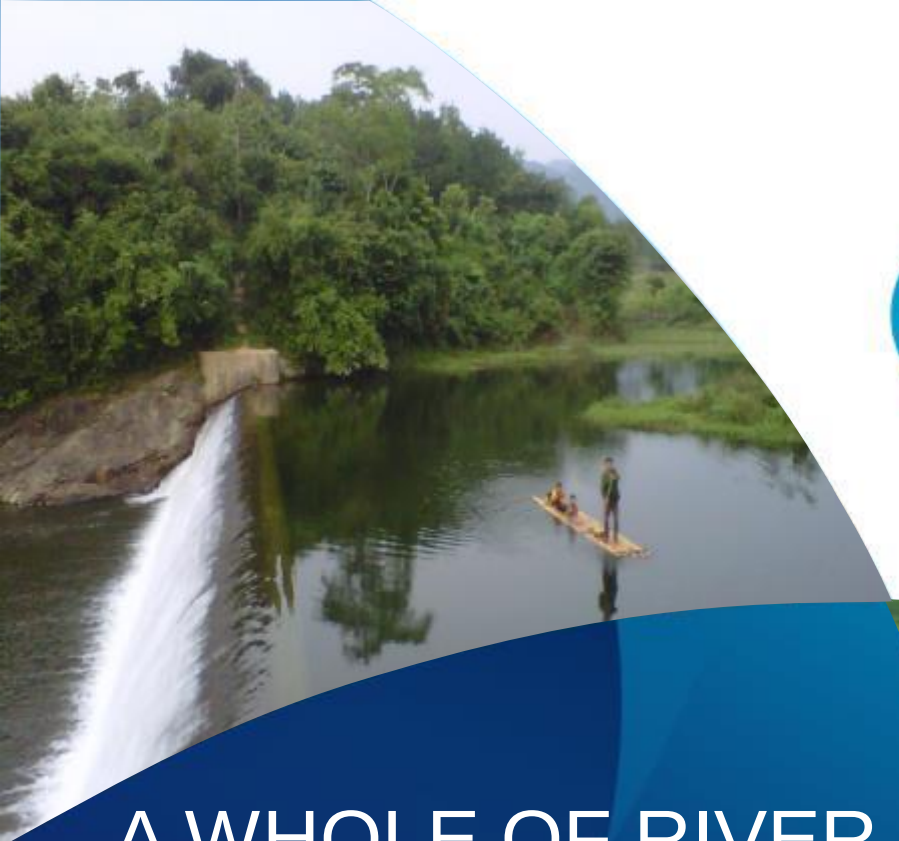


# A WHOLE OF RIVER BASIN APPROACH TO HYDROPOWER DAM SAFETY

12 November 2015

Rebecca Knott, Damwatch Engineering
Kelvin Berryman, GNS Science
New Zealand

# Contents

# Introduction

- Damwatch and GNS - International consultants
- 30+ years working together on design and safety assessment of new and existing dams

Dam engineering specialists

* design and rehabilitation

* dam safety & monitoring

* instrumentation

www.damwatch.co.nz

New Zealand's leading provider of Earth, geoscience and isotope research and consultancy services.

http://www.gns.cri.nz

# Introduction

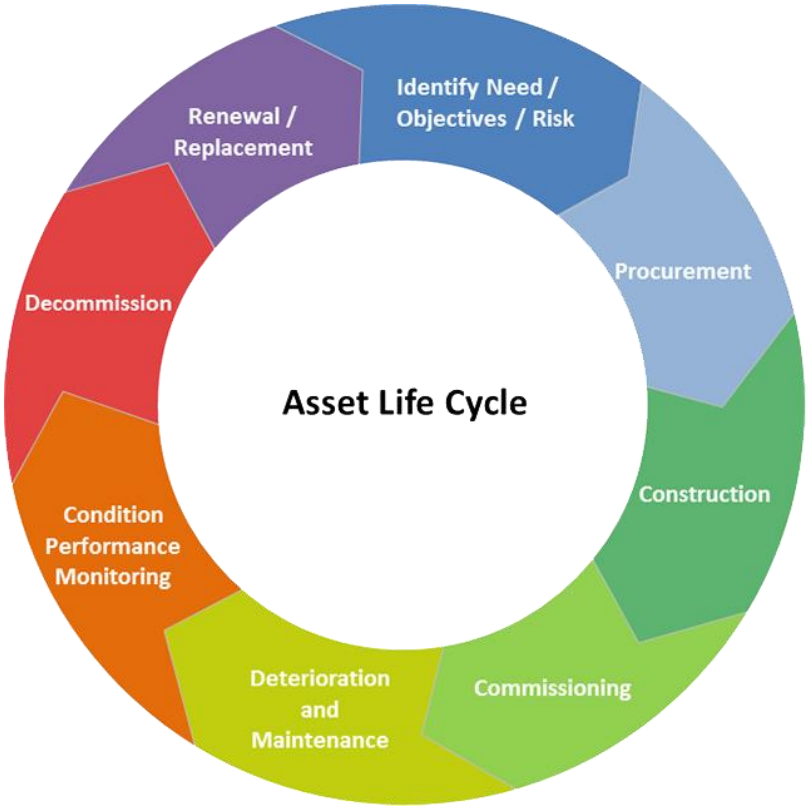
Rebecca Knott
Principal Engineer,  Manager Dam Safety Programme
Damwatch Engineering Ltd
rebecca.knott@damwatch.co.nz

