Using tolerable risk guidelines to manage flood risk

Floodplain Management Association: Reno

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There is an important distinction between flood hazard and flood risk.

Hazard is important. But…

We need to understand communicate, and manage flood risk.
Today’s discussion

• What is risk and tolerable risk?
• How to use risk analysis in floodplain management
• International Examples
• Takeaways

Netherlands

New Zealand
What is risk?
What is Risk?

What is the hazard and how likely is it to occur?

What is the pathway of hazard to the receptor?

How will infrastructure perform?

Who and what are in harm’s way?

How vulnerable are they to harm?

How much harm will be caused?
What is risk?

**Risk** = Probability x Consequences

Image adapted from HR Wallingford and Anna Serra Llobet
How do we measure risk?

**Loss of life: Expected Annual Fatalities (EAF)**

- Considers the *probability* of flooding
- **Consequences** of flooding:
  - Number of individuals exposed to floodwaters
  - Affected by warning time, water depth and velocity, rate of rise, water temperature, etc.
How do we measure risk?

Damage to property and infrastructure: *Expected Annual Damages (EAD)*

- **Probability** of flooding
- **Consequences** of flooding
  - Assets, infrastructure
  - Depth Damage curves
- Integrates the product of these over all flood levels
Quantifying risk enables

• “If you can’t measure it, you can’t manage it”
• How much risk is there?
• Where risks are greatest?
• What actions to take?
• Are risks tolerable? Is more risk reduction warranted?

How do we decide whether risks are tolerable?
What is tolerable risk?
Consider that risk cannot be eliminated.
Tolerable risk is

The level of risk that people are willing to live with in order to secure certain benefits

Unacceptable | Broadly acceptable
---|---
Range of Tolerability
We make decisions everyday on what level of risk is tolerable to us
With the NFIP, we tend to focus on the hazard

Risk = **Probability** \(\times\) Consequences

Image adapted from HR Wallingford and Anna Serra Llobet
And often ignore consequences

Risk = Probability \times Consequences
Limitations of the NFIP approach

- Insurance standard
- Measures water level, not risk
- Implies risk can be eliminated
- Favors structural solutions
- Hard to measure
  - Risk reduction
  - Cost-effectiveness

LOP prevents discussion of how safe is safe enough?
Current approach ignores residual risk

Residual risk is the flood risk that remains after actions have been taken to reduce that risk

Adapted from Eisenstein et al (2007)
Ignoring residual risk has adverse consequences

- Public safety
- Land use
- Infrastructure investment
- Preparedness

Principles of Tolerable Risk

Life safety is paramount
Risk cannot be ignored
Absolute safety cannot be guaranteed
Equity and efficiency

ALARP: As Low As Reasonably Practicable
Tolerable Risk Guidance in the US

Best practices identified by USACE and USBR (2015)

Manual encourages risk assessment procedures (revised 2018)

Risk-informed planning manual (revised 2017)
Tolerable risk guidance from other settings

Nuclear Power Plants

Commercial Aviation

Dams

Hazardous Occupations
How safe *is* safe enough?

- Informed by analysis, risk assessment, and *communication*

- Considers:
  - Individual risks
  - Societal risks
  - Equity

*A policy decision with expert input*
Risk-informed decision making in FPM
Applying tolerable risk principles

Characterize Risk
- Inventory assets
- Identify Hazards
- Assess vulnerabilities
- Calculate risk & uncertainty

Identify Options to Reduce Risk
- Structural
- Non-structural
- Nature-based
- Calculate risk reduction

Implement Measures & Continuously Review
- Communicate risks
- Adapt to change
- Perform robust OMRR&R*

Evaluate Options
- Do measures reduce risk to tolerable levels?
- Compare cost-effectiveness measures, trade-offs
- Assess residual risk

*Operations, maintenance, repair, replacement, and rehabilitation
Advantages of a risk-informed approach over the NFIP approach

Facilitates

• Understanding risk
• Communicating risk
• Managing risk

Enables

• Evaluation of trade-offs and **cost-effectiveness**
• Allocating scarce resources
• Fair treatment

Recognizes

• Risk cannot be eliminated
• Absolute protection is not possible
Example: Applying risk analysis to decision-making

- 81 percent residential
- 19 percent commercial and infrastructure
Applying risk analysis to decision-making

DISTRIBUTION OF ASSETS

- 81 percent residential
- 19 percent commercial and infrastructure

- ~90 percent of EAD occurs from floods having a return period of < once in 10 years
Applying risk analysis to decision-making

DISTRIBUTION OF ASSETS

• 81 percent residential
• 19 percent commercial and infrastructure

EAD vs. RETURN PERIOD

• ~90 percent of EAD occurs from floods having a return period of < once in 10 years

Non-structural solutions may be the most cost-effective
International Examples of Risk-informed Decision making
Netherlands: a long history of flood prevention until...
1953 North Sea flood informed contemporary Dutch floodplain management
Intolerable Risk: Never again!

