Victoria's Dam Safety — The Risk Management Journey: A Risk-Informed Regulatory Approach

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Portfolio Stratified Sampling Approach – Basis for Transfer of Responsibility for State Dams to Private Corporations

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PRESENTER’S INVOLVEMENT IN VICTORIA

- 1996-2000: Advisor for development and implementation of a statewide risk-informed dam safety regulatory program, State of Victoria
- 2008: International Reviewer on the Dam Safety Regulatory Review State of Victoria
- 1996-1998: Risk assessment of Lake Buffalo Dam, Goulburn-Murray Water
- 1996-1998: Risk assessment of Pykes Creek Dam, Southern Rural Water
- 1995 – 2017: >100 other risk assessments, consulting boards and reviews in Australia: New South Wales, Tasmania, Western Australia, Queensland, ACT and Southern Australia.
1. Purpose, Context and Scope

Risk assessments covering over 250 dams from the regulator’s perspective
VICTORIA'S REGULATION - STATEMENT OF OBLIGATIONS (SoOs)

- The SoOs are the primary regulatory instrument for public dams owned by Victoria’s water corporations. They impose obligations on water corporations in relation to risk management and dam safety.

- The SoOs state that owners must have ... regard to the ANCOLD Guidelines and have particular regard to:
  a) prioritising risks posed by the ... dams over all dams, components of dams and the types of failure; and
  b) giving priority to reducing risks to life above other risks; and
  c) basing the urgency of reducing the risk posed by a dam on the relativity of risks to the tolerability limits as defined in the ANCOLD Guidelines; and
  d) basing programs for reducing risk on the concept "As Low As Reasonably Practicable" as defined in the ANCOLD Guidelines; and
  e) where feasible, progressively implementing risk reduction measures to achieve the best outcomes for the available resources.
ANCOLD SOCIETAL RISK LIMIT OF TOLERABILITY

Figure 4. ANCOLD (2003) societal risk guideline for existing dams.

Figure 5. ANCOLD (2003) societal risk guideline for new dams and major augmentations.
ANCOLD INDIVIDUAL RISK LIMIT OF TOLERABILITY

- Existing dams: 1 in 10,000/year
- New dams or major augmentations of existing dams: 1 in 100,000/year
1.1 Purpose of the Risk Assessment

- To understand the safety status of the state’s large dams
- Determine a safety upgrade strategy and program
- Identify an investment program to manage risks
- Develop a comprehensive information portal
- Establish a risk-informed regulatory regime
Strategic Framework for Dam Safety Regulation
Water Group 2012

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1.2 CONTEXT FOR THE RISK ASSESSMENT

- Screening level RAs funded by government – 1995 Review of Headworks
- Once off co-funding for high risk dam fixes by government (1997) based on:
  - Owners undertaking Portfolio Risk Assessments
  - Detailed RAs for high priority dams
  - Developing and implementing a prioritized upgrade program
  - Reporting key information to the regulator annually
1.3 Scope of the Risk Assessment

- **Screening level** – using existing information, desk top, sampling techniques, expert opinion, development of high level priorities

- **Portfolio level** – some investigations, site visits, high level event trees, high level consequence mapping, workshops and peer reviews

- **Detailed level** – detailed investigations, modelling, expert panels, detailed event trees, consequence mapping
2. Baseline Risk Assessment

Statewide baseline and benchmarking
2.1 Potential failure modes identification

- Failure modes identified at each dam and summarized at portfolio and state level
- Using best available information at time of RA
- Identification of additional investigations and studies
- Expert workshops with regulator involvement
2.2 Evaluation against Dam Safety Standards

- **1995** regulatory policy – risk assessment for prioritization only with standard based fix
  - ANCOLD 1994 RA Guidelines
- **1997** policy changed to decision making based on risk but check against standards and identify gap
- **2004** policy changed to allow risk-informed decision making and optional checking against standards
  - After ANCOLD 2003 RA Guidelines
  - Note: ANCOLD position allows risk-informed decisions but need an eventual standards based fix
    - Implicit assumption that standards based fixes are lower risk than risk-based fixes
  - Now asking if they need to continue collecting standards information
2.3 Risk Model Form

- Statewide risk model
- Information collected on a web-based portal by regulator
  - Dam specifications and attributes
  - Failure probabilities
  - Consequences – potential life loss, economic, etc.
  - Individual and societal risk
  - Level of RA (uncertainty, confidence)
  - F-N plots, ALARP position
  - Planned upgrades
  - Costs
2.4 Estimation of Load Probabilities

- Various based on RA Level
2.5 Estimation of System Response Probabilities

- Various based on RA Level
2.6 ESTIMATION OF CONSEQUENCES

- Various based on RA Level
2.7 EXISTING DAM RISK ESTIMATES AND TOLERABLE RISK EVALUATION

- Regulatory position in SoOs: Must *have regard* to ANCOLD Guidelines
  - Means that ANCOLD should be used but allowed to deviate if an acceptable case is made
- ALARP – additional guidance provided to supplement ANCOLD
- Demonstration of continuous and progressive improvement
2.7 EXISTING DAM RISK ESTIMATES AND TOLERABLE RISK EVALUATION

- In practice, the **timeframe** for implementing a major dam safety upgrade from identification of risk through to investigations, approvals, design, implementation and commissioning can range from a few years to up to about ten years.