Kelvin Berryman
Director, Natural Hazards Research Platform
GNS Science
K.Berryman@gns.cri.nz

# What is Dam Safety?

- The safe operation and management of dams and their reservoirs for all stages of the dam's lifecycle

From: *initial planning, investigation, design, construction, commissioning, assessment, rehabilitation and operation through to decommissioning*



# What is Dam Safety?

Necessary to protect :

**people, property and the environment**

from the potentially catastrophic impacts of a dam failure or unexpected release from the impounded reservoir.


DAMWATCH
ENGINEERING BEYOND THE SURFACE

# Why should we focus on Dam Safety?

- **Avoid these events !!!:**

# Why should we focus on Dam Safety?

Loss of lives, loss of assets, loss of trust and reputation

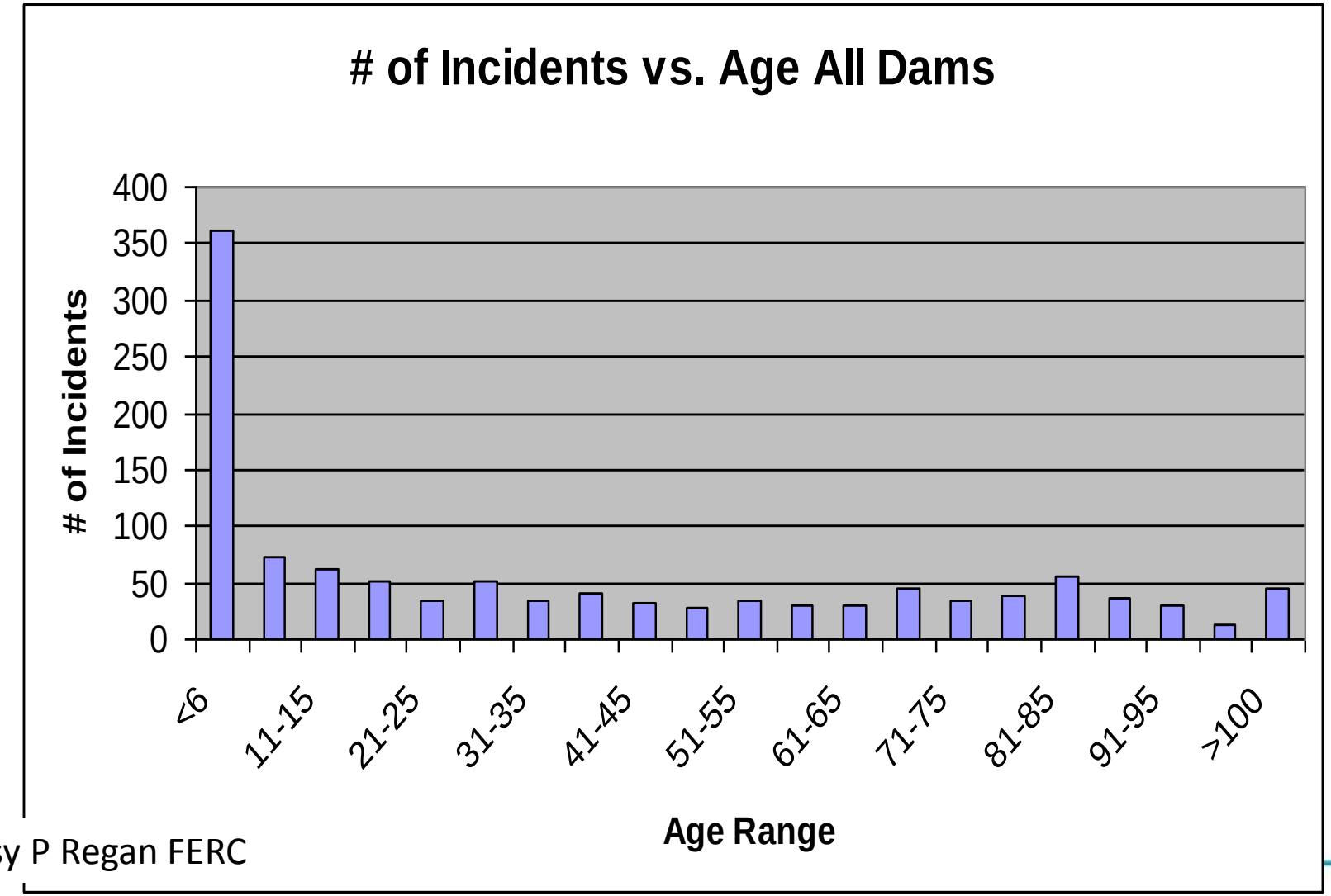
# Dam Safety and Mekong River Commission aim:

