GUIDELINES FOR MAINTENANCE AND INSPECTION OF DAMS IN KENTUCKY

KENTUCKY NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DIVISION OF WATER

JULY, 1985

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INDEX

ACKNOWLEDGMENTS

The Division of Water wishes to express its gratitude to the following:

Mr. Harry Keith Honaker, P.E., formerly with Kentucky Division of Water, for the compilation of this publication.

Dr. George F. Sowers, Regents Professor of Civil Engineering, Georgia Institute of Technology; Chairman of the Board/Consultant, Law Engineering Testing Company, Atlanta, Georgia, for the information on Earth Dam Failures.

Dr. Bruce A. Tschantz, Associate Professor of Civil Engineering, University of Tennessee, for his valuable assistance, information, and comments on the contents of this booklet.

Dr. Staley F. Adams, Professor of Civil Engineering, University of Kentucky and students in the Division of Water Training Program at the University of Kentucky for the assistance in compiling the information and illustrations.

The Engineering Foundation Conference and Dr. Sanford S. Cole for the information obtained from conferences held by the Engineering Foundation on Dam Safety.

The Federal Emergency Management Agency for funds to reprint the publication; the views expressed in this publication are not necessarily those of the funding agency.

Other state agencies for information including invaluable lessons learned through experience.

Caulk Dam Failure
Taylor County, Kentucky
December, 1973

1. INTRODUCTION

Guidelines for Maintenance and Inspection of Dams was prepared to help you maintain and inspect your dam on a regular schedule—to detect problems and prevent a failure of the dam.

Experience in Kentucky and other states shows that when dams are not properly maintained, it's usually because the owners don't understand the techniques necessary for a maintenance program. Understanding and following the guidelines in this booklet may prevent a catastrophic failure of your dam.

2. GENERAL INFORMATION

A. WHAT IS A "DAM"?

Kentucky statutes (KRS 150.100) defines a dam as any artificial barrier (including appurtenant works) which does, or can, impound or divert water and is, or will be:

(1) twenty-five feet or more high from the natural bed of the stream or watercourse at the downstream tow of the barrier, as determined by the Department for Environmental Protection, or

(2) has, or will have an impounding capacity of fifty acre-feet or more at the maximum water storage elevation.

B. STATE PERMITS AND INSPECTIONS

Since 1948 anyone in Kentucky proposing to construct a dam has been required to submit a plan to the state for review to obtain a permit. In 1966, adoption of guidelines for evaluating dams was required by a revision made to the law.

In 1974, the permit system was revised to include regular state inspections of dams—KRS 150.295 directs the Secretary of the Natural Resources and Environmental Protection Cabinet to inspect dams and reservoirs on a regular schedule.

C. REGULAR MAINTENANCE AND INSPECTION IS ESSENTIAL

A dam failure can cause considerable loss of capital investment, loss of income, and even tragic loss of life. Some lakes have existed for such a long time that their pools have been accepted as the natural level, and many homes, industries and utilities rely on the maintenance of the lake at the existing level. They depend on the owner to properly operate, maintain and inspect the dam to prevent the creation of hazardous conditions to downstream properties and residents.

Aside from moral obligation to keep the dam safe, the owner could be subjected to liability claims, or even criminal charges, if the dam fails. So it's good business practice to have an effective program of maintaining and inspecting you dam.

This booklet will help you to inspect your dam, but it's not intended as a design manual for making repairs. Use it to tell you when to call in a professional. Remember that all problems may not be exposed in the course of your maintenance and visual inspection. Do not rely on "home remedies". Call in an experienced design engineer to remedy problems.

3. PROMINENT TYPES OF DAM FAILURE

Dam failures are usually produced by improper design, construction, and maintenance. All dams built in the future must follow guidelines in the regulations, and problems will hopefully be minimized.

On many older dams, very little is known about their design and construction, so most conclusions are based on knowledge from superficial inspections. With these older structures it is important to be aware of the prominent types of failures and the tell-tale signs the may warn you of failure.

Earth dam failures can generally be grouped into three classifications, briefly described below:

A. HYDRAULIC FAILURE:

Hydraulic failures result from the uncontrolled flow of water over the dam, around the dam, and adjacent to the dam, plus the erosive action of water on the dam and its foundation. Earth dams are particularly susceptible to hydraulic failure since earth erodes at relatively small velocities.

