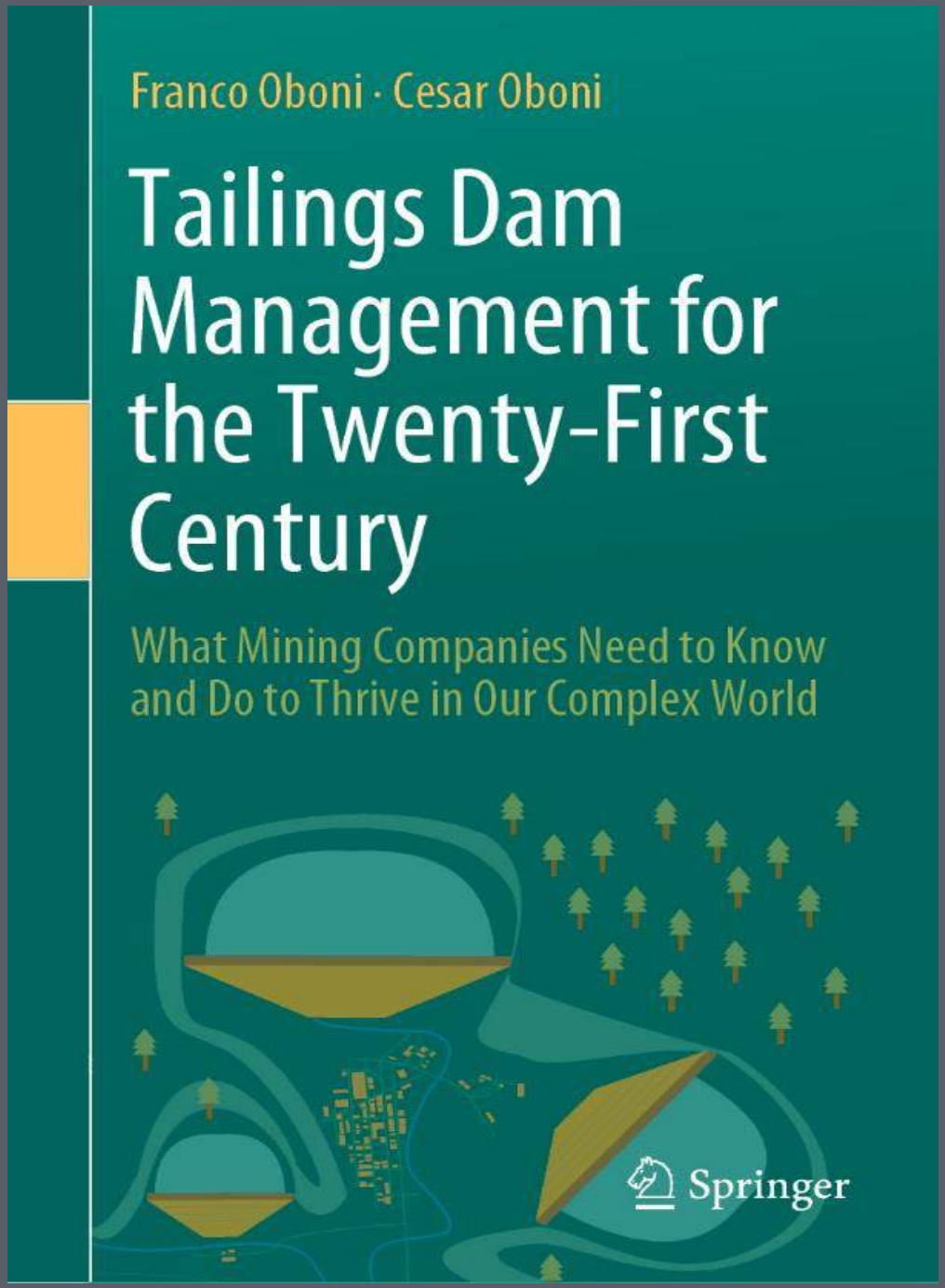


Book Presentation

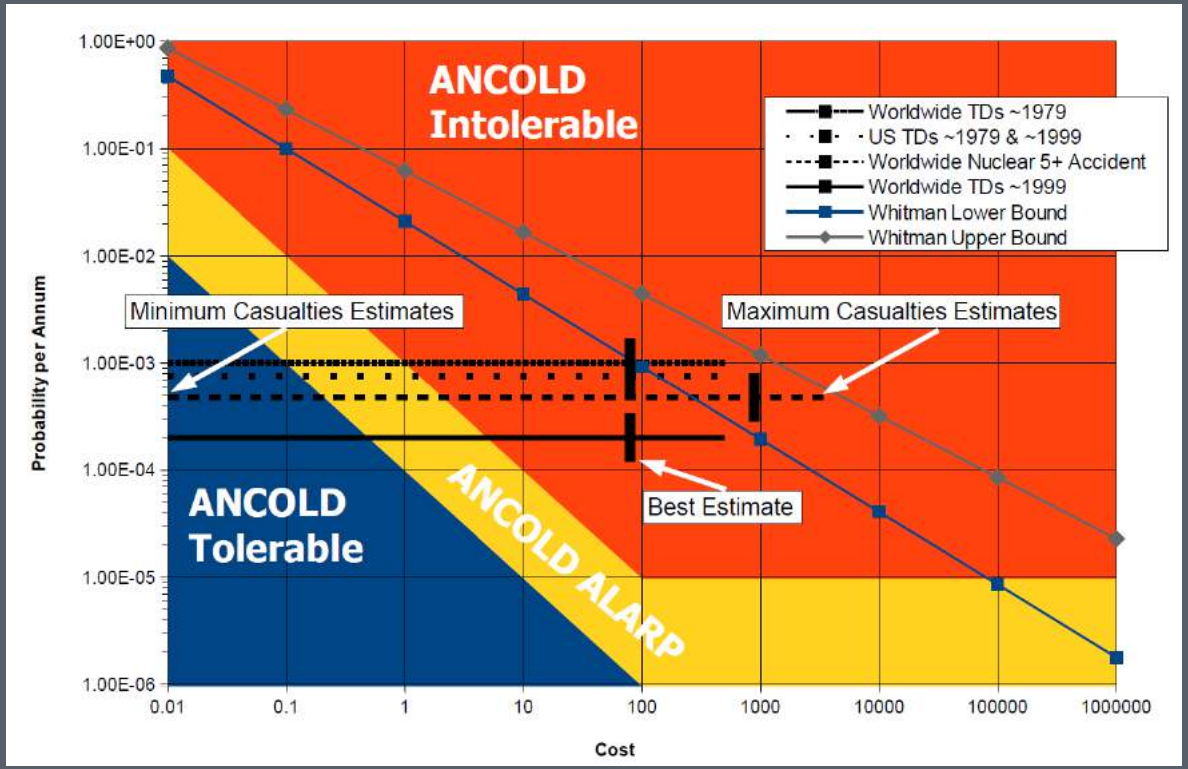
Riskope's Research History

After twenty years of continuous applied R&D we started publishing…

Tailings and Mine Waste - TMW 2013

First world estimate of the rate of failure of major tailings dams.

Compared their human casualties risks to well known social tolerance.



Riskope's research showed quantitatively

how, over time, multiple hazards hits would significantly increase the probability of failure of a dam, leading to intolerable future risks.

We noted: "... Especially in the case of TDs located in areas where demographic pressure leads to settlements in the downstream areas, social and legal consequences of a failure will dramatically increase."

Riskope's Research

Long term survivability of TD was further detailed at TMW 2014.