"…the MRC aims to ensure that the Mekong water is developed in the most efficient manner that **mutually benefits** all Member Countries and **minimises harmful effects on people and the environment** in the Lower Mekong Basin."

http://www.mrcmekong.org/about-mrc/

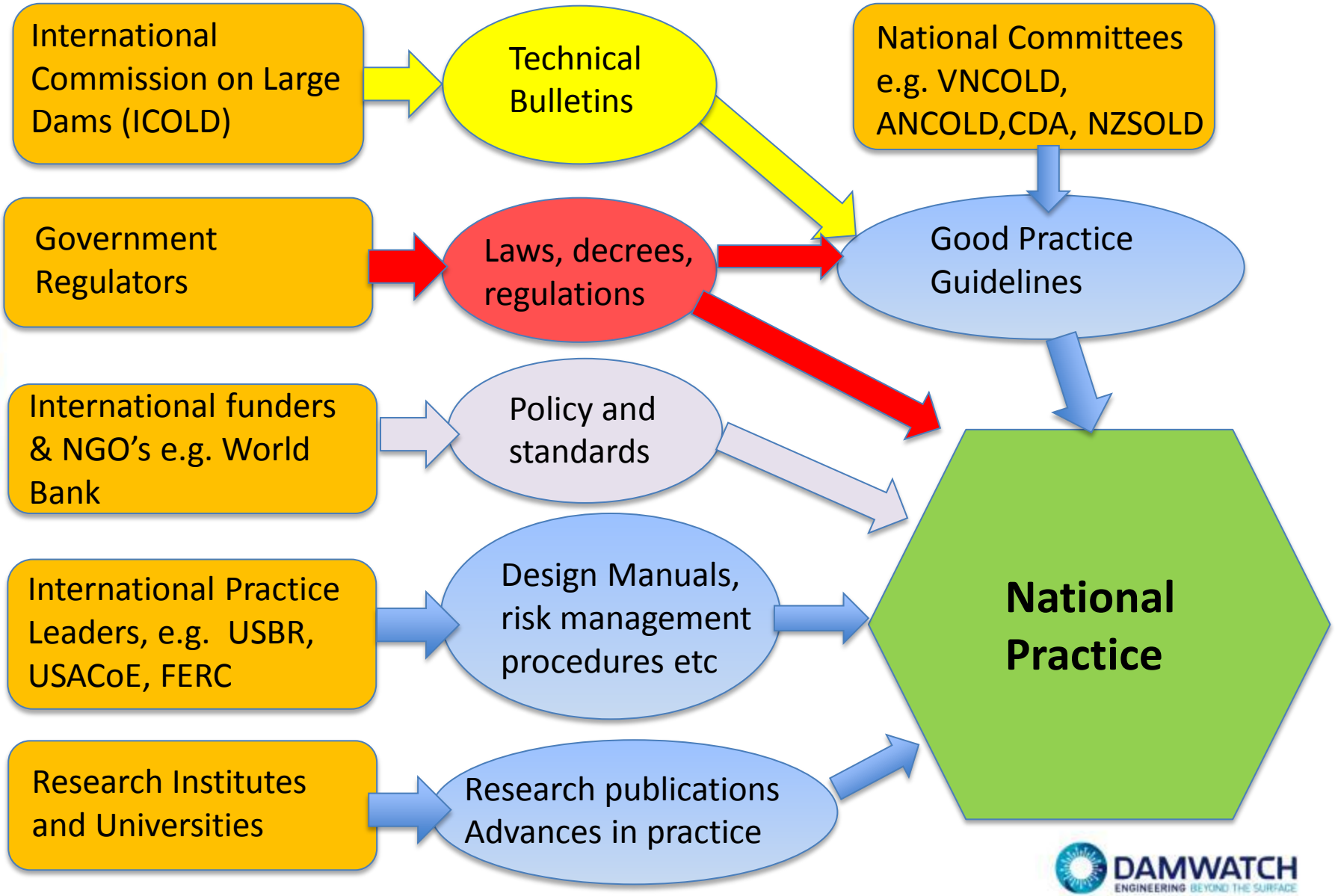
# Why should we focus on Dam Safety?

