



# DAM OWNERSHIP

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# FACT SHEET

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## TOPIC: UPSTREAM SLOPE PROTECTION

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Slope protection is usually needed to protect the upstream slope against erosion due to wave action. Without proper slope protection, a serious erosion problem known as “beaching” can develop on the upstream slope.

The repeated action of waves upon a vegetated embankment surface over time may erode embankment material and deposit it farther down the slope, creating a “beach.” The amount of erosion depends on the predominant wind direction, the orientation of the dam, the steepness of the slope, water level fluctuations, boating activities, and other factors. Further erosion can lead to cracking and sloughing of the slope which can extend into the crest, reducing its width. When erosion occurs and beaching develops on the upstream slope of a dam, repairs should be made as soon as possible. However, an erosion scarp less than 1 foot high may be stable and not require repair.

The upstream face of a dam is commonly protected against wave erosion by placement of a

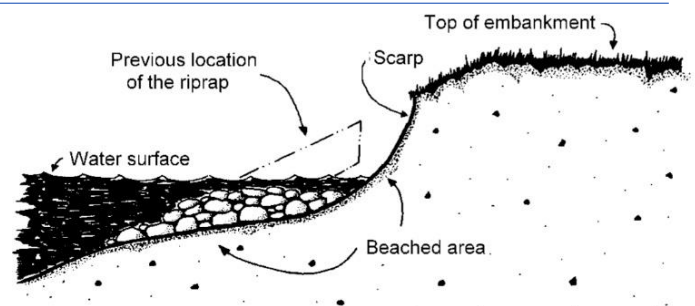


Figure 1 - Beaching

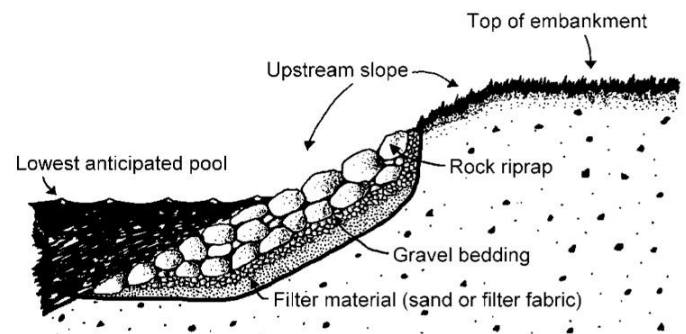


Figure 2 - Rock Riprap

layer of rock riprap over a layer of bedding and a filter material. Other material such as concrete facing, soil-cement, fabri-form bags, slush grouted rocks, steel sheet piling, and articulated concrete blocks can also be used. Vegetative protection combined with a berm on the upstream slope can also be effective.

## Rock Riprap

Rock riprap consists of a heterogeneous mixture of irregular shaped rocks placed over gravel bedding and a sand filter or geotextile fabric. The smaller rocks help to fill the spaces between the larger pieces forming an interlocking mass. The filter prevents soil particles on the embankment surface from being washed out through the spaces (or voids) between the rocks. The maximum rock size and weight must be large enough to break up the energy of the maximum anticipated wave action and hold the smaller stones in place. If the rock size is too small, it will eventually be displaced and washed away by wave action. If the riprap is sparse or if the filter or bedding material is too small, the filter material will wash out easily, allowing the embankment material to erode. Once erosion has started, beaching will develop if remedial measures are not taken.

Technical Release No. 69 developed by the USDA, Natural Resources Conservation Service can be used to help design engineers develop a detailed design for riprap slope protection.

The dam owner should expect some deterioration (weathering) of riprap. Freezing and thawing, wetting and drying, abrasive wave action, and other natural processes will eventually break down riprap. Its useful life varies with the characteristics of the stone used. Stone for riprap should be rock that is dense, well cemented, abrasion resistant, and angular in shape to resist deterioration and create an interlocking barrier. Vegetative growth within the slope protection is undesirable because it can displace stone and disturb the filter material. Heavy undergrowth prevents an adequate inspection of the upstream slope and may hide

potential problems. For additional information, see the "Trees and Brush" fact sheet.

Sufficient maintenance funds should be allocated for the addition of riprap and the removal of vegetation. Severe erosion or reoccurring problems may require a registered professional engineer to design a more effective slope protection.