We looked at multidimensional estimate of consequences. Conclusion: "... Should consequences increase, ...then even an "excellent dam" would soon become societally unacceptable.

Any dam starting its life with a small initial FoS or reduced standards of care (...) would become intolerable, even if its consequences of failure remain constant

Riskope's Research Context

… and then we kept publishing on methodological approaches and the possible use of space observation…

TMW 2015:

We stated that "...
The common practice approach of using oversimplified consequence functions (with "and/or" clauses) is ubiquitous.

However, it should not be accepted for a rational world-wide approach to decision making and risks management for an industry that has significant societal impacts like mining.

What Mining Companies Need to Know and Do to Thrive in Our Complex World

Recent dam failures have demonstrated the need for improvements in the design, management and regulation of tailings management facilities to reduce, and eventually eliminate, the risks of failure of existing and future facilities.

Tailings Dams Management for the Twenty-First Century, 2019: Book PART I

State of Affairs,
looks at several examples of recent catastrophic failures from a forensic analysis point of view, as they were performed by various independent review panels and entities.

Part II: How to Build a Twenty-First-Century Comprehensive Risk Management Program

Shows how to build a predictive model based on lesson learned and risk assessments based on facts, observations, as opposed to fear and gut-driven statements.

References can be found in the following papers:

- Innovation in Dams Screening Level Risk Assessment, ICOLD 2019
- Space Observation, Quantitative Risk Assessment Synergy Deliver Value to Mining Operations & Restoration, Symposium on Mines and the Environment, Rouyn-Noranda, 2018
- Screening Level Risk Assessment for a Portfolio of Tailings Dams, Canadian Dam Association Vol. 28 No. 4 Fall 2017

PART III Case Histories and a Look into the Future

Features a risk-informed decision-making deployment example on a portfolio of real-life dams.

It includes:

- benchmarking existing facilities,
- enabling decision based on evidence and not fear,
- notes on enhanced risk communication.

PART I State of Affairs

Numerous accidents have stirred attention

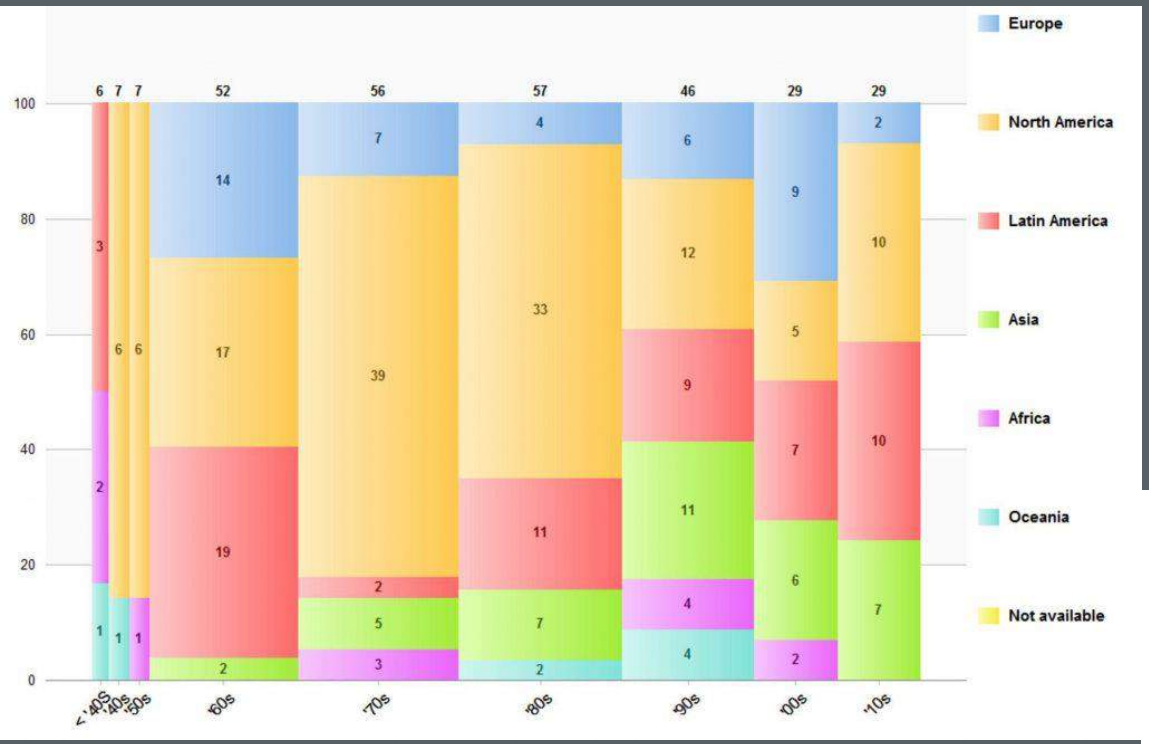
Data set example: www.wise-uranium.org

Date	Location	Release
2019, July 10	Cobriza mine, San Pedro de Coris district, Churcampa province, Huancavelica region, Peru	67,488 m^3 of tailings
2019, Apr. 22	Hpakant, Kachin state, Myanmar	?
2019, Apr. 9	Muri, Jharkhand, India	?
2019, Mar. 29	Machadinho d'Oeste, Oriente Novo, Rondônia, Brazil	?
2019, Jan. 25	Córrego de Feijão mine, Brumadinho, Região Metropolitana de Belo Horizonte, Minas Gerais, Brazil	12 million m^3
2018, June 4	Cieneguita mine, Urique, Chihuahua, Mexico	249,000 m^3 of tailings and 190,000 m^3 of embankment material
2018, Mar. 9	Cadia, New South Wales, Australia	1.33 million m^3 of tailings
2018, Mar. 3	Huancapatí (Huancapetí), Recuay province, Áncash region, Peru	80,000 m^3 of tailings
2018, Feb. 17	Barcarena, Pará, Brazil	?
2017, Sep. 17	Kokoya Gold Mine, Bong County, Liberia	discharge of 11,500 m^3 of slurry containing cyanide into Sien Creek, a major water source for residents in Saywehta Town
2017, June 30	Mishor Rotem, Israel	100,000 m^3 of acidic waste water
2017, Mar. 12	Tonglvshan Mine, Hubei province, China	approx. 200,000 m^3 of tailings
2016, Dec. 28	Satemu, Hpakant, Kachin state, Myanmar	?
2016, Oct. 27	Antamok mine (inactive), Itogon, Benguet province, Philippines	at least 50,000 t of tailings (an amount considered "negligible" by the company)
2016, Aug. 27	New Wales plant, Mulberry, Polk County, Florida, USA	840,000 m^3 of contaminated liquid released (as of Sep. 17, 2016)
2016, Aug. 8	Dahegou Village, Luoyang, Henan province, China	?
2015, Dec. 14	Lamaungkone, Hpakant, Kachin state, Myanmar	?
2015, Nov. 21	San Kat Kuu, Hpakant, Kachin state, Myanmar	?
2015, Nov. 5	Germano mine, Bento Rodrigues, distrito de Mariana, Região Central, Minas Gerais, Brazil	32 million m^3
2014, Sep. 10	Herculano mine, Itabirito, Região Central, Minas Gerais, Brazil	?
2014, Aug. 7	Buenavista del Cobre mine, Cananea, Sonora, Mexico	40,000 m^3 of copper sulphate
2014, Aug. 4	Mount Polley mine, near Likely, British Columbia, Canada	7.3 million m^3 of tailings, 10.6 million m^3 of water, and 6.5 million m^3 of interstitial water
2014, Feb. 2	Dan River Steam Station, Eden, North Carolina, USA	about 82,000 short tons [74,400 t] of toxic coal ash and 27 million gallons [100,000 m^3] of contaminated water