- **Serious incidents and dam failure can occur at any time in a dam's lifetime**




Courtesy P Regan FERC

# International Organisations leading Dam Safety

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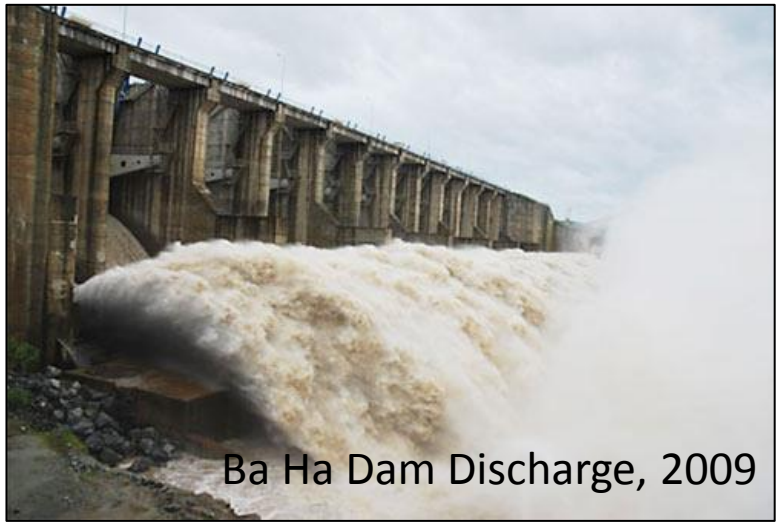
# The Viet Nam-NZ Dam Safety Project

The Viet Nam-NZ Dam Safety Project objective is to:

- reduce loss of life and economic damage resulting from extreme dam discharges

(i.e. dam spillway releases or dam failure events)


Ba Ha Dam Discharge, 2009


Ia Krel 2 Dam Failure, 2013

# The Viet Nam-NZ Dam Safety Project

## The V-NZ Dam Safety Project Phase 1 is being carried out over 2012 to 2015 with collaboration between

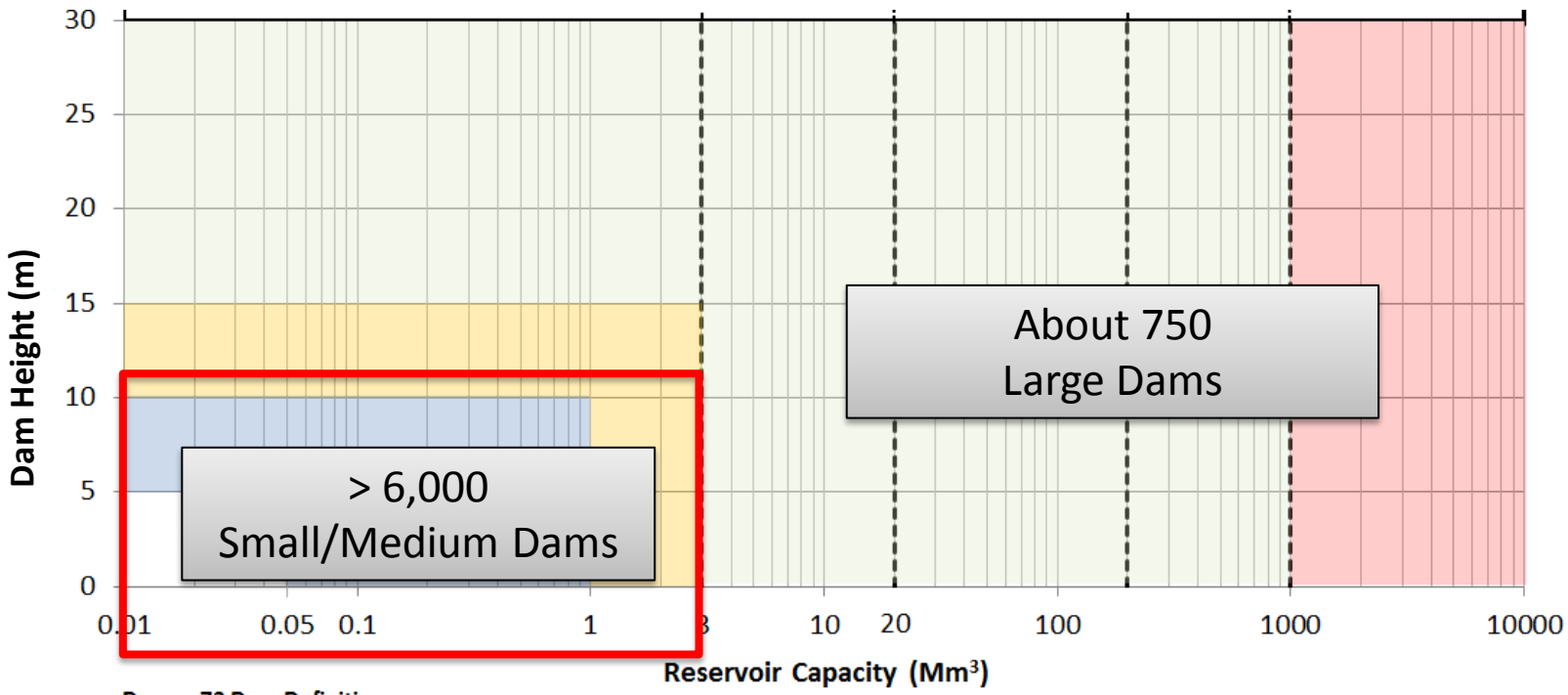
- **New Zealand Partners (Damwatch and GNS):**
  Experience in management of cascade dam systems
  Expertise in international dam safety regulations
  Expertise in flood risk assessment
  Expertise in seismic and landslide risks to dams
  Expertise in renovation of existing dams
  Successful history of dam safety