Late 1950’s move toward risk-informed standards

- Higher levels of protection in areas with greater number of people and assets
- Lower levels of protection with fewer people and assets
Flood Prevention: “Dry feet”
Recognizing increasing risk, Dutch flood policy evolves

Flood control to flood risk management

“Multi-layered safety”: Prevention, Protection, Preparedness

Image adapted from HR Wallingford and Anna Serra Llobet
Netherlands sets risk-based safety standard

- **Individual life risk standard**: 1/100,000 chance of dying from a flood per year.
- Higher safety standards in areas of great “societal risk”
- Investment priorities determined by economic efficiency
Netherlands sets risk-based safety standard

- Use “Multi-layered safety” where levee investment cannot be justified
- Use benefit-cost analysis to determine levee height
How one might apply this risk-based standard

**EAF:** 1/100,000 annual chance of dying from flood

Option 1: Levee: 1/100,000 water level
Option 2: smaller levee, 1/10,000 water level + elevate + evacuate for additional x 10
Dutch Takeaways

- It is possible to shift a decades-old paradigm from flood control to flood risk management
- Setting a risk-based standard (instead of probability-based) enables more flexibility in meeting standards
- Using risk analysis enables a cost-effective and efficient means of prioritizing actions
New Zealand: Franz Josef Glacier
The West Coast town facing an impossible choice: move or face destruction

SAM STRONG
Last updated 05:00, October 8 2017

Franz Josef township attracts up to 500,000 visitors a year.

Franz Josef Glacier, a jewel in the crown of New Zealand's tourism industry, is constantly on the move.

The frozen river of ice that meets sub-tropical forest in spectacular fashion on the has been steadily retreating since 2008.
Flood risk management in New Zealand

New Zealand is highly exposed to multiple geologic hazards

Central government: emergency response

Local & regional governments: floodplain management and flood defense

No national “level of protection” standard
Image: Jessica Ludy

Franz Josef Glacier

Waiho River
Franz Josef Glacier: Tourism Hot Spot

- Population: 510
  - (444 rateable properties)
- Tourism
- Unesco World Heritage Site
Retreating glacier, alluvial fan, stopbanks
Flooding
March 2016

“1-meter of gravel through the hotel”

An aerial view of the flooding. Photo from the Greymouth Star

Also... earthquakes.

Source: Natural Haz. Assessment for town of Franz Josef Glacier
Risk-informed planning

1. Characterized Conditions
2. Analyzed Risk and Vulnerability
3. Identified Possible Solutions
4. Evaluated and Compared Solutions
Characterize, Quantify Risk & Vulnerability

Hazards
- Earthquake
- Flood
- Landslide

Assets
- Infrastructure
- 510 people
- Tourism industry
- Unesco World Heritage site
Identify options to reduce risk

**Living with Nature’s Challenges**
- Relocate main assets off of fault
- Allow the Waiho River more room, stop improving levees

**Avoiding Nature’s Challenges**
- Relocate the entire town

**Defending against nature’s challenge**
- Stay put
- Improve levees
- Remove gravel
Evaluate Risk Reduction Options

- Risk Reduction
  - Earthquake Risk
  - Flood risk
  - Landslide risk
- Disruption to community
- Investment certainty
- Cost (Benefit cost)
- Tradeoffs
Top performers:
Both require level of understanding and tolerance of risk which they cannot do if they do not assess/quantify risk

**Living with Nature’s Challenges**
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Next steps for Franz Josef Glacier

• Stakeholder groups
• Governance
• Decision
Next steps and Takeaways

• Convene stakeholder groups and decide.

• Quantifying risk enables evaluating alternatives for how well they reduce all types risks

• Communicating all risks and alternatives allows stakeholders to determine whether risks are tolerable as they are, or whether more action is warranted
Conclusions
Why use a risk-informed approach?

• Facilitates understanding, managing, and communicating **risk**
  - Whereas the NFIP only considers the hazard
• **How safe is safe enough?**
• Enables selection of measures from full suite of options based on risk reduction and cost effectiveness
• Promotes efficient use of public resources
• Recognizes that absolute protection is not possible
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