B. SEEPAGE FAILURE:

All dams exhibit some seepage, which must be controlled in velocity and amount. Seepage occurs both through the dam and the foundation. If uncontrolled, it can erode material from the foundation of an earth dam to forma conduit through which water can pass, which often leads to complete failure of the structure. This phenomenon is known as "piping".

C. STRUCTURAL FAILURE:

Structural failure involves the rupture of the dam and/or its foundation. This is particularly a hazard for large dams and for dams built of low strength materials such as silts, slag, fly ash, etc.

Dam failures generally result from a complex interrelationship of these failure modes. Uncontrolled seepage may weaken the soils and lead to a structural failure. A structural failure may shorten the seepage path and lead to piping failure. Surface erosion may lead to structural or piping failures. Tables I, II and III give a summary of failure and possible remedies.

TABLE I

FORM	CHARACTERISTICS	CAUSES	PREVENTIVE OR CORRECTIVE MEASURES
		HYDRAULIC FAILURES (30% of all failures - less in dams under 50 ft.)	
Overtopping	Flow over embankment, washing out dam	Inadequate spillway capacity	Spillway designed for maximum flood
		Clogging of spillway with debris	Maintenance; trash booms; clean design
		Insufficient freeboard due to settlement, skimpy design	Allowance for freeboard and settlement in design; increase crest height or add flood parapet
Wave Erosion	Notching of upstream face by waves, currents	Lack of riprap, too small riprap	Properly designed riprap
Toe Erosion	Erosion of toe by outlet discharge	Spillway to close to dam	Training walls
		Inadequate riprap	Properly designed riprap
Gullying	Rainfall erosion of dam face	Lack of sod or poor surface drainage	Sod; fine riprap; surface drains

SOURCE: George F. Sowers
Chairman of the Board/Consultant
Law Engineering Testing Company

FORM	CHARACTERISTICS	CAUSES	PREVENTIVE OR CORRECTIVE MEASURES
		SEEPAGE FAILURES (40% of all failures)	
Loss of Water	Excessive loss of water from reservoir and/or occasionally increased seepage or increased ground water levels near reservoir	Pervious reservoir rim or bottom	Blanket reservoir with compacted clay or chemical admix; grout seams, cavities
		Pervious dam foundation	Use foundation cutoff; grout; upstream blanket
		Pervious dam	Impervious core
		Leaking conduits	Watertight joints; waterstops; grouting
		Settlement cracks in dam	Remove compressible foundation; avoid sharp changes in abutment slope; compact soils at high moisture
		Shrinkage cracks in dam	Use low plasticity clays for core; adequate compaction
Seepage Erosion or Piping	Progressive internal erosion of soils from downstream side of dam or foundation backward toward the upstream side to form an open conduit or "pipe". Often leads to a washout of a section of the dam.	Settlement cracks in dam	Remove compressible foundation; avoid sharp changes; internal drainage with protective filters
		Shrinkage cracks in dam	Low plasticity soil; adequate compaction; internal drainage with protective filters
		Pervious seams in foundation	Foundation relief drain with filter; cutoff
		Pervious seams, roots, etc. in dam	Construction control; core; internal drainage with protective filter
		Concentration of seepage at face	Toe drain; internal drainage with filter
		Boundary seepage along conduits, walls	Stub cutoff walls, collars; good soil compaction
		Leaking conduits	Watertight joints; waterstops; durable materials
		Animal burrows	Riprap wire mesh

SOURCE: George F. Sowers, Chairman of the Board/Consultant, Law Engineering Testing Company

TABLE III

FORM	CHARACTERISTICS	CAUSES	PREVENTIVE OR CORRECTIVE MEASURES
		STRUCTURAL FAILURES (30% of all failures - less in dams under 50 ft.)	
Foundation Slide	Sliding of entire dam, one face or both faces in opposite directions, with bulging of foundation in the direction of movement	Soft or weak foundation	Flatten slope; employ broad berms; remove weak material; stabilize soil
		Excess water pressure in confined sand or silt seams	Drainage by deep drain trenches with protective filters; relief wells
Upstream Slope	Slide in upstream face with little or no bulging in foundation below toe	Steep slope	Flatten slope or employ berm at toe
		Weak embankment soil	Increased compaction; better soil
		Sudden drawdown of pond	Flatten slope; rock berms; operating rules
Downstream Slope	Slide in downstream face	Steep slope	Flatten slope or employ berm at toe
		Weak soil	Increased compaction; better soil
		Loss of soil strength by seepage pressure or saturation by seepage or rainfall	Core; internal drainage with protective filters; surface drainage
Flow Slide	Collapse and flow of soil in either upstream or downstream direction	Loose embankment soil of low cohesion triggered by shock, vibration, seepage, or foundation movements	Adequate compaction

SOURCE: George F. Sowers
Chairman of the Board/Consultant
Law Engineering Testing Company

4. WHAT ARE THE MAIN ELEMENTS OF A DAM?

The main elements of an earth-fill dam—and most dams in Kentucky are earth-fill dams—are the embankment and foundation, the principal or mechanical spillway, the emergency spillway, and the drawdown facility.