## Vegetated Wave Berm

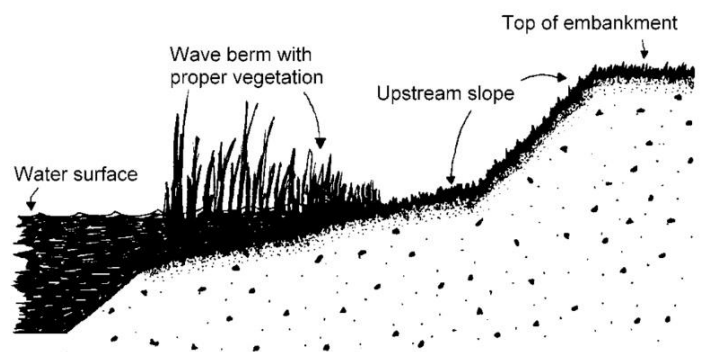


Figure 3 - Vegetated Wave Berm

Vegetated wave berms dissipate wave energy and protect the slope from erosion. Berms are constructed on the upstream slope at the normal pool level and should be no less than 20 feet wide. This method of slope protection will not work well where the water surface fluctuates regularly from normal pool. If improper or sparse vegetation is present, the wave berm may not adequately dissipate the wave energy, allowing erosion and beaching to develop on the upstream slope.

Technical Release No. 56 developed by the USDA, Natural Resources Conservation Service provides design and layout information.

The vegetation on the wave berm should be monitored regularly to verify adequate growth. Sufficient funds should be allocated for the regular

maintenance of the vegetation. Severe erosion or reoccurring problems may require a registered professional engineer to design a more effective slope protection.

### Concrete Facing

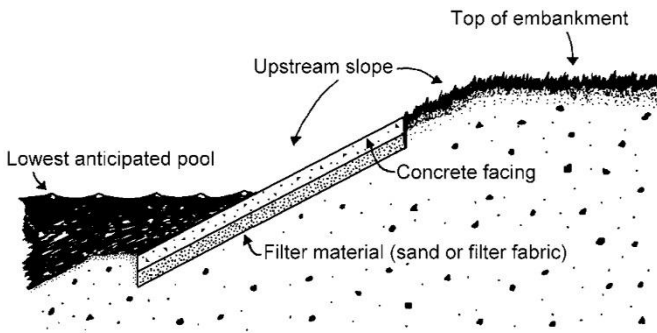


Figure 4 - Concrete Facing

Concrete facing can be used if severe wave action is anticipated, however, settlement of the embankment must be insignificant to insure adequate support for the concrete facing. A properly designed and constructed concrete facing can be expensive. This slope protection should extend several feet above and below the normal pool level. It should terminate on a berm or against a concrete curb or header. Granular filter or filter fabric (geotextile) is required under the concrete facing to help reduce the risk of undermining.

As with any type of slope protection, problems will develop if the concrete facing has not been properly designed or installed. Concrete facing often fails because wave action washes soil particles from beneath the slabs through joints and cracks. This process is known as undermining, which will continue until large voids are created.

Detection of voids is difficult because the voids are hidden. Failure of the concrete facing may be sudden and extensive. Concrete facing should be monitored for cracks and open joints. Open joints should be sealed with plastic fillers and cracks should be grouted and sealed. For additional information, see the "Problems with Concrete Materials" fact sheet.

### Inspection and Monitoring

Regular inspection and monitoring of upstream slope protection is essential to detect any problems. It is important to keep written records of the location and extent of any erosion, undermining, or deterioration of the riprap, wave berm or other slope protection. Photographs provide invaluable records of changing conditions. A rapidly changing condition may indicate a very serious problem, and appropriate dam safety officials should be contacted. All records should be kept in the operation, maintenance, and inspection manual for the dam.

### RESOURCES

The ASDSO website houses guidelines on dams.

Go to: [DamSafety.Org/ManualsandGuidelines](https://www.damsafety.org/manualsandguidelines)

For more information, videos and tools for dam owners go to: [DamOwner.Org](https://www.damowner.org)

Natural Resources Conservation Service Technical Releases can be found at:

<https://directives.sc.egov.usda.gov/>

Access your state's Dam Safety Program by clicking your state at: [DamSafety.Org/States](https://www.damsafety.org/states)