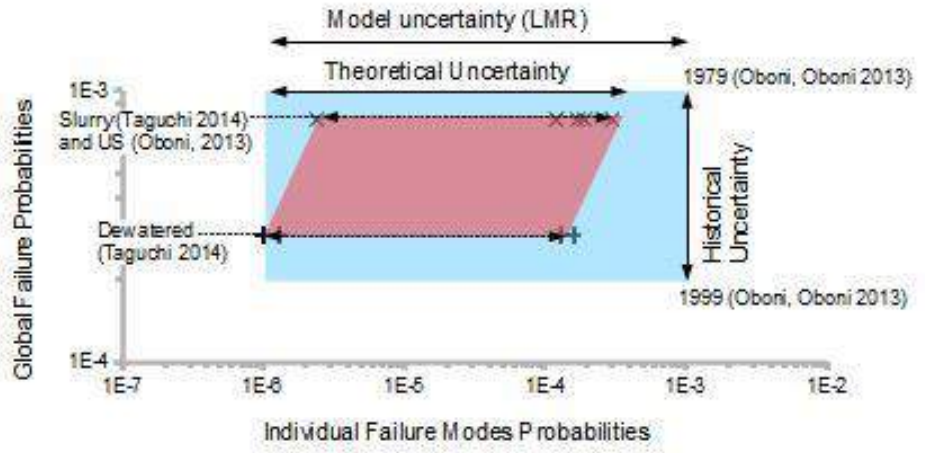
PART I State of Affairs

Media, activists and public satellite observation have stirred emotions and politicians have come to the debate.

PART I: Failure Data



Data exist (although imperfect). In some cases they have been manipulated to stir more emotions, draw "correlations" of doubtful nature… but there are ways to remain scientifically sound!



PART I State of Affairs

"Trust us" no longer works. Demonstrated commitment supported by leading edge risk assessments will.

A strategic intent is required to meet the needs of modern society and allow miners to pursue a sustainable future.

Self-identified common practices and even so-called "best practices" have failed in preventing catastrophic failures.

PART I State of Affairs remarks

Many codes "talk" about what should be done but offer no solution.

For example the MAC says that it is best practice for an EoR to monitor
"performance objectives and indicators" but it doesn't say what these are.

PART I State of Affairs remarks

In October 2017 the United Nations Environment Program (UNEP) in Geneva released a UNEP-GRID Arendal assessment report entitled “Mine Tailings Storage: Safety Is No Accident” (Roche et al. 2017).

The report urges States and the industry to end deadly and damaging mining waste spills by adopting a zero-failure objective.

Again it gives general advice but does not say how.