The following descriptions of these elements will acquaint you with the nomenclature, or terms, used in the parts of this booklet on maintenance and inspection. Figure 1 shows the elements of a typical earth dam and illustrates the nomenclature followed in this booklet.

A. The embankment is the primary part of the dam. It's the section which impounds the lake and holds the water. Earth-fill embankments fall into two main classifications: homogeneous and zoned.

A homogeneous embankment is composed of essentially the same material throughout, while a zoned embankment is divided into zones where different materials, such as rock, are incorporated into some areas.

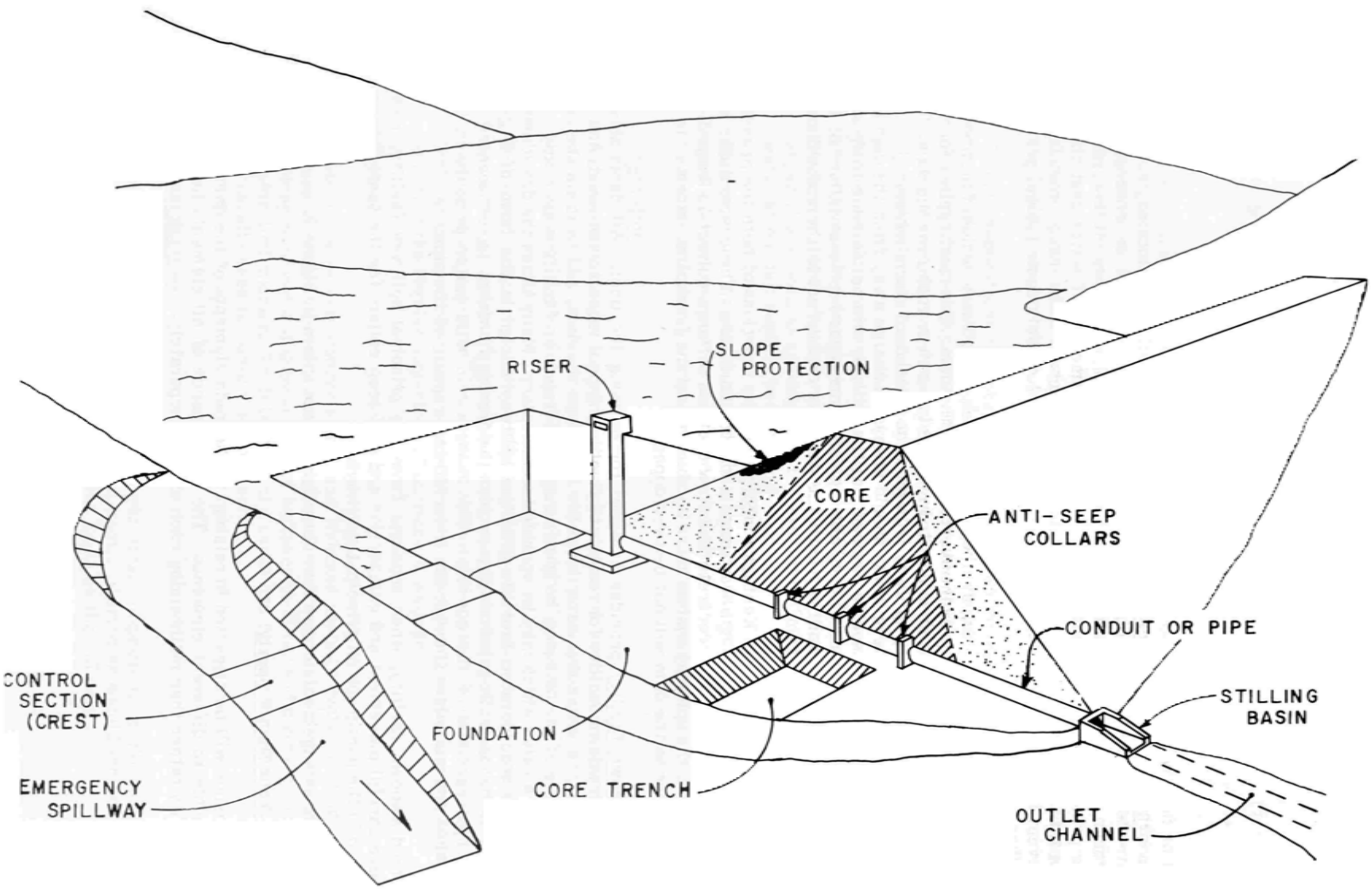
Most dams are zoned to some degree with compacted clay forming a relatively impermeable zone for cutting off water flow. A cutoff core trench is used in many dams to prevent the flow of water through the foundation material. The impermeable clay zone is generally surrounded by a more pervious material, which will allow drainage. Seepage through the dam is collected and controlled y means such as toe drains, rock toes, drainage blankets, relief wells, and chimney drains. All of the seepage control systems involve a means of filtering the clay particles from the seepage and a method of discharging the water in a safe manner.

