Hydro Québec Production

Une division d'Hydro-Québec

Dam safety risk analysis using bayesian networks

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Geohazards

Technical, Economical and Social Risk Evaluation

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Introduction

Dam failures : not common
important consequences

Always a residual risk → must be **MANAGED** by dam owner

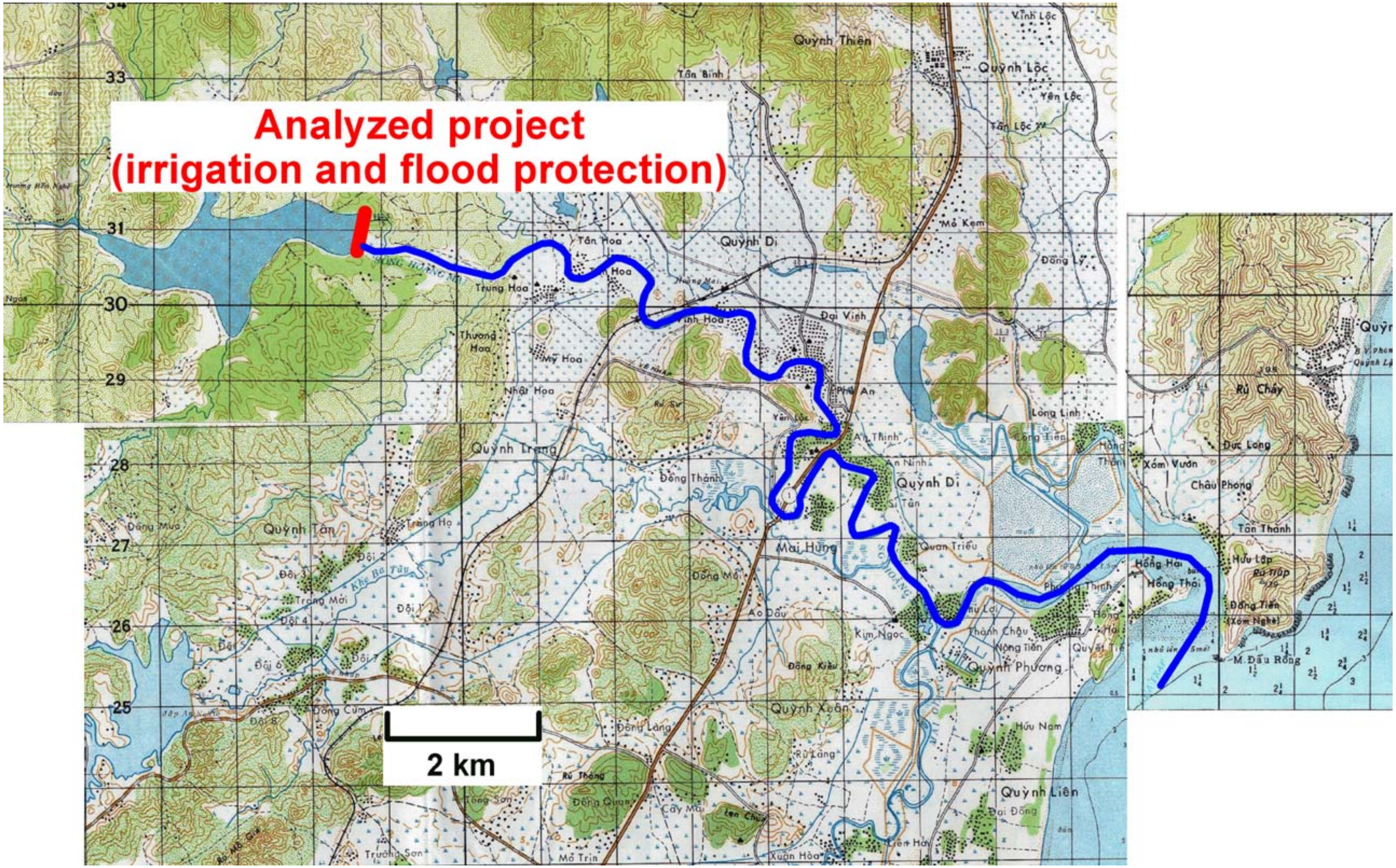
Two of the main characteristics of risk

COMPLEXITY
and
UNCERTAINTY

UNDERSTOOD

ANALYZED

Problem description



Problem description

overtopping

unreliable gate components

internal erosion

unsufficient spillway capacity

Interrelations between failure mechanisms

Geotechnical, hydrological and structural risks have to be compared

Interrelations between failure mechanisms


parapet wall?


increase capacity?


filtering berm?


gate rehabilitation?

