

cause adjustment should be considered before adding the risks from the two potential failure modes. Without such a correction, it is possible for the total conditional failure probability to sum to a value greater than 1.0. The total conditional failure probability is equal to $1 - (1 - P_1)(1 - P_2)$, where P_1 and P_2 are the uncorrected conditional failure probabilities for potential failure modes 1 and 2. According to the unimodal bounds theorem, this results in the upper bound conditional failure probability, while the lower bound is simply the largest of the uncorrected individual conditional failure probabilities. When adjusting individual conditional probabilities to account for common cause, as a convenient and reasonable simplification the reduction associated with the joint conditional failure probability is typically distributed proportionally to each of the potential failure modes. The individual probabilities are multiplied by the ratio of the corrected total failure probability to the sum of the uncorrected individual probabilities.

In this case, the mean conditional probability of overtopping failure (P_1) was estimated to be about 0.049 and the probability of lift joint sliding (P_2) about 0.051 for the common load range. The total conditional probability of failure is $1 - (1 - 0.049)(1 - 0.051) = 0.098$ (as opposed to 0.1 if they were simply added). The approximate corrected values for overtopping and lift joint sliding are $0.049(0.098/0.1) = 0.48$ and $0.051(0.79/0.81) = 0.50$, respectively. In this case, since the conditional failure probabilities are small, there is little error in simply adding the results. The results of the risk analysis for these two failure modes are summarized in Table 4.

Table 4 – Mean Flood Risks

Potential Failure Mode	Annual Failure Probability	Annualized Life Loss
Sliding Non-Overflow Section	5.8×10^{-6}	3.5×10^{-5}
Overtopping	7.6×10^{-6}	7.6×10^{-6}
Total	1.3×10^{-5}	4.3×10^{-5}

Reclamation's Public Protection Guidelines (Reclamation, 2003) indicate there is increasing justification to take action when the annual failure probability exceeds 10^{-4} , or the annualized life loss (risk) exceeds 10^{-3} . There is decreasing justification to take action as the annual failure probability and risk progress in a direction lower than these guideline values. Based on these guidelines, the risk assessment for the example presented above would indicate there is decreasing justification to take further action. However, the numbers are only approximate, and by themselves are not intended to be the sole basis for decision-making. The "dam safety case" must be made to justify the numbers and recommended actions, and other considerations, such as confidence in the numbers or ease of addressing "low hanging fruit," must also be considered.

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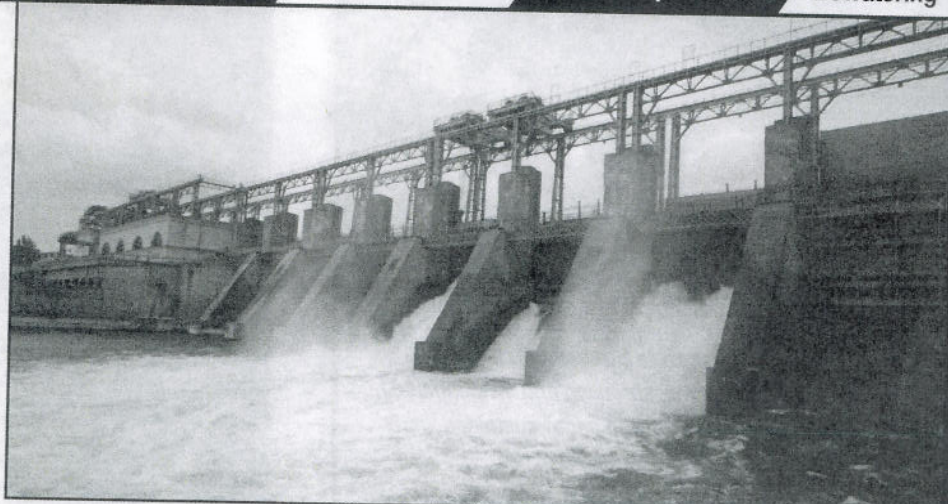
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