- **Viet Nam Partners (MARD - WRU, VNCOLD, IGP)**
  Expertise in flood estimation
  Expertise in flood modelling
  Knowledge of Vietnamese dam safety regulations
  Expertise in design of dams
  Vietnamese agency for seismic hazard analysis

## The funding partner is the New Zealand Government Aid Programme

# Viet Nam Dam Population

- **Viet Nam has about 7,000 dams in total:**




**Decree 72 Dam Definitions:**

Small Dams

**Reservoir Capacity (Mm³)**

**Small Dams**

**Medium Dams**

**Large Dams**

rtance*

**Dams of National Importance**

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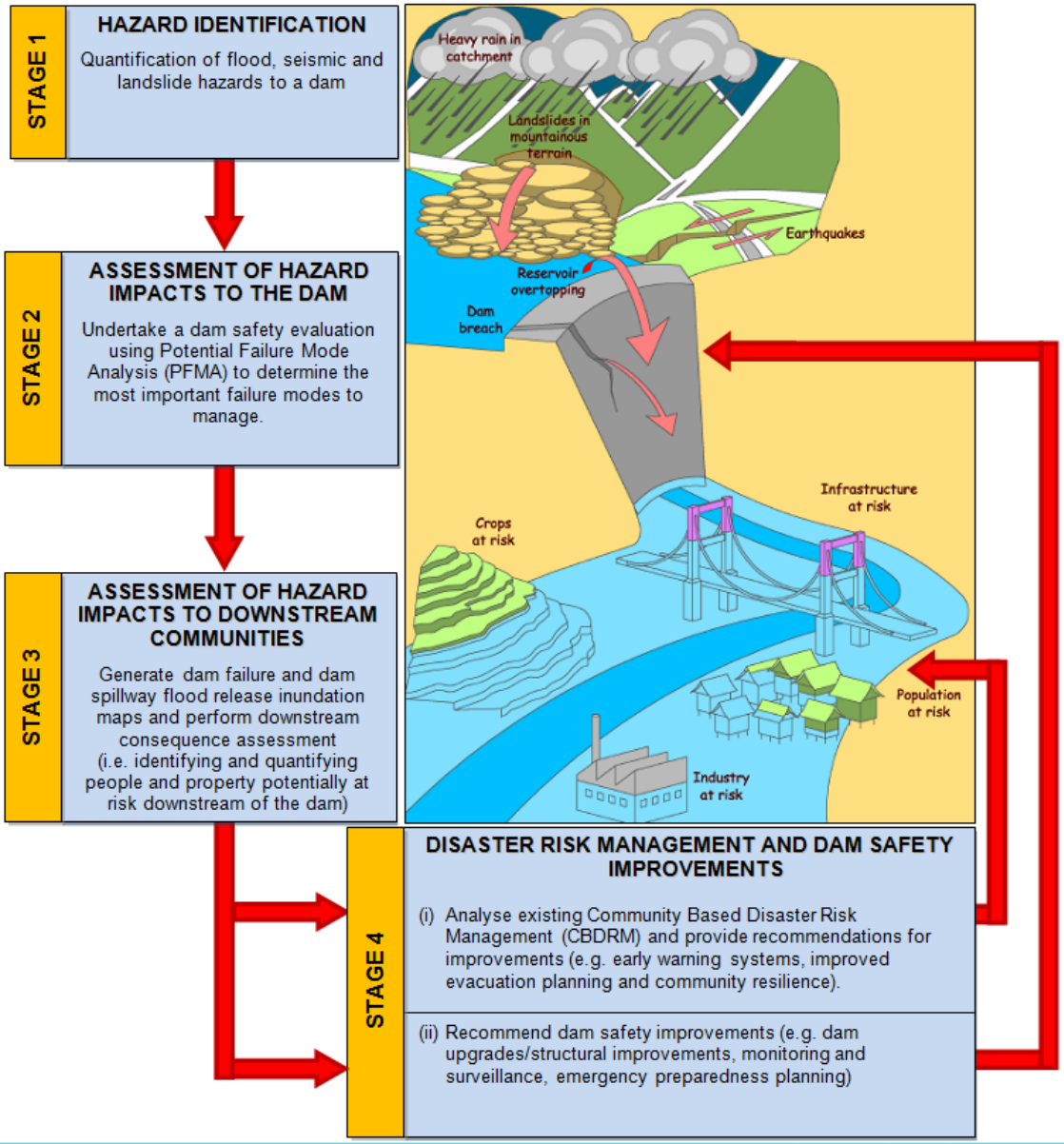
# The Viet Nam-NZ Dam Safety Project Methodology