- Special requirements apply for dams that are **over an order of magnitude > LoT**:
  - Owners should investigate and implement short term or **interim measures to reduce risk to within at least one order of magnitude of the Limit of Tolerability**.
  - Interim measures may include a combination of **non-structural measures** (such as drawdown or operating restrictions within a **one year timeframe**) and **structural measures** (for example within a **two year timeframe**).
  - In these cases it is important to ensure that a **well exercised emergency plan** is in place.
  - In circumstances where it becomes apparent that there is an **imminent risk of failure**, immediate action is required.

- **Less than an order an order of magnitude > LoT**:
  - **Structural measures within 5 years with additional surveillance and well-exercised DSEP (EAP) in interim.**

- Similar requirements should apply to dams with deficiencies that have substantial economic consequences.
LIFE SAFETY RISKS BY LOADING CONDITION: TOTAL BY WATER CORPORATION

Comparison of societal risk across water corporations
- Flood (lives/year)
- Normal (lives/year)
- Seismic (lives/year)

Life Safety Risk (Statistical Lives/year)

Increasing risk, logarithmic scale

Water Corporation Identifier (No. of Assessments)

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Relative Life Safety Risks

Total Portfolio Societal Risk Across Water Corporations

Water Corporation Reference Number

RELATIVE LIFE SAFETY RISKS

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**Benchmarking - Two Dam Owners**

(a) ANCOLD Consequence Category - Hypothetical

(b) Compliance with ANCOLD Risk Guidelines - Hypothetical

(c) Surveillance Programs

(d) Dam Safety Emergency Plans
Goal is Green & Blue
Relative Life Safety Risks - Confidence Limits

Societal Dam Safety Risk by Corporation (Maximum, Minimum, Mean)

Life Safety Risk (log scale)

Water Corporation Reference Number

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2.8 INSIGHTS AND RECOMMENDATIONS

- RA skills and expertise improved over time (23 years) and now mainstream:
  - Owners (incl Boards), consultants, regulator (incl Board) & Independent Pricing Regulator
- Uncertainty of RAs are important and part of regulator/owner discussion
- Need to provide guidance where there is lack of clarity in ANCOLD and other publications
- Statewide – collectively, dam safety risks reduced by one order of magnitude over a 10 year period with a $200M investment
2.8 Insights and Recommendations

- Variations in risk numbers over time were analyzed and justification sought.
- Early assessments showed seismic risk dominating – surprising result for Australia.
  - due to highly conservative seismic attenuation relationships.
  - more realistic now with research and improved knowledge.
DOMINANT FAILURE MODES – STATE WIDE

Societal risk assessment results - dominant failure modes

- Piping through the embankment: 44%
- Stability: 17%
- Flood overtopping: 25%
- Foundation liquefaction: 1%
- Piping through the foundation: 8%
- Other: 5%
3. RISK REDUCTION ASSESSMENT

CONTINUOUS AND PROGRESSIVE IMPROVEMENT
3.1 IDENTIFICATION OF RISK REDUCTION ALTERNATIVES

- Short term non-structural options where time is needed for permanent fixes
- Efficiency in risk reduction
  - Low hanging fruit
  - Return for $ spent
  - Opportunities once mobilized on site
  - No price shocks for customers – full cost recovery principle
    - WA example
  - One case where a very costly fix has been postponed but the project is operating at a lower level with additional surveillance and EAP exercises
3.2 REPRESENTATION OF RISK REDUCTION ALTERNATIVES IN RISK MODEL

- Risk reduction per $ spent – key indicator at a dam, portfolio and state level
- Plots over time
- Representation on F-N diagram of options
PROGRESS OVER TIME: SINGLE DAM

- Monitor projected and achieved risk reduction – example is life safety risk
- Track expenditure/investment

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INVESTMENTS & RISK PROFILES

Completed and Future Cumulative Dam Safety Expenditure in Victoria

- Cumulative Completed Upgrade Expenditure
- Cumulative Future Upgrade Expenditure

Financial Year Ending

Cumulative Expenditure ($M)

$0.0  $50.0  $100.0  $150.0  $200.0  $250.0  $300.0  $350.0  $400.0


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MONITORING TRENDS

Demonstrates
• value for money
• Investment efficiency
3.3 Risk estimates and tolerable risk evaluation for alternatives

- Done by owner
- Proposed upgrade plan is reported to regulator
4. Limitations, Decisions, Risk Communication and Lessons Learned

Regulatory Policy and Organizational Governance
4.1 LIMITATIONS

- RA needs to supplement with other processes: inspection & surveillance, O&M, emergency plans
- Areas of uncertainty: piping failure, seismic behavior – require further research
- Need to better understand ALARP
4.2 Decision and Risk Management Recommendations

- Organizational governance
  - Clear roles & responsibilities in decisions
  - Risk culture within organizations
  - Assurance programs and audits
- Victoria’s large dams are below LoT and approaching ALARP
- This situation can change anytime!
**RISK REDUCTION PER $1 MILLION SPENT**

- Clear justification for safety upgrades
- Value for money
- Assists in ALARP

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**Risk Reduction Achieved per $1M Spent**

- > 1 order above ANCOLD LoT
- within 1 order above ANCOLD LoT
- within 1 order below ANCOLD LoT
- > 1 order below ANCOLD LoT

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4.3 Risk Communication

- Risk plots and maps are valuable for communicating risk
- Useful in developing business cases for funding proposals
  - Dam Safety and Pricing Regulator may review
- Language that policy makers and funding organizations understand
- Tool for engaging the community
- Appreciated by emergency response agencies
4.4 Lessons Learned

- Valuable to involve regulator in RAs
- Need to undertake forensic analysis after incidents and failures for use in future RAs
- RAs can be used to provide assurance to regulator, government and community

‘the journey is the destination’
QUESTIONS?