	The Division of Water Resources should work with the Division of Wildlife to develop an owner's engineer dam safety inspection report and related policies and procedures acceptable to both agencies and utilize Division of Wildlife routine safety inspection reports in order to reallocate general fund costs of duplicating routine safety inspections.	Division of Water Resources	Agree	1999
9	38	The Division of Water Resources should reduce costs of inspections performed by the owner's engineer, by amending Rule 14.D in the *Rules and Regulations for Dam Safety and Dam Construction*, to require similar inspection frequencies for both Division of Water Resources' Dam Safety Engineers and dam owner's engineers.	Division of Water Resources	Agree	2000

RECOMMENDATION LOCATOR

Rec. No.	Page No.	Recommendation Summary	Agency Addressed	Agency Response	Implementation Date
10	45	The Division of Water Resources should require adequate emergency access to dams on U.S. Forest Service property. This could be accomplished with locking gates on restricted roads and prior notification to the State Engineer about restrictions on USFS roads leading to dams.	Division of Water Resources	Agree	1999
11	46	The Division of Water Resources should add the potential for loss of life when designated recreation areas along streams and rivers do not feature man-made improvements or large established campgrounds to the criteria for evaluating the suitability of a Class I hazard rating.	Division of Water Resources	Agree	1999
12	48	The Division of Water Resources should enforce their rule requiring all owners of Class I and II dams to submit and keep current an Emergency Preparedness Plan.	Division of Water Resources	Agree	Currently being implemented.
13	49	The Division of Water Resources should modify the *Engineer's Inspection Report Form* to require the Dam Safety Engineer to document their review and verification of Emergency Preparedness Plan accuracy.	Division of Water Resources	Agree	1999
14	50	The Division of Water Resources should implement procedures to verify the accuracy of the data in the dam safety database.	Division of Water Resources	Agree	1999