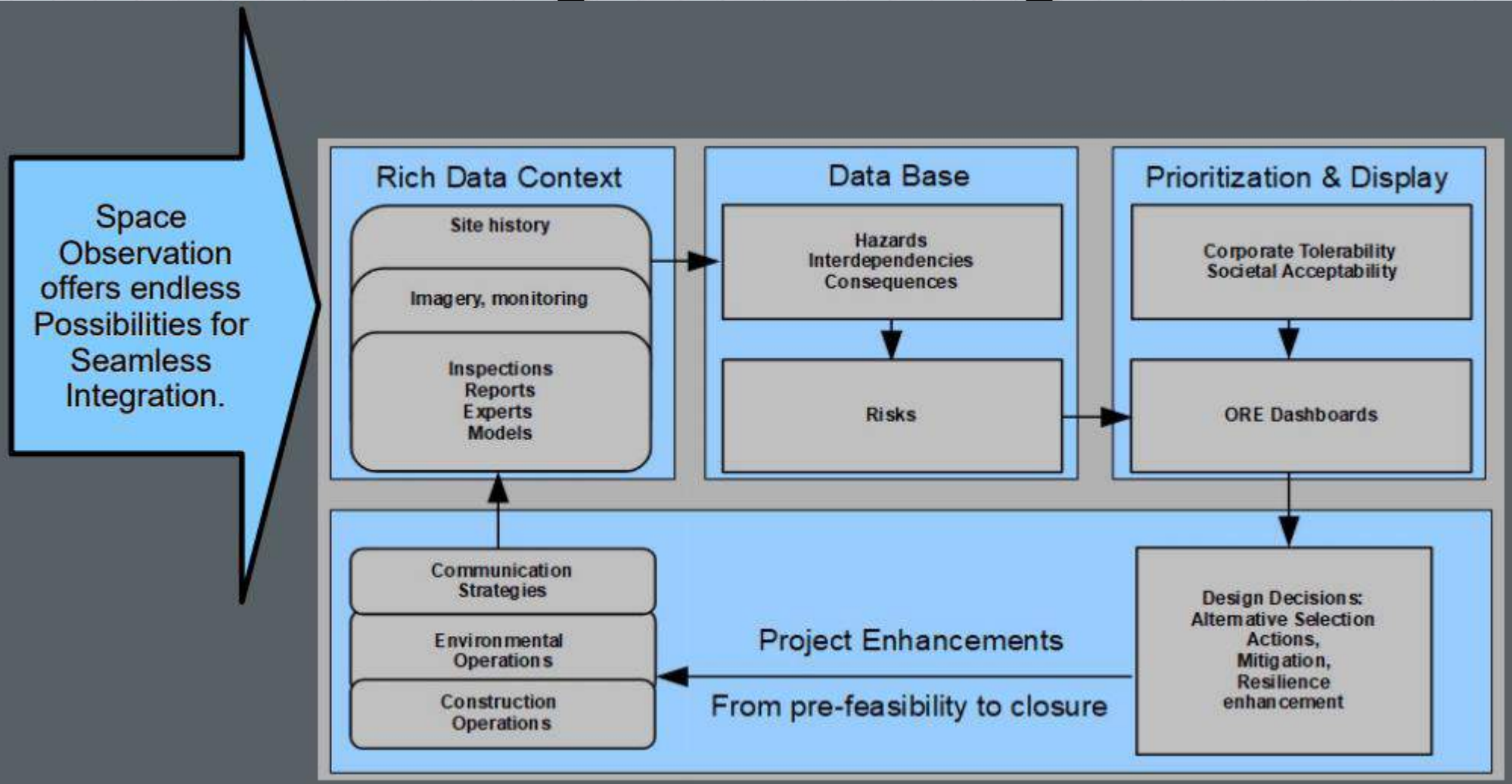
PART I State of Affairs remarks

Public Hearing in the NWT: Environmental Rehabilitation of the Giant Mine

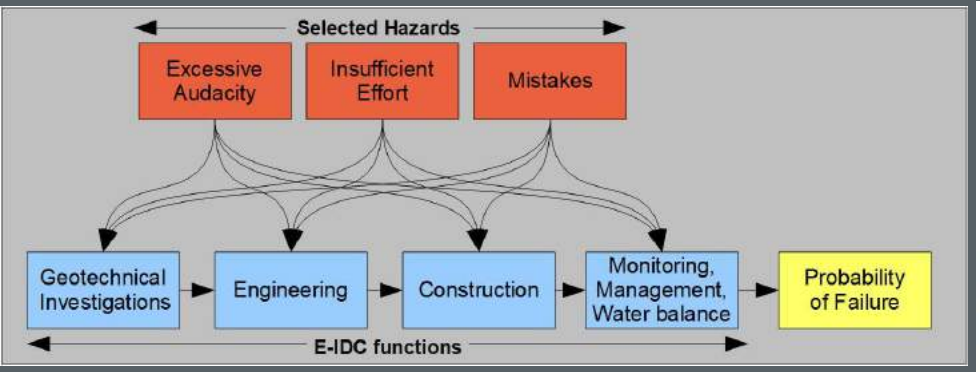
Sendai Framework

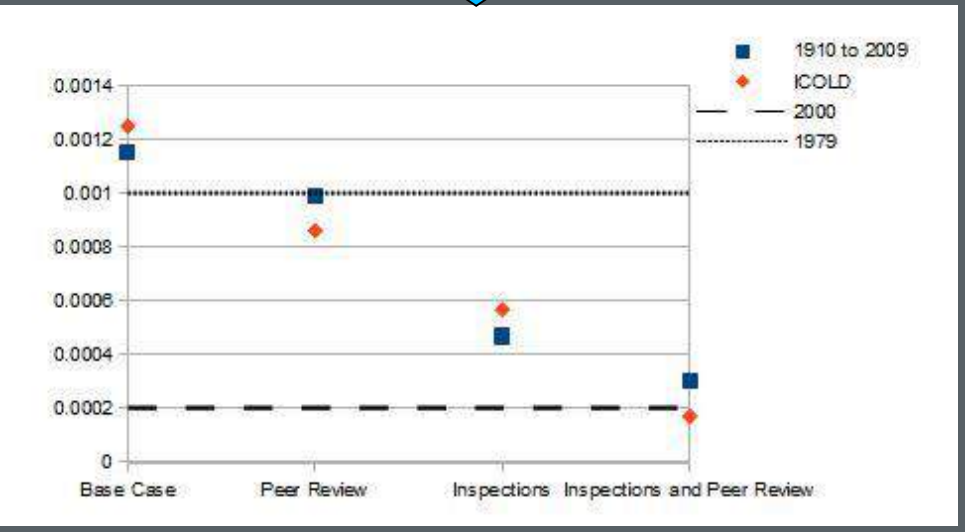
State what "people want"!

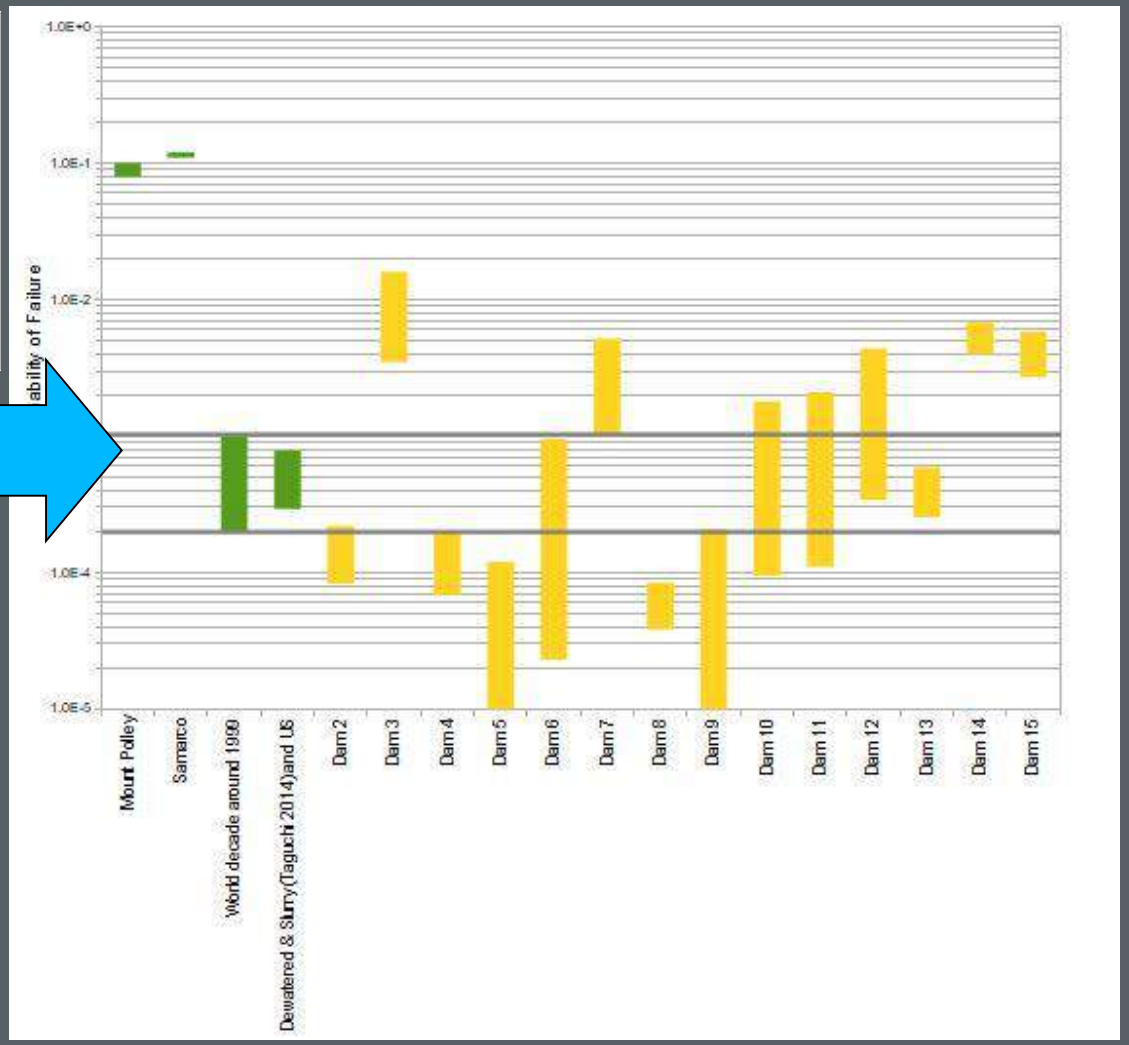
Part II: How to Build a Twenty-First-Century Comprehensive Risk Management Program



Part II: How to Build a Twenty-First-Century Comprehensive Risk Management Program

