REMR TECHNICAL NOTE GT-RE-1.1

ROCK EROSION IN EMERGENCY SPILLWAY CHANNELS

PURPOSE: To identify a source of information on geotechnical aspects of rock erosion in emergency spillway channels.

REFERENCE: Geotechnical aspects of rock erosion in emergency spillway channels. C. P. Cameron, et al. US Army Engineer Waterways Experiment Station, Vicksburg, MS, Oct 1986. Technical Report REMR-GT-3.

APPLICATION: Database amplification. Studies conducted by the Waterways Experiment Station (WES) during FY 85 are summarized in this report which highlights recent case histories, impacts of emergency spillway flow, factors controlling erosion and other responses to spillway flow, and spillway evaluations.

ADVANTAGES: The amplified database provides the necessary framework for further research which will focus on: (a) the influence of stratigraphic and structural discontinuities on the initiation and rate of erosion in sedimentary rocks, (b) erodibility indices, and (c) downstream impacts of erosion in emergency spillway channels. Erodibility indices should be structured for expansion into a guidance manual for personnel in the field. The amplified database and proposed research will improve capabilities with respect to selection of effective preventive and remedial measures in spillway channels where the risk of excessive scour appears high.

BACKGROUND: The database contains reports and photographic documentation of twenty-seven project visits conducted during FY 85, as well as videotapes of spillway overflows at Saylorville (Rock Island District) and Black Butte (Sacramento District) reservoirs, and the catastrophic release of the privately owned DMAD Reservoir during erosion-induced spillway failure in 1983. These data are summarized in the referenced report and comprise the documentation of major impacts and controlling factors of spillway erosion.

IMPACTS OF EMERGENCY SPILLWAY FLOWS: Responses to high-level emergency spillway flow include channel floor and bank erosion, sediment transport and deposition, and overbank flooding. Erosion of the material underlying unlined channels is the most serious of spillway flow impacts, since channel floor degradation can undermine spillway structures and threaten reservoir integrity. However, responses to spillway flow are not limited to the immediate area of the dam. Spillway overflow can act to cause stream thresholds (which limit change on the system) to be exceeded in the main channels into which spillway flow exits, and can influence or induce changes for significant distances downstream. The DMAD Reservoir disaster provides ample evidence that knickpoint migration and headcutting can be initiated at a point considerably downstream from a control structure. Sediment deposition can build bars and

deltas in spillway channels, at exit channel-main channel confluences, and in downstream reaches of the main channel. Deposition in the main channel can impede passage of the reservoir overflow and, by deflecting flow into the channel banks, cause irregular channel widening. Sediment deltas and bars deposited farther downstream can initiate or accelerate erosion of streambanks and levees, impact navigation, endanger ecological balances, and increase the danger of overbank flooding.

CONTROLLING FACTORS: Response to spillway overflow is controlled by a variety of hydraulic and geological factors, the most important of which are:

a. Hydraulic factors:

1. Flood frequency and magnitude.
2. Engineering design.
3. Channel gradient(s).

b. Geological factors:

1. Discontinuity of earth materials.
2. Erodibility of earth materials.

The referenced report identifies as a major controlling factor of erosion in spillway channels the interrelated effect of hydraulic gradient change and stratigraphic discontinuity. Work to date shows that these factors combine to initiate and control headward migration of knickpoints, where resistant layers are undercut by scouring of softer, underlying strata. In terms of erodibility of earth materials, the scale of the hydraulic forces generated during high-level flows suggests that rippability and rock quality designation (RQD) may serve as the best point of departure in describing the relative resistance to erosion of earth materials in unlined spillway channels. Available case histories also prove that erosion is not restricted to sedimentary rocks but can occur in igneous and metamorphic rocks as well. Because little is known about the quantitative effects of stratigraphic variation on erosion rates in rocks, laboratory tests will be conducted using simulated earth materials and designed stratigraphic variability with the WES self-contained, recirculating and tilting, hydraulic flume. Research will also be conducted towards developing a method which will combine the individual factors controlling erosion, and allow for the ranking of unlined channels according to their susceptibility to scour during overflow events. Methods which use additive and multiplicative probability formula concepts will be tested by comparison with well documented case histories where a maximum amount of preflood information is contained in the database. Erosion indices produced by factor analysis will also be tested during the flume experiments.