The foundation material must have the strength to safely support the embankment and reservoir. Seepage through the foundation must be controlled in such a manner that the embankment will be stable under the design conditions and that the dam will store water for its intended purpose.

The slopes of the embankment must be vegetated to protect from the erosive effects of rain. The upstream slope must have protection from wave action. This is usually accomplished by a rock blanket (riprap) or by a berm.

The dimensions of the dam depend on the purpose and the hazard classification of the structure. The top width is a function of height, but is sometimes enlarged to accommodate a roadway. The steepness of the slopes is a function of the material used in construction, but is affected by such things as maintenance and access.

The hazard classification of the structure dictates minimum storms, which the dam must be able to withstand. Regulations have guidelines for the minimum storms on which the design is based and depend on the hazard classification. The top of the dam must be at an elevation sufficient to pass the freeboard storm and any accompanying wave height. An earth dam can fail rapidly if it is overtopped.


RISER
SLOPE PROTECTION
CORE
ANTI-SEEP COLLARS
CONDUIT OR PIPE
STILLING BASIN
OUTLET CHANNEL
CONTROL SECTION (CREST)
FOUNDATION
EMERGENCY SPILLWAY
CORE TRENCH

FIGURE

B. The principal or mechanical spillway is the spillway, which maintains the normal water level of the lake. This spillway is usually either a metal or concrete pipe through the dam and usually incorporates a stand pipe or riser intake structure. The principal spillway's function is to pass normal amounts of water past the dam in a safe and nonerosive manner. The intake structure must have provisions to prevent its clogging with trash and debris. Figure 2 depicts some typical principal spillway arrangements.

C. The emergency spillway is, as the term implies, a spillway, which functions in emergency conditions to prevent overtopping of the dam. Th most typical form of the emergency spillway is an excavated channel in earth or rock near the dam. The function of the emergency spillway is to pass the freeboard storm without overtopping the dam. The spillway should always discharge away from the dam and should be constructed in such a manner that the spillway will not fail die to erosion when it functions. Failure of the spillway can be as catastrophic as failure of the dam. Discharge of the spillway onto the dam can rapidly erode the embankment and cause failure of the dam.

Many of the older dams in Kentucky incorporate the functions of both the principal spillway and emergency spillway into a single structure. These structures are generally in the form of concrete overflow sections or large culverts. Regardless of the form, the spillway systems must be able to pass the freeboard storms in a safe manner so the dam will not be overtopped.

D. The drawdown facility provides a means for draining the pool. All dams should have a drawdown facility for reasons of fluctuating pool level, to kill weeds and mosquitoes, to lower the water level for repairs to the dam, and to drain the lake when failure of the dam may be imminent. The drawdown facility is generally a pipe with a valve, which may be operated as necessary. Many times the drawdown facility is incorporated into the principal spillway design in the form of a gate valve in the riser. Regulations now require the drawdown valve to be located on the upstream end of the conduit. This assures minimum water pressure in the conduit and minimizes the risk due to an internal rupture of the pipe.

The drawdown facility, when separate from the principal spillway facility, must have a careful placement and compaction and anti-seep collars for the same reasons listed in the paragraph on principal spillways.

Common arrangements of the drawdown facility are shown in Figure 2.