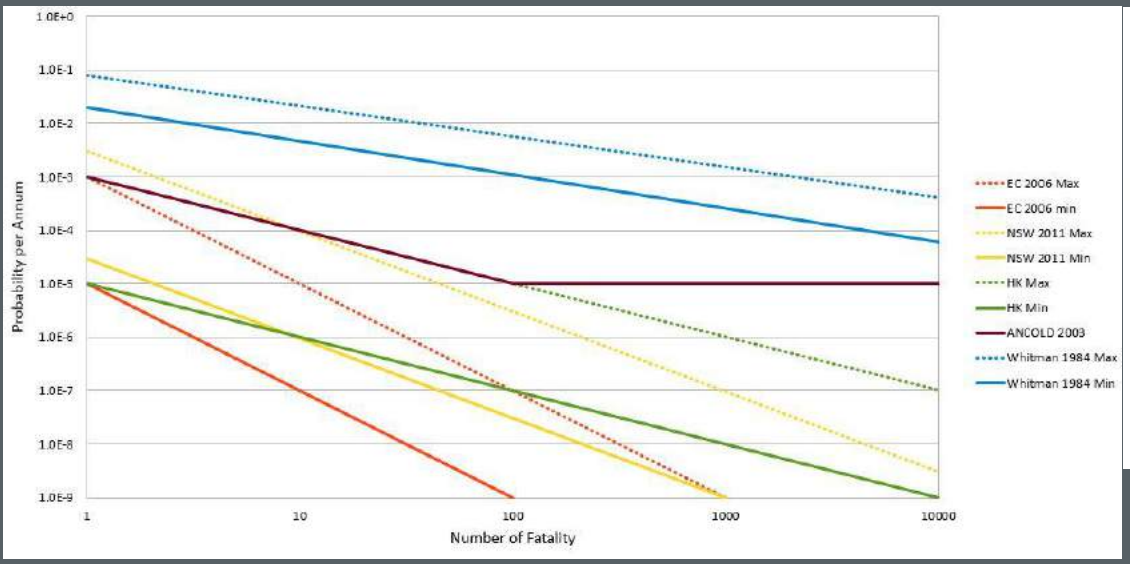




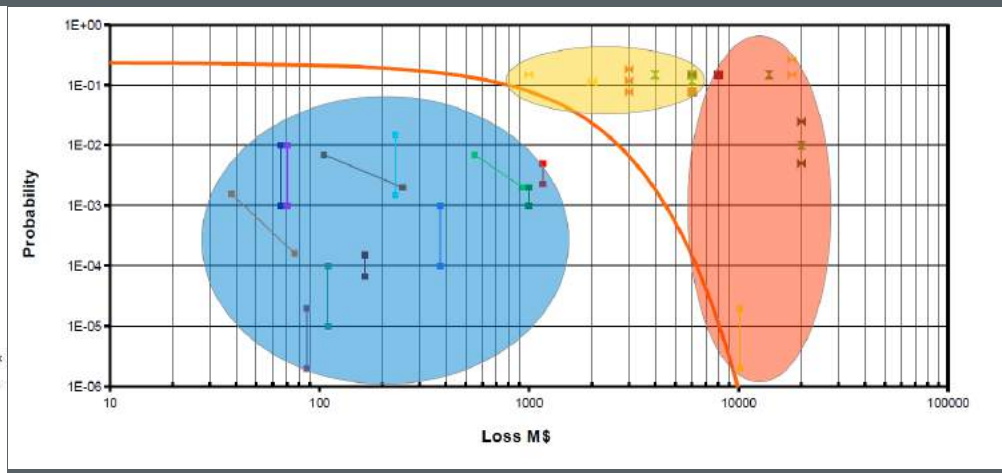


Part II: How to Build a Twenty-First-Century Comprehensive Risk Management Program

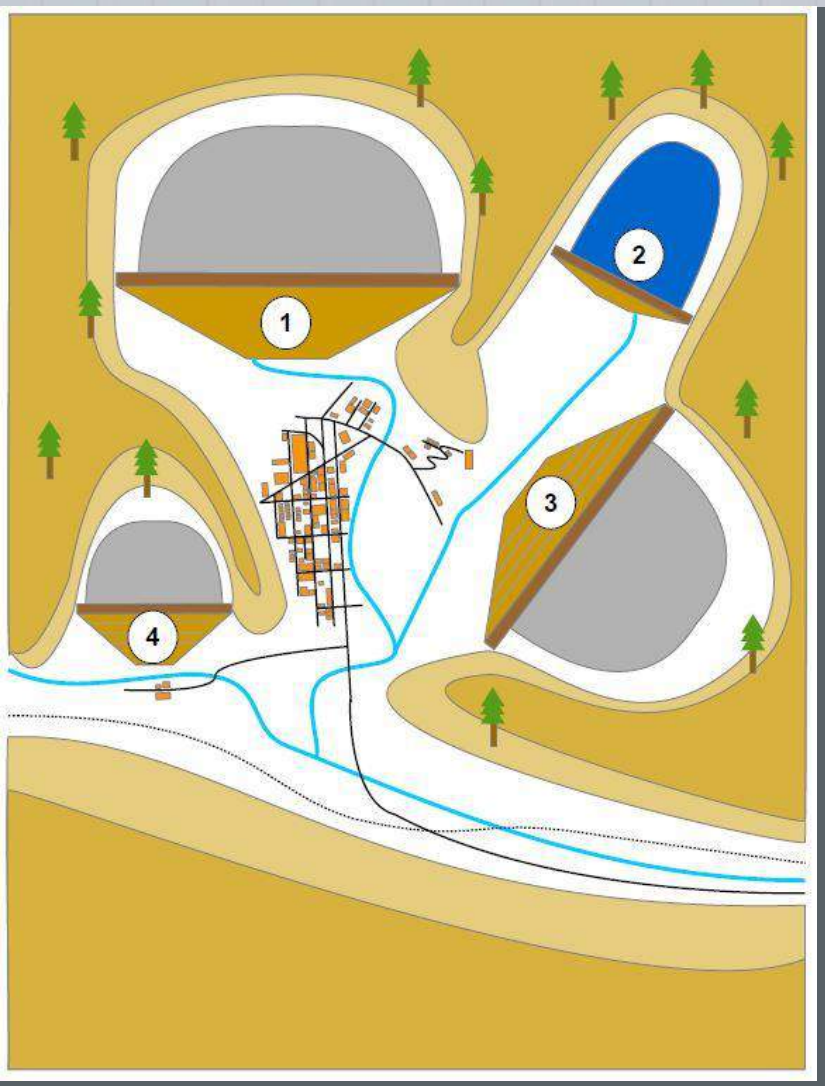
Risk tolerance has to be considered. Societal (by jurisdiction):



There are two types: Corporate (by company, project, operation):



PART III Case Histories and a Look into the Future

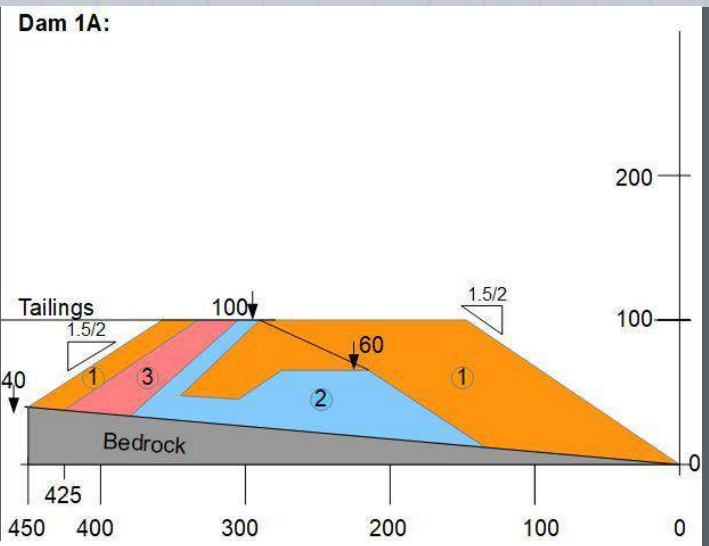


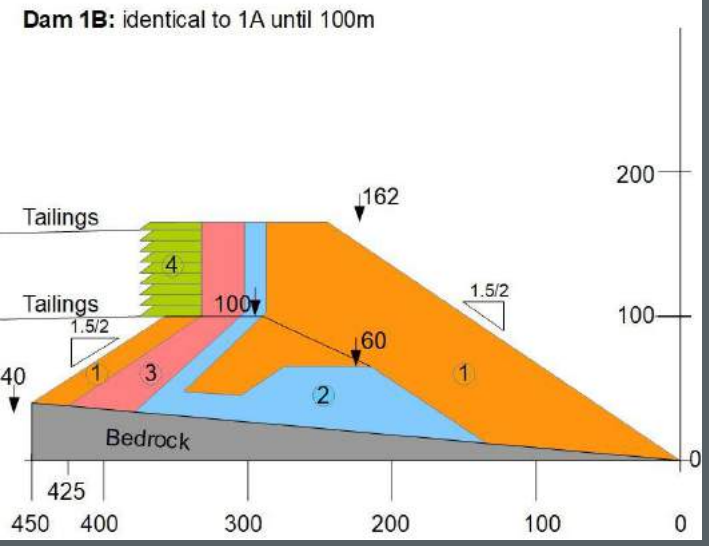
Fictitious portfolio of real-life dams of different types.