The project involves:

- Application of internationally recognized methods on a catchment-wide basis to identify and quantify risks to dams and communities downstream of the dams.
- INTEGRATED APPROACH - unique



- PLAY VIDEO

# VN-NZ Dam and Downstream Community Safety

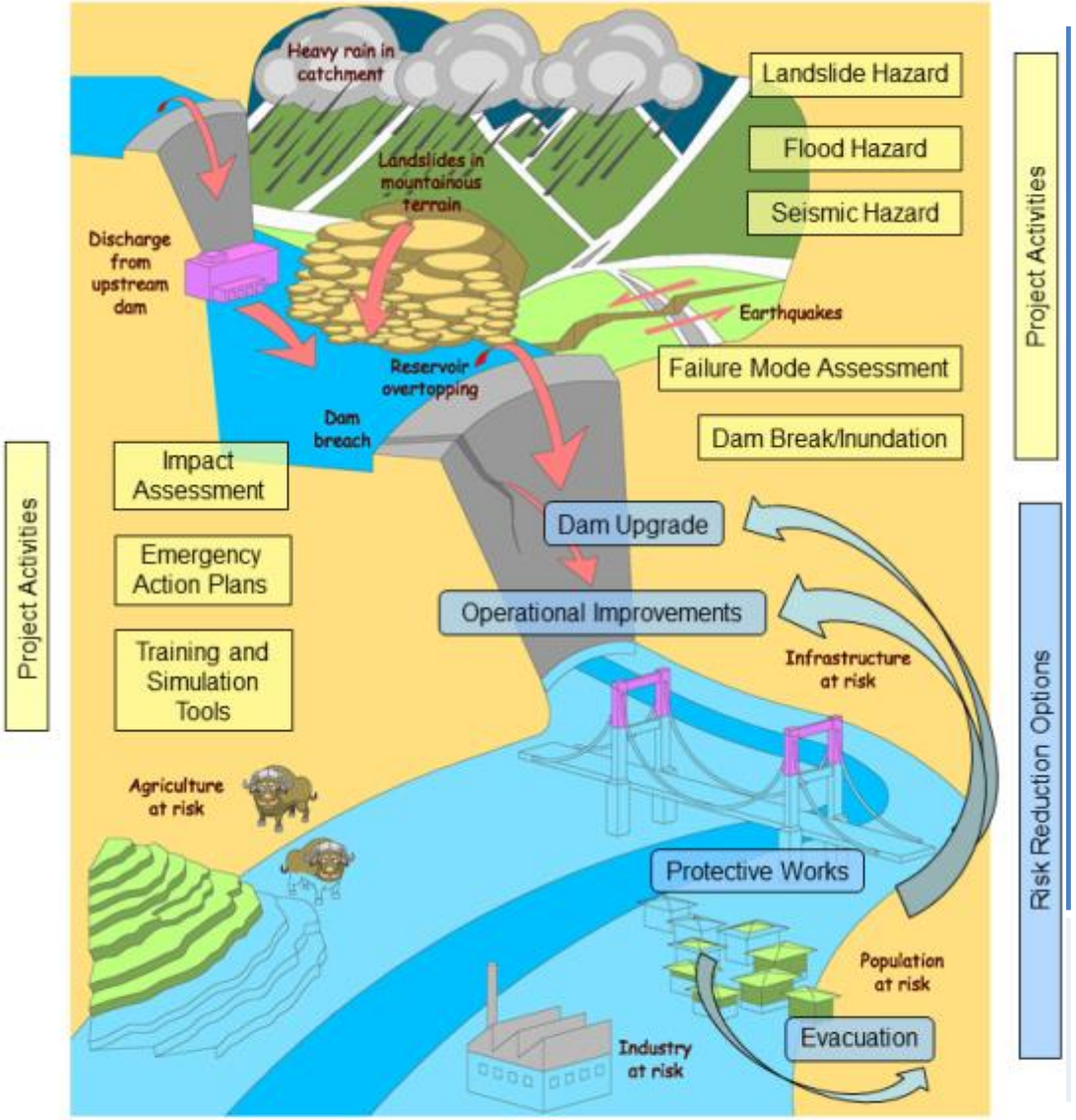
## Methodology

### 1. Quantify hazards
- Flood, Landslide, Earthquake

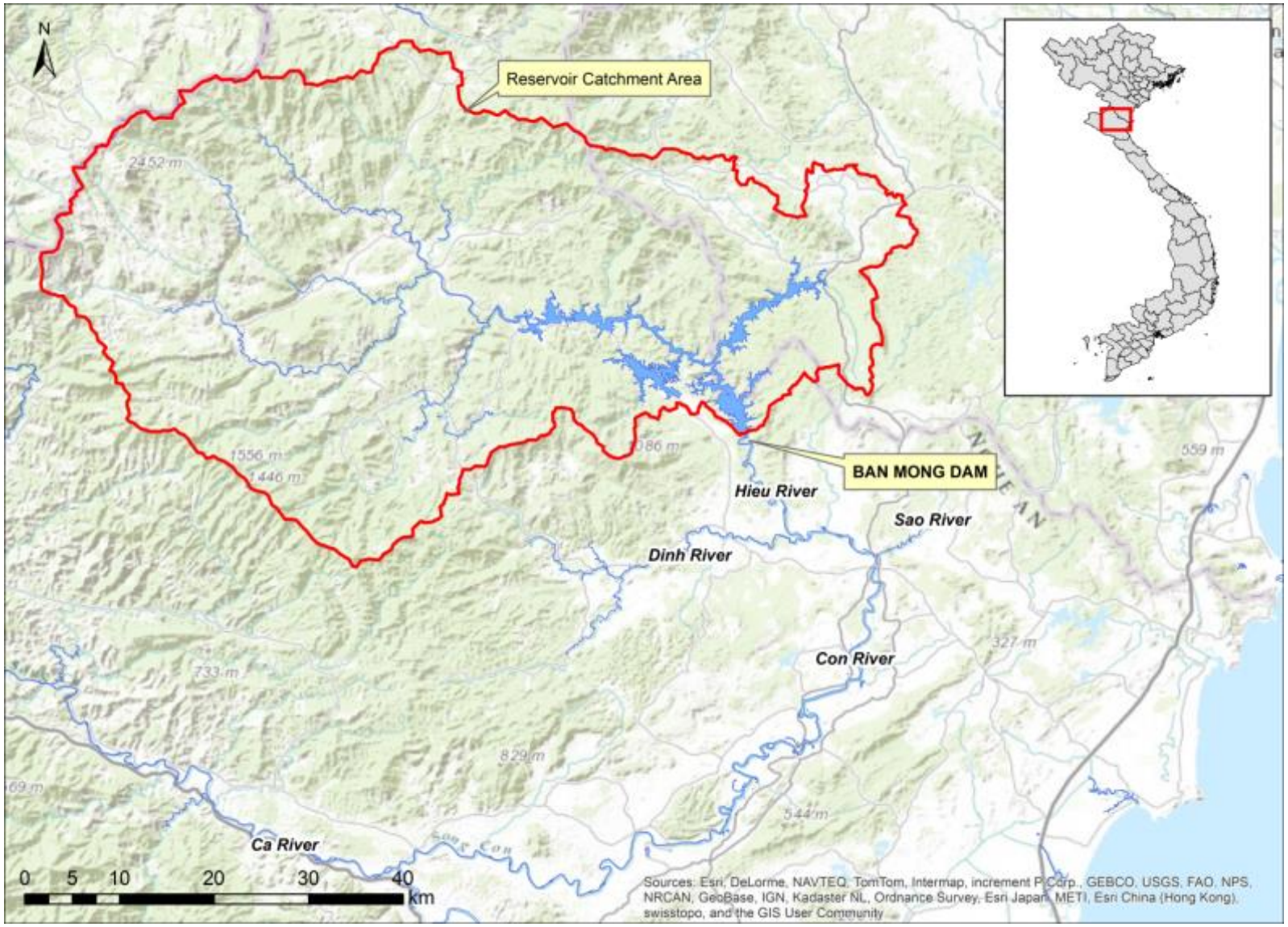
### 2. Assess dam fragility
- Spillway adequacy
- Dam stability
- Dam safety assessment