A. What are the most significant factors contributing to the overall risk?

B. What are the rehabilitation works to be realized in priority?

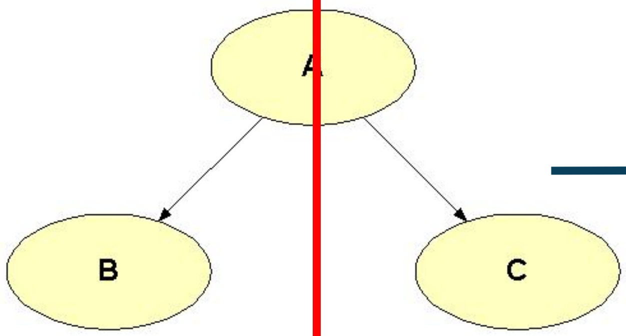
Complexity and uncertainty have to be taken into account

Bayesian networks

knowledge

Overall technical risk analyzed using bayesian networks

bayesian network



A is the cause of B and C

complexity

Probability tables → **uncertainty**

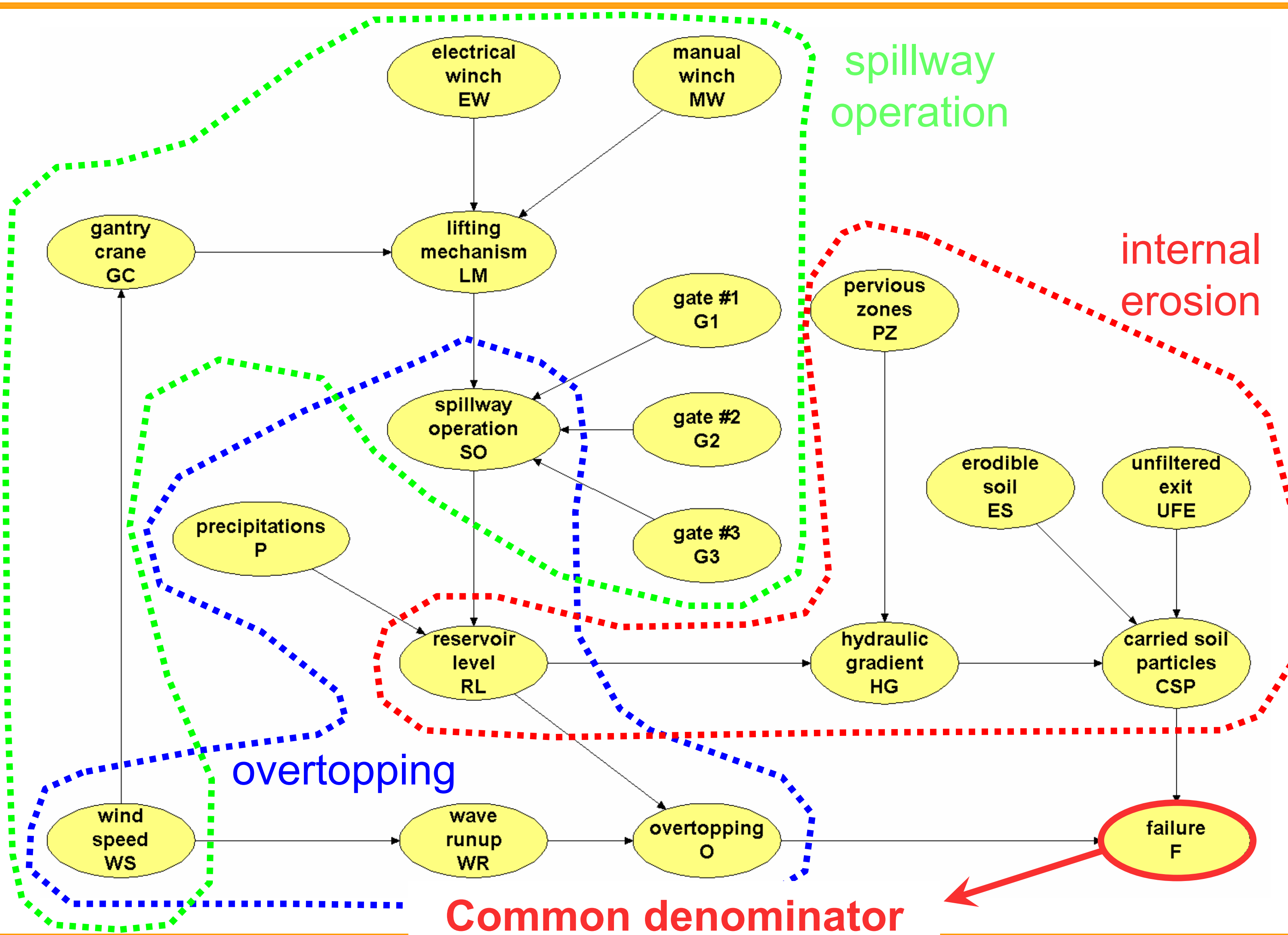
P(C | A) = 0,9 etc.