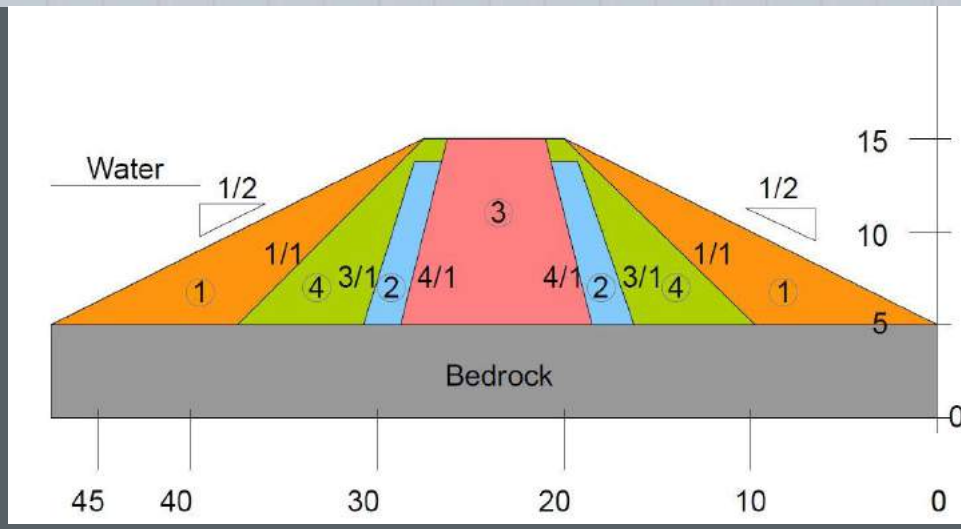
Complex environment.

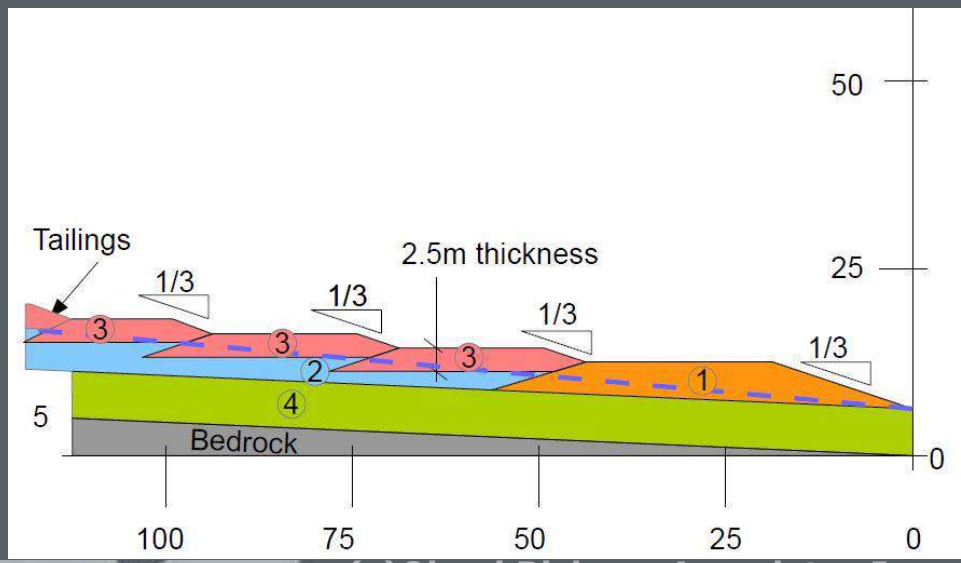
Interdependent failures.