5. MAINTAINING YOUR DAM PROPERLY

The maintenance will be discussed in relation to the main elements of the dam. Several items are applicable to different elements. The maintenance of all elements needs to be viewed as an entity rather than maintaining each element separately.

TYPICAL PRINCIPAL SPILLWAY
&
DRAWDOWN FACILITY ARRANGEMENTS

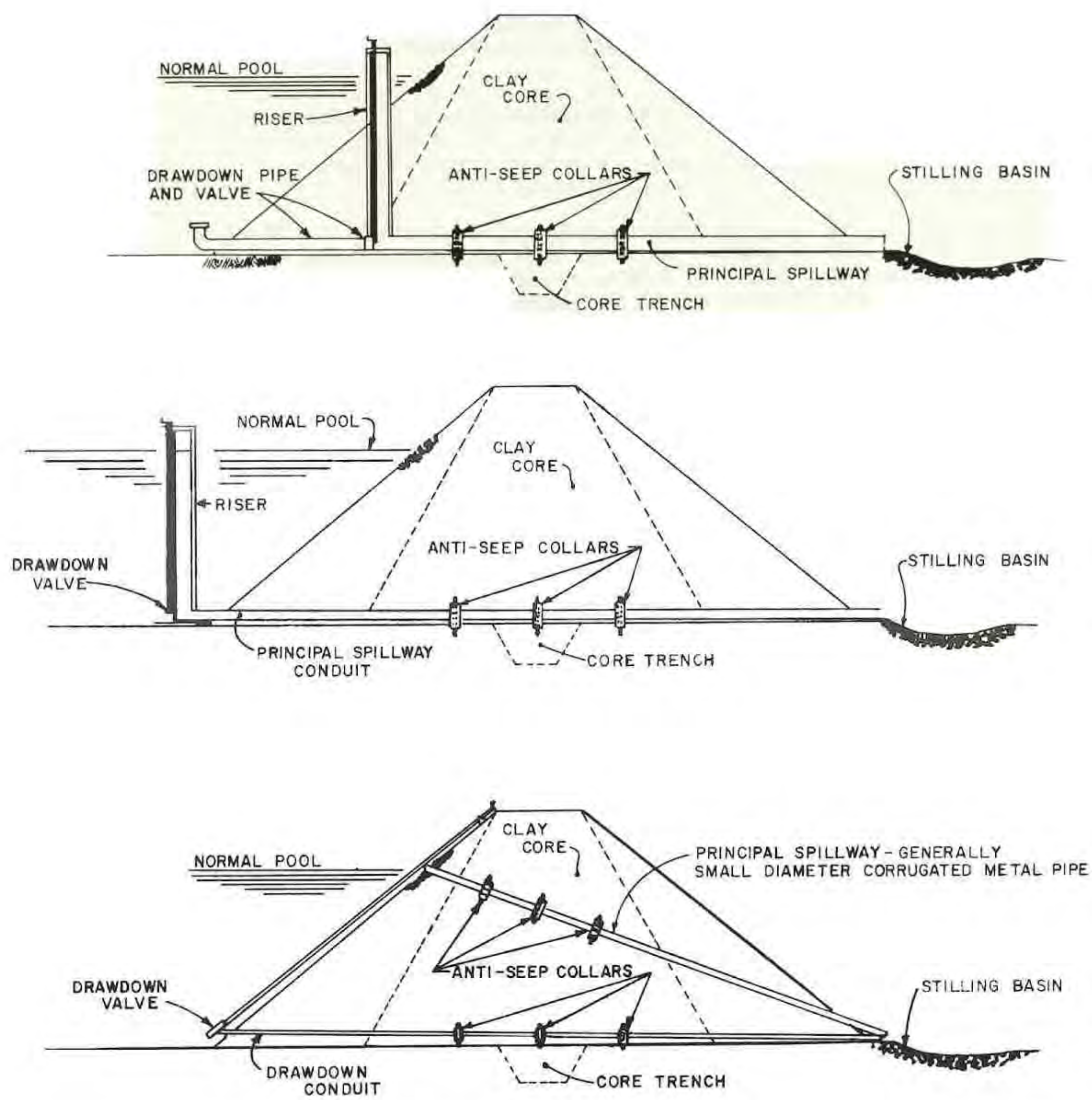


FIGURE 2

A. <u>Embankment</u>

1. Vegetation: A good cover of grass should be established and maintained.

    a. Seed, fertilize, and mulch areas, which are refilled, barren, or thinly vegetated. Apply fertilizer applications at regular intervals. Watering may be necessary in dry seasons.

    b. Mow the vegetation as needed. Mowing allows the grasses to establish a thick erosion-resistant god and also makes it much easier to detect any potentially dangerous conditions such as seepage, erosion channels, cracks, and burrowing animals.