what is the most probable effect of A ?

reasoning

inferences are based on Bayes' theorem and realized using a specialized software

Causal model



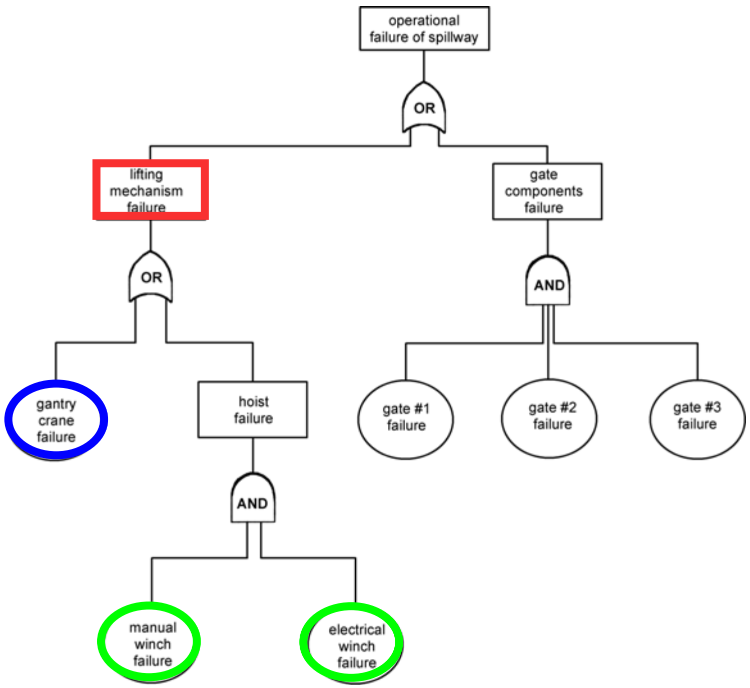
Probability tables

Probabilities are determined using :