PART III Case Histories and a Look into the Future



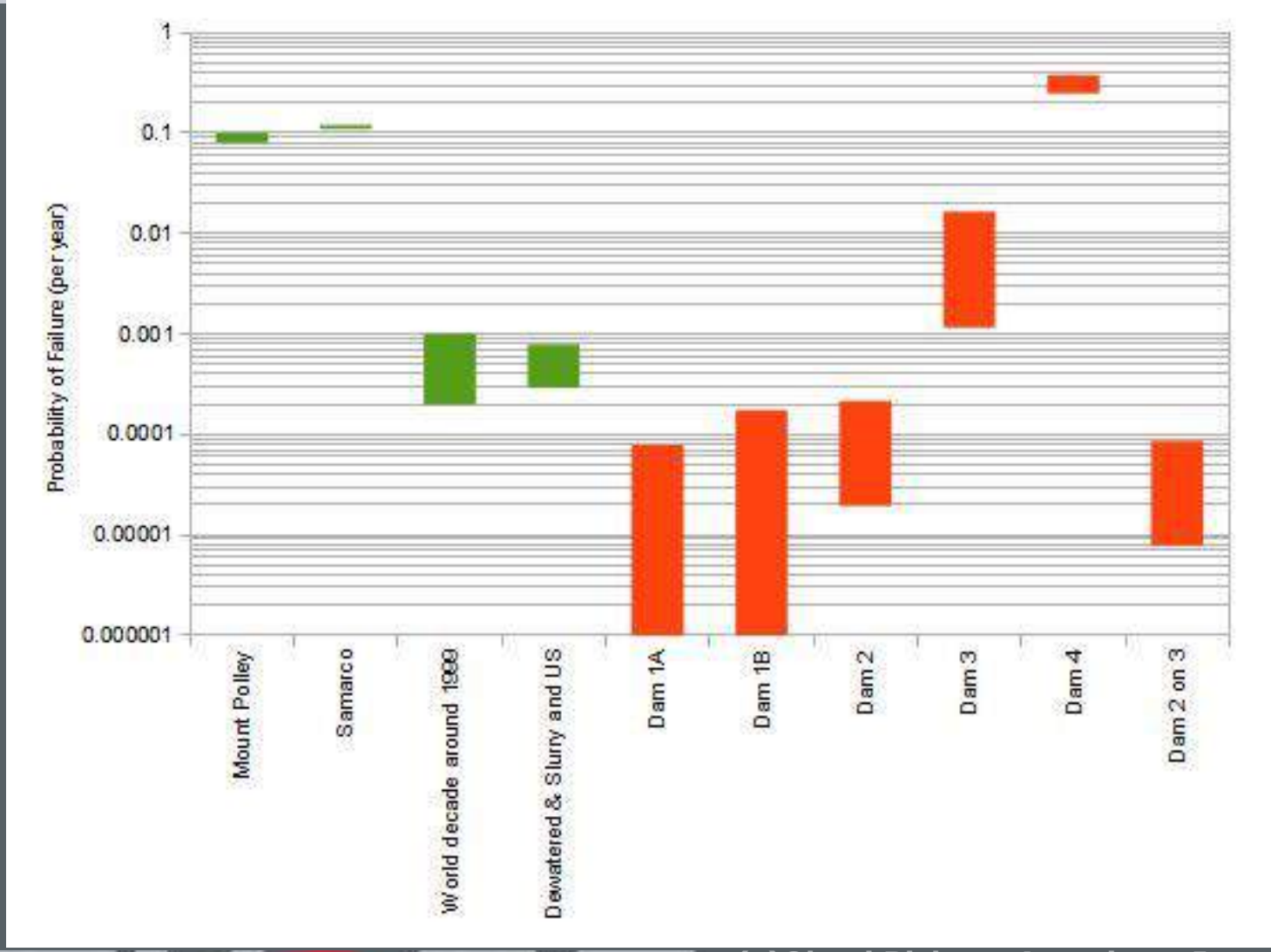






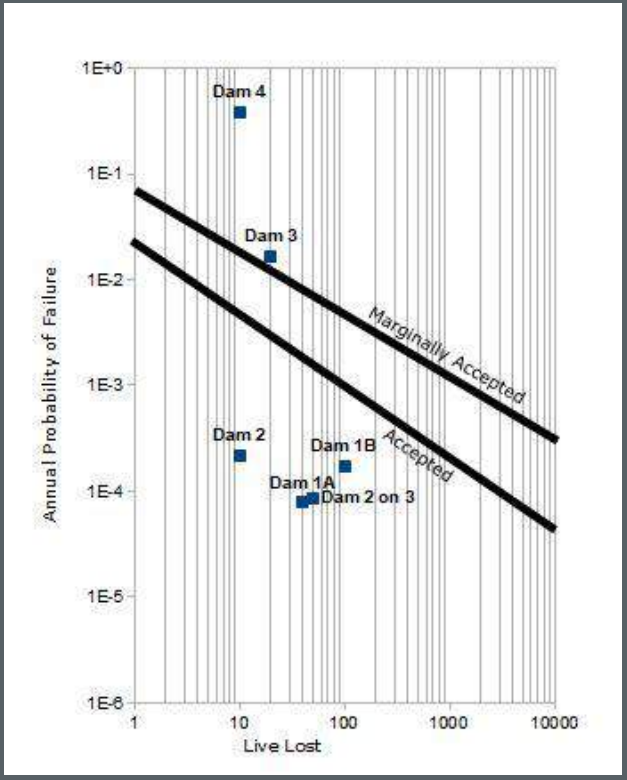
PART III Case Histories Results

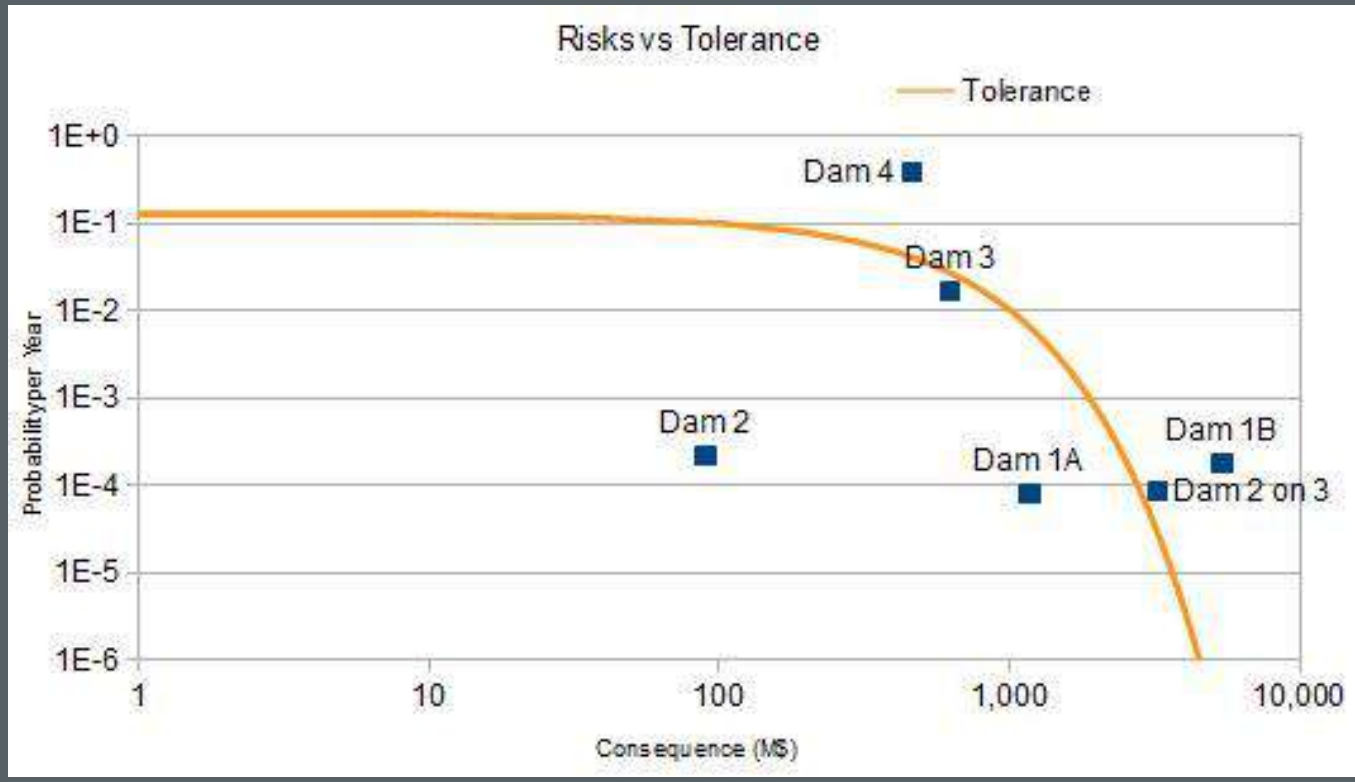
Benchmarking of the probabilities of failure vs. catastrophic accidents, vs. hundred years records.



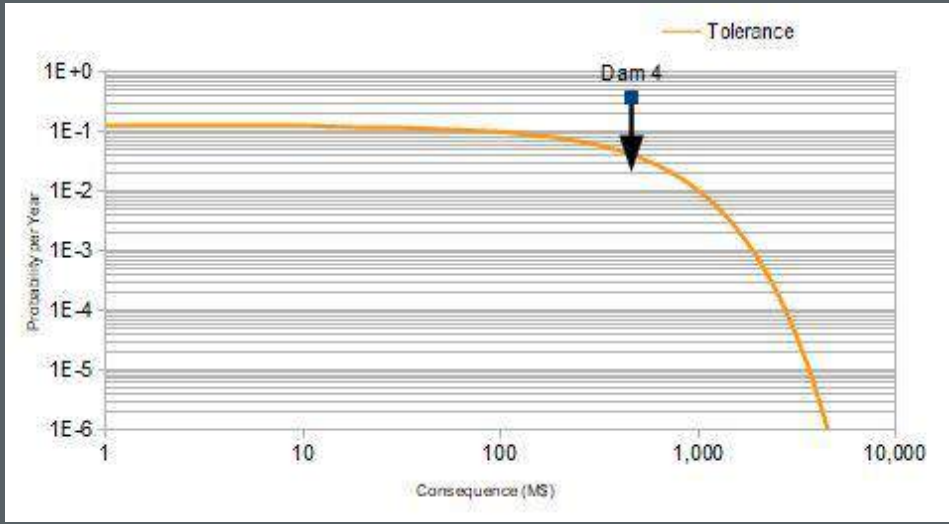
PART III Case Histories Risks vs. Societal and Corporate Tolerance