2. Trees and Brush: Removal and prevent the growth of trees and brush. These develop large roots systems, which can provide seepage paths. Toppling of these can leave large holes, which can weaken the embankment. Brush, vine, and kudzu obscure the surface, limit inspections, and provide a haven for animals.

3. Erosion: Erosion control and repair is essential. Refill and compact all erosion channels on the dam. Erosion channels occur on all areas of the dam, but are frequently most severe along the line of contact at the abutments.

4. Slumps: the repair of slumps and slides on the dam is important. A slump occurs for many reasons such as improper compaction, side slopes being too steep, and as a result of seepage. Determine the cause of the slump before repair. Correcting the underlying causes will save you time, labor, and expenses over the life of the structure.

5. Wave Protection: Slope protection is particularly susceptible to weathering. The action of waves, rain, freezing, and mechanical impacts can cause the movement, settlement, and/or destruction to conform to the original section of the embankment.

6. Animals: The dam and surrounding area should be free of animal traffic and habitation. Domesticated animals can damage the sod covering, especially if the cover is thin or the dam is wet from rainfall. Overgrazing can reduce the erosion resistance of the vegetation. Keep burrowing animals off of the dam by whatever means necessary. If dens are found, promptly repair them.

B. <u>Principal Spillway:</u>

1. The primary purpose of the spillway is to pass normal flows of water in a safe manner. If this is not being accomplished, then actions must be taken to accomplish it.

2. The conduit, or pipe must be sound and watertight. The conduit must have the strength to support the external loads of the embankment and lake. When the pipe is composed of jointed sections, those sections must be properly designed to remain watertight.

Immediately repair a collapsed or separated of any portion of the pipe; this will usually involve drawing down the lake, and probably reconstructing part of the embankment.

3. All concrete structures should be sound and on firm foundations. Back fill with any undermining and tightly seal with mastic joint filler. Any weep holes or drains associated with concrete structures should be open and functional. Failure to keep drains operative can cause damage to concrete structure and major cost in repairs.

4. The principal spillway must pass flows in a manner, which is not erosive to the dam, foundation or the spillway. Erosion at the principal spillway outlet is caused by the high velocity of the flow. Unchecked erosion can cause failure of the structure. Use measures such as stilling basins to minimize erosion. Stilling basins are generally constructed of riprap or concrete.

5. Obstruction of the principal spillway caused a reduction of flow carrying capacity and consequent increase in use of the emergency spillway with increased possibility of hydraulic failure of the structure. Principal spillways should be equipped with trash racks and these racks must be cleaned as a part of regular maintenance.

C. <u>Emergency Spillway</u>

1. The function of the emergency spillway is to convey flood flows past the dam so the dam is not overtopped. This function must be accomplished.

2. The earth portion of the spillway will require vegetation like that on the embankment. Grasses should be thick, well-bedded sods that is mown and fertilized regularly. Barren areas and thinly vegetated areas reseed and fertilize. Keep the spillway area free of trees and brush.

3. Repair and vegetate all erosion gullies, slides and slumps as soon as they occur. Erosion repair in earth spillways is of particular importance after any period of flow in the spillway. The outlet channel and control sections of spillways are prime erosion areas and their repair is crucial because erosion can expand very rapidly in the spillway.

4. On dams with combined principal and emergency spillways, concrete structures are prominent. The concrete must be kept sound by filling joints and cracks with mastic filler. Keep drains in concrete structures open and functional. In earth spillways, concrete is used to form control sections and chutes. Keep this concrete sound and functional.

5. Keep the emergency spillway area clear of trash, debris, and undesirable vegetation such as trees and brush. Other obstacles are buildings, fences, fish screens, and guardrails. If left in place, all these obstructions can catch trash and reduce the capacity of the spillway, which can cause hydraulic failure of the embankment.

D. <u>Drawdown Facility</u>

1. The drawdown facility must be tested periodically to make sure it is functioning. It must be operable at any time for various purposes, including need for water downstream, repair of spillway structures, and repair of the embankment.

2. The drawdown should be used in a controlled manner so erosion is minimized. Drawdown facilities typically discharge into stilling basins or other erosion resistant structures.