### 3. Quantify flooding and impacts
- Inundation maps
- Consequence assessment

### 4. Evaluate improvements
- Dam upgrades
- CBRM improvements

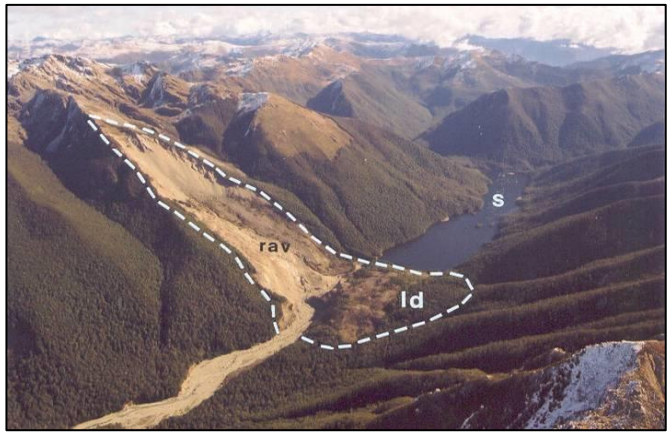


# Dam Safety Project Pilot Catchment – Hieu River Nghe An Province , Viet Nam

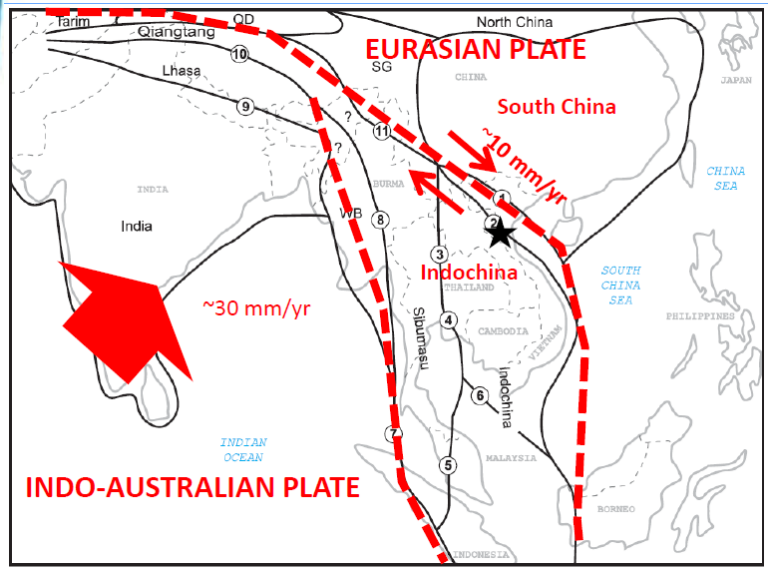


# VN-NZ Dam Safety - Seismic and Landslide Hazards

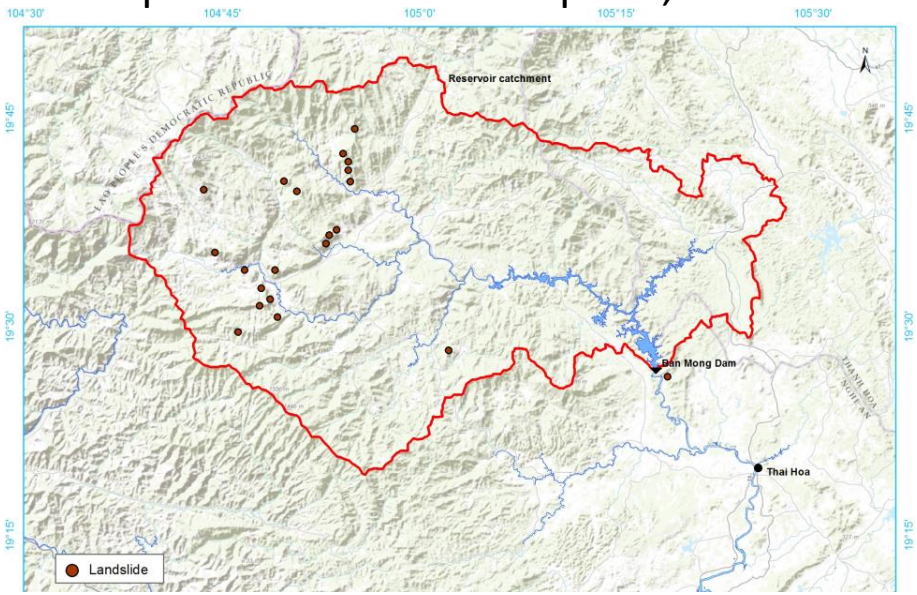
San Fernando dam, USA post Mw = 6.7 earthquake, 1971




Landslide dammed lake, New Zealand post Mw = 7.8 earthquake, 1929




Seismic hazard relating to inter-plate slip




Large landslides in upper catchment of Hieu River

# Impacts on dam safety from natural hazards

Need to understand the