The following publications are available from the Association of State Dam Safety Officials (ASDSO) or your state dam safety office.

Responsibility and Liability

Procuring the Services of a Professional Engineer

Dam Safety: An Owner's Guidance Manual, FEMA Publication 145 (available from ASDSO only)

ASSOCIATION OF STATE DAM SAFETY OFFICIALS

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RESPONSIBILITIES OF DAM OWNERSHIP

INTERNAL EROSION OF EARTH DAMS

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Mr. A. Peter Barranco, Dam Safety Engineer of the state of Vermont, provided valuable input and many of the photos in this brochure.

This document is dedicated to the memory of Ronald C. Hirschfeld.

COVER PHOTOS

Internal erosion that was discovered in time for the owner to draw down the reservoir and prevent failure of the dam.

Top: Shallow subsidence on the downstream slope of the dam.

Middle: A cavity in the dam, revealed when the embankment was excavated with a back-hoe in the vicinity of the subsidence after the reservoir was lowered.

Bottom: Close-up of the cavity, 6 feet wide and extending 85 feet into the embankment from the downstream toe of the dam.

INTRODUCTION

Internal erosion of soil particles from within a dam by water that seeps through the dam (called *piping* by dam engineers) is one of the most common causes of failure of earth dams.

Internal erosion is especially dangerous because there may be no external evidence, or only subtle evidence, that it is taking place. A dam may breach within a few hours after evidence of the internal erosion becomes obvious.

Internal erosion may develop the first time water is impounded behind a dam, or it may develop over many years. You cannot assume that your dam is safe against internal erosion just because it has performed satisfactorily for many years.

Internal-erosion failures are often associated with "penetrations" of dams, such as outlet pipes buried in the embankment and concrete spillways that cross the embankment.

An experienced dam engineer may be able to detect the subtle signs of internal erosion during routine periodic inspections, but you should be aware of what signs to look for between inspections. If you do observe signs of internal erosion, you should get help from an experienced dam engineer.

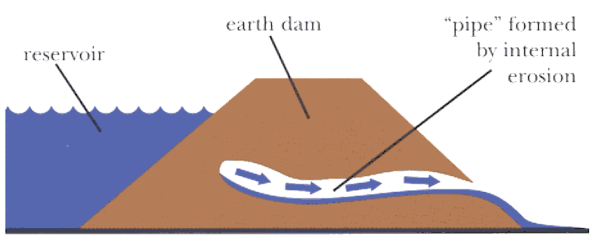
WHAT IS INTERNAL EROSION?

Internal erosion of an earth dam takes place when water that seeps through the dam carries soil particles away from the embankment, foundation, or abutments of the dam.

If the seepage that discharges at the downstream side of the dam carries particles of soil, an elongated cavity or "pipe" may be eroded backward toward the reservoir through the embankment, foundation, or an abutment.

When a backward-eroding pipe reaches the reservoir, a catastrophic breaching of the dam will almost certainly occur. A pipe that was discovered before it reached the reservoir is shown in the photos on the cover of this brochure.

Internal erosion usually takes place in episodes of erosion and discharge of muddy water interspersed with periods of clear-water discharge or no discharge at all. Internal erosion may be taking place even if there is no visible discharge of water or if the water that is discharging from the soil on the downstream side of a dam is not muddy.



Schematic view of internal erosion in an earth dam embankment.

A spring discharging at the downstream toe of an embankment.

Within two hours, the spring became much larger . . .

and later the dam failed!

CAUSES OF INTERNAL EROSION

Poor design of the dam.

Deterioration of outlet pipes and other penetrations through the dam, especially rusting of corrugated-metal pipes and opening of joints or poor sealing of joints in concrete pipes.

Poor construction—for example, inadequate compaction of the embankment around pipes and other penetrations of the embankment; placement of unsuitable materials in the embankment.

Seepage from the downstream side of the dam and failure to inspect the dam and to construct remedial measures if needed.

In cold climates, freezing and thawing of embankment soil next to outlet pipes, behind retaining walls, or beneath the floor slabs of spillways (similar to frost heaving in highways), which may open cracks in the soil that, in turn, become avenues of internal erosion in dams.

Trees on the embankment blowing over, followed by the development of springs where the roots of the trees have been pulled out of the ground.

Rotting of the roots of dead trees on the downstream side of the dam. The holes left by rotting of the roots become potential avenues for internal erosion.

Animal burrows on the upstream or downstream slopes of an embankment dam.

Corroded corrugated-metal outlet pipe removed from a dam that had developed large sinkhole.

Failure at a concrete dam caused by internal erosion of the soil abutment (shown at arrow).

WHAT TO LOOK FOR

SIGNS OF IMMINENT DANGER

Muddy water discharging from the downstream side of a dam or from a drain or low-level outlet pipe, which may indicate that the dam is failing.

Sinkholes or subsidence anywhere on the embankment or an abutment. Water flowing into a sinkhole below the reservoir surface on the upstream slope of a dam is especially dangerous.

Sinkhole on the crest of an earth dam. The reservoir was lowered, and a 10-foot-diameter cavity was found under the sinkhole.

SIGNS OF POTENTIAL DANGER

Water discharging on the downstream slope of an earth dam or within a few hundred feet downstream from the dam. Look for any accumulation of sediment downstream from the discharge.

Water flowing along the outside of a pipe, concrete spillway, or other structure that penetrates the embankment.

Trees that are uprooted on the embankment or abutments or in the valley bottom immediately downstream from the dam.

Dead trees (the rotting roots of which may become avenues of internal erosion) on the embankment or abutments or in the valley bottom immediately downstream from the embankment.

Animal burrows on the embankment.

Spring (rust-colored water) that developed where the root ball of a tree pulled out of the ground near the downstream toe of a dam.

Failure of an earth dam by internal erosion along concrete outlet pipe.

WHAT TO DO

IF YOU SEE SIGNS OF IMMINENT DANGER

Immediately, call 911, call the emergency number of your state dam safety office, and implement your emergency action plan if you see:

Muddy water or a large flow of clear water discharging (1) from soil anywhere on the downstream side of the dam, (2) next to a spillway, pipe, or other structure that penetrates the embankment or abutments, or (3) from drain pipes in the embankment.

A large new sinkhole (more than 8 inches in diameter) or new subsidence anywhere on the embankment or abutments.

YOUR STATE DAM SAFETY OFFICE

IF YOU SEE SIGNS OF POTENTIAL DANGER

As soon as possible, contact your state dam safety engineer or other qualified professional dam engineer to inspect the dam if you see:

Springs that discharge a small quantity of clear water on the downstream slope of the embankment or in the valley bottom within a few hundred feet downstream from the dam.

A small quantity of clear water flowing next to a pipe, spillway, or other structure that penetrates the embankment.

Water discharging near the roots of a living or dead tree.

Corrosion or deterioration of the visible portion of a low-level outlet pipe or other structure that penetrates the embankment.

A tree uprooted on the embankment or in the valley bottom within a few hundred feet downstream from the dam.

A small new sinkhole (less than 8 inches in diameter) or animal burrow or an old sinkhole or subsidence anywhere on the embankment or abutments.