Photographs of some dams on the following pages indicate the general appearance of a properly maintained structure.

Photo A: An example of a well maintained dam and spillway.

Photo B: Note stand of dense, well mown grass. Inspection will easily reveal any cracks, erosion, seepage, etc.

Plate 1

Photo C: An example of well maintained downstream slope and principal spillway.

Photo D: A vegetated spillway. Grass is dense and mown just as on dam.

Plate 2

6. Inspecting Your Dam Regularly

The regular inspection of dams is the heart of your care and maintenance program. Only by regular inspection can problems be detected at early stages. Early detection and remedy are essential to preserve the integrity of your structure.

Inspections should include areas other than the dam and spillway. The scope of the inspection should include areas downstream, on the abutments, and a general overview of the pool area. The dam and lake areas have to be viewed in the proper perspective with the surrounding terrain. Failure to do so ignore the possibility of unseen problems in the valley and abutments, which can be influenced by the dam and lake.

During an inspection, the owner should be aware of various signs of danger. These danger signs are often not detected unless the inspection is thorough and the dam has been properly maintained. An inspection cannot be adequately performed by driving at 30 miles per hour and seeing if the dam is there. Signs of danger that should be searched for are the following:

A. Seepage

The appearance of seepage on the downstream slope, abutments, of downstream area is cause for concern.

The type and quantity of seepage should be studied. If the water is muddy murky and is coming up from a well-defined hole, material is probably being eroded from inside the embankment and a potentially dangerous situation can develop. This type of problem requires immediate attention to stop the removal of material and control the seepage. Failures due to piping are examples of this type of seepage problem.

If the water is clear, it may be coming from an older hole and should be monitored closely for any changes in color and quantity.

Seepage can also occur on abutments, under spillways, and through the foundation and may at times exit some distance from the dam. Generally speaking, the further seepage exits from the dam, the less the probability of danger. However, it is important that all areas of seepage related to the dam be watched for changes.

B. Erosion

Erosion on the dam and spillway is one of the most evident signs of danger. The size of erosion channels and gullies can increase greatly with slight amounts of rainfall. Early detection of erosion channels can greatly facilitate necessary repairs of refilling, regarding, and revegetation. Left unattended, erosion can reach proportions, which damage the integrity of the dam.

Erosion along the water line due to wave action is another visible danger sign easily detected. Remedies usually involve refilling the area with rock or earth and the necessary revegetation.

Erosion from seepage through the dam, foundations, and abutments is a danger signal. This is more difficult to repair due to the seepage water. Repair generally involves the refilling of the areas, along with measures to collect and filter the seepage water. Repairs usually require the services of an engineer.

C. Cracks

The entire embankment should be closely inspected for cracks. Short isolated cracks are not usually significant, but larger, well-defined cracks indicate a problem is developing. Cracks are of two types: transverse and longitudinal.

Transverse cracks appear perpendicular to the axis of the dam and indicate settlement of the dam. Such cracks are an available avenue for seepage water and piping could develop very quickly.

Longitudinal cracks run parallel to the axis of the dam and may be the signal for a slide or slump on either face of the dam.

Cracks usually call for lowering the lake and taking reconstruction measures. They generally require the consultation of an engineer for remedy.

Cracks may be evident in other areas such as spillway cuts and landslides around the pool area.

D. Slides and Slumps

Slides and slumps are usually the most detectable danger signal. A massive slide can mean catastrophic failure of the dam. Slides occur for many reasons, and their occurrence can mean major reconstruction effort.

Slides and slumps are normally preceded by cracks and regular inspection can prevent sudden failure. Repair will usually involve the lowering of the pool, but this can cause slides on the dam and around the pool in saturated material if the drawdown is too rapid.

Remove slides in the spillway areas immediately since their presence reduced hydraulic capacities. Slides into the lake area can cause the sudden displacement of the lake volume and overtopping of the embankment.

E. Subsidence

Subsidence is vertical movement of the foundation materials due to failure of consolidation. Rate of subsidence may be so slow that its detection can go unnoticed without proper inspection procedures.

Foundation settlement is the result of placing the dam and reservoir on an area not having suitable strength or over collapsed caves or mines. At its onset subsidence refers to movement over and beyond that anticipated. Subsidence may not have any well-defined cracks or seepage associated with it.

Danger signals of subsidence include conduit displacements or separations at joints, conduit ruptures or collapses, and associated with it.

Conduit separations or ruptures can result in water leaking into the embankment and the subsequent weakening of the dam. Pipe collapse can result in hydraulic failures due to diminished capacity. It should be noted that rigid pipes, such as concrete pipes, are most likely to separate and crack, while flexible pipes, such as metal pipe conduits, are more subject to collapse.

Structure movements can be noticeable signs of subsidence. Listing or tilting of structures set in foundation material is signs of distress. Movements of intake or discharge structures can cause loss of function or conduits and diminished hydraulic capacities as well as endangering the stability of the dam due to introduction of water at conduit rupture points.

Subsidence is measured on embankments by referencing of some permanent type of markers on the dam and associated structures to points off the dams. Check elevations regularly for readings, which can give indications of subsidence.

F. Vegetation

A prominent danger signal is the appearance of undesirable types of vegetation such as cattails, reeds, mosses, and other wet area types of vegetation. The “wet environment” types of vegetation can be a sign of seepage.

Prominent areas for undesirable vegetation are the toe of the dam, the area downstream, and the abutments. Look closely in these areas for signs of seepage and take appropriate measures as discussed under the paragraphs on seepage. Maintenance on these areas should involve the mowing and clearing necessary to maintain the regular inspection of changes in seepage.

G. Boils

Boils are a serious danger signal and indicate seepage water exiting under some pressure. Boils typically occur in areas downstream of the dam. In boils, material is being removed and measures must be taken to filter and discharge the seepage in a controlled manner. To determine the cause and provide a permanent remedy, you will usually need to consult an engineer.

H. Animal Burrows

Animal burrows are a potential danger area. Inspection should include a careful search for dens on the dam and abutments. Remedies should include the removal of the animals and the refilling of dens made by the animals.

I. Debris

The collection of debris on the dam and spillways has a potential for danger. Remove debris as soon as possible so it cannot reduce the function of spillways, damage structures and valves, and destroy vegetative cover.

Photographs on the following pages are illustrative of the items mentioned above and are the types of problems, which can be readily identified by the owner during his inspection and maintenance program. Remedial measures undertaken at the early stages of a problem can usually save you effort and expense.

Photo E: Uncontrolled seepage eroding material from downstream slope. Measures must be taken to fill and discharge water in a nonerosive manner.

Photo F: Sand boils in an outlet channel below a dam. The seepage must be filtered and discharged.

Plate 3

Photo Failure dam along the principal spillway due "piping"

Photo H Note section which failed and depth **of** water Water impounded not very deep.

Plate

Photo I: Erosion down abutment. Repair will include refilling gully and revegetation.

Photo J: Erosion along shoreline due to wave action and water level fluctuation. Maintenance will require some riprap or erosion resistant vegetation.

Plate 5

Photos K and L: The onset of a major slump is indicated by well-defined cracks and displacement. Downstream slope is steep and repair measures will require flattening of slope.

Plate 6

Photo M: Slump on downstream slope. Repair will be a major reconstructive effort. Maintenance has been minimal.

Photo N: Slump on downstream slope. Material has covered drawdown and rendered it inoperable.

Plate 7

Photos O and P: Wet area vegetation. Prominent are willows and cattails. This type of vegetation usually indicates uncontrolled seepage through the dam or foundation.

Plate 8

Photos Q and R: Collections of debris at the riser and shoreline: Debris had damaged trash rack on riser and further flows could reduce hydraulic capacities. Debris on shoreline should be removed as well as that on riser.

Plate 9

Photos S and T: Consequences of the lack of inspection and proper maintenance of dams.

Plate 10

7. REPORT OF EMERGENCIES

In the event that the owner notices conditions that indicate the structure may be in a state of failure, actions must be taken to reduce the potential effects of failure. The following office should be contacted immediately by telephone:

Commonwealth of Kentucky
Natural Resources and Environmental Protection Cabinet
Department for Environmental Protection
Division of Water
14 Reilly Road, Fort Boone Plaza
Frankfort, Kentucky 40601
Telephone: (502) 564-3410

After 4:30 p.m. or before 8:00 a.m. Eastern Time, call Disaster and Emergency Services at (502) 564-7815 for assistance.

In addition, local authorities in the city and county and the local Civil Defense Office should be contacted. If danger signals or potential hazardous conditions are spotted in time, action can hopefully be initiated which will minimize any dangers or hazards, which would result in catastrophic failure of the dam.