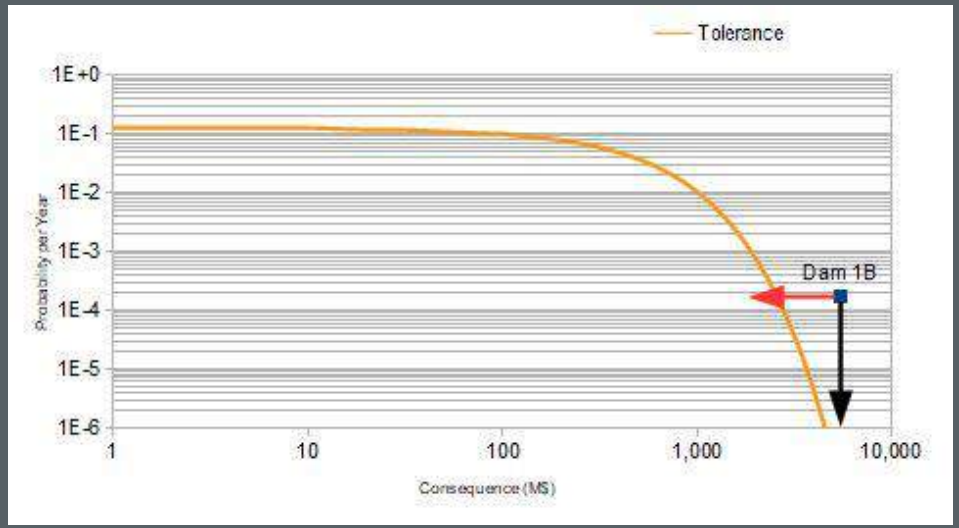
Using societal and corporate risk tolerance.

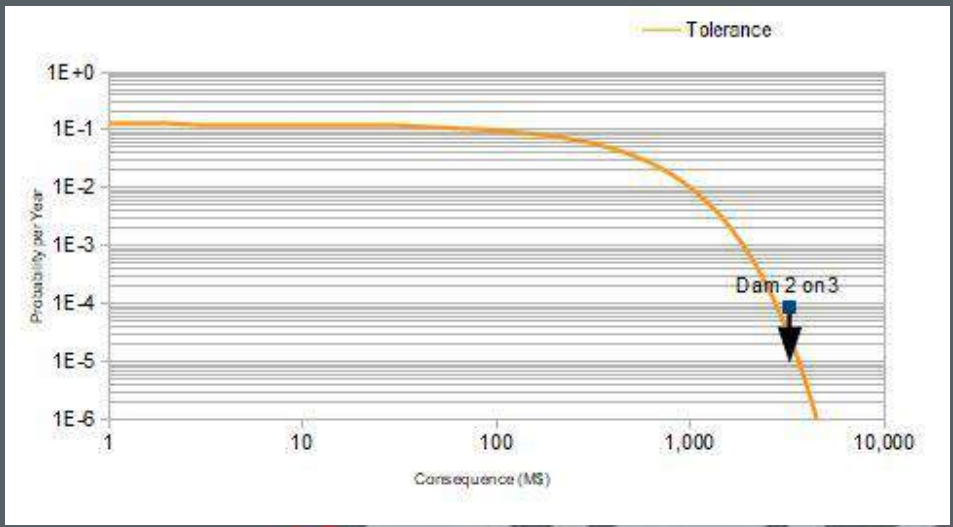




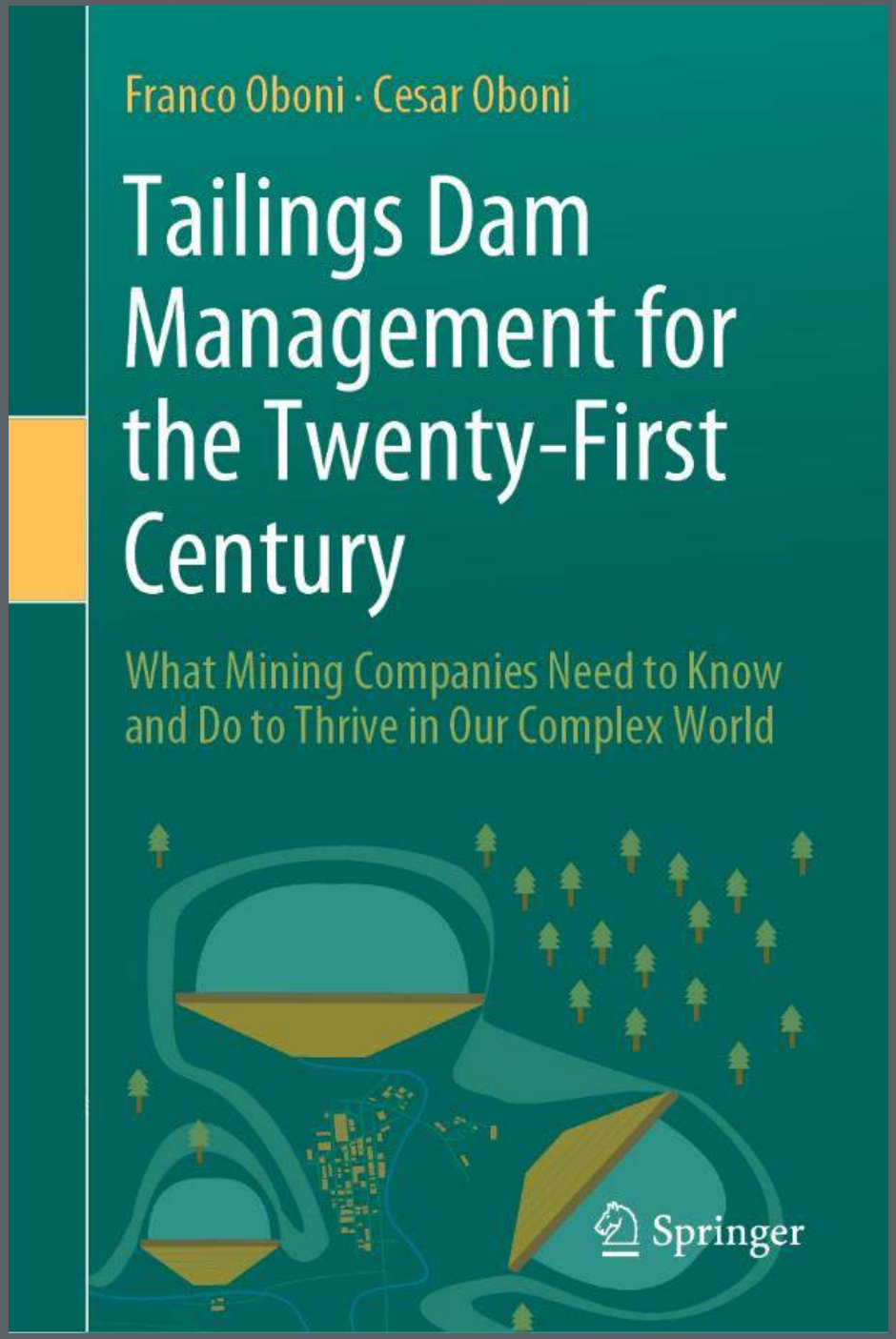
PART III
Risk Informed Decision Making







Tactical and strategic risks result from analysis, not from a priori decisions. They can be tackled rationally and efficiently.



Oboni F., Oboni C.
Tailings Dam Management for the Twenty-First Century.

From the same authors and friends:

- Global Hot Spots: How Project and Enterprise Risk Management Practices Drive Business Results Around the World
- The Long Shadow of Human-Generated Geohazards: Risks and Crises