1. Statistical techniques

2. Models

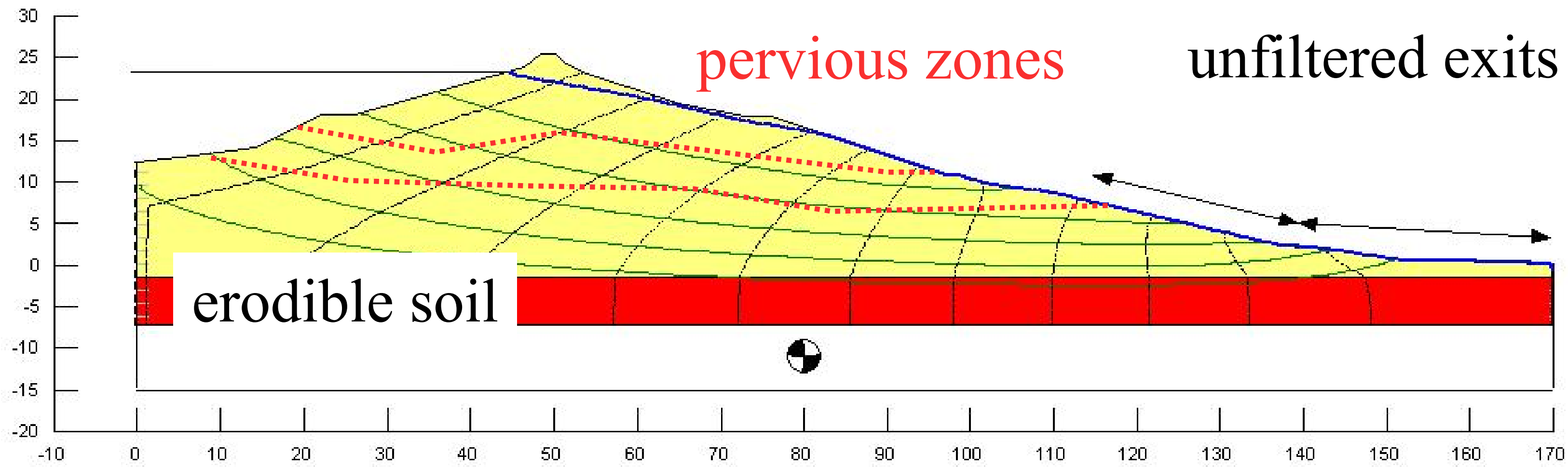
P(failure of lifting mechanism)



Probability tables

Probabilities are determined using :

3. Expert knowledge about the dam and its behaviour



carried soil particles : P(CSP) is high

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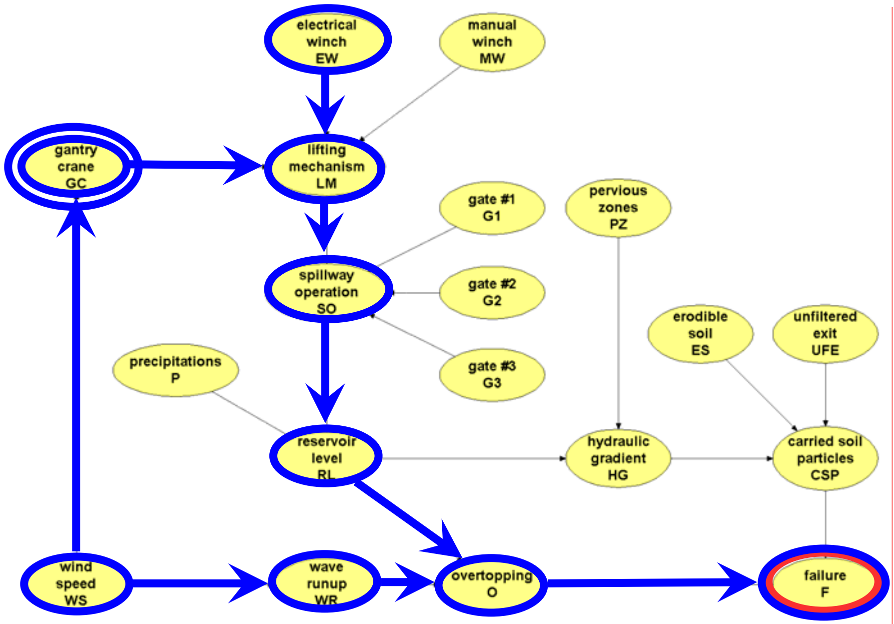
Optimal risk-reduction measures

A. What are the most significant factors contributing to the overall risk?



P(F)

P(F | Va) = max.(-)

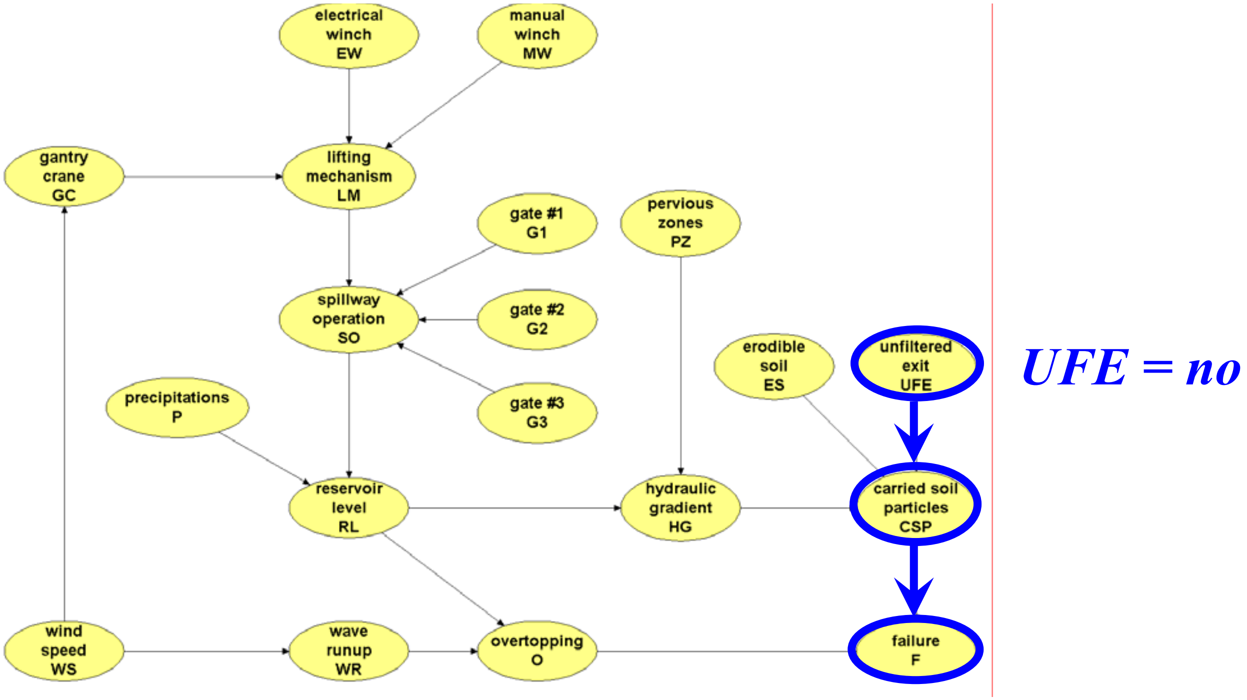
The variables *Va* (*WS, GC, EW*) having the most negative impact on *P(F)* are related to overtopping

The most critical variable is the operation of the gantry crane

impact (-)↑ *P(GC)*↑

Optimal risk-reduction measures

B. What are the rehabilitation works to be realized in priority?



P(F | UFE = no) = max.(+)

In technical and monetary terms, the optimal risk-reduction measure is the construction of a filtering berm:

$$priority\_index = \frac{impact\,(+)}{\cos t} = max.$$

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Optimal risk-reduction measures

This analysis should be considered as an aid to decision regarding the technical and monetary aspects of the problem

Social, environmental and legal aspects are also important

Ex. a minimal spilling capacity could be prescribed by law

Must consider the potential negative impacts of the proposed rehabilitation measures to assess their overall net outcome

Ex. an increased spilling capacity provides more safety for the structures but could endanger the population living downstream

Conclusions

The presented concepts allowed the determination of the overall risk by considering the complexity (interrelations) and uncertainty

P(F) was considered as common denominator to compare the geotechnical, hydrological and structural risks

P(F) can be used to judge the potential relative effectiveness of risk-reduction measures

It was therefore possible to determine :

What could go wrong?

What should be done about it?

→ among the main responsibilties of a dam owner