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Evaluation of dam surveillance requirements by reference to failure modes

Much if not most of the surveillance instrumentation at many dams was installed during construction. Attrition, particularly at older dams, has left many facilities with a fraction of their original complement of instruments. Those that remain may be poorly suited to monitoring the long term safe performance of the dam leaving owners with difficult questions: what and where should instruments be installed to meet due diligence obligations? A similar challenge faces designers of new dams – over the full life of a project how can the safe performance be confirmed? This paper presents a methodology for doing so that uses fault trees to inventory a dam's failure modes. This procedure takes advantage of the fact that ultimately, catastrophic release of a dam's reservoir can only happen in one of two ways: some part of the dam or its abutments must drop or the reservoir itself must rise. There are a manageable number of ways that either of these states can be achieved; certainly far fewer than apply to nuclear power plant failure where fault tree analysis was pioneered. Furthermore, dam failure modes are generally common amongst facilities of similar type. This means that once a failure mode inventory is completed for one installation, it can be adapted to another with minimal modification. Once defined, the failure modes are assessed using the following criteria: what manifestations accompany a failure mode's propagation; where would existing surveillance systems detect the failure mode progression; would this degree of warning provide sufficient time to intervene and arrest the failure mode; if not, what detection requirements would be necessary to do so and what instrumentation would provide this capability? In addition to defining adequate surveillance requirements, a priori tabulation of failure mode manifestations provides a benchmark against which surveillance outputs can be compared. This in turn provides a useful framework for decision making when observed dam behaviour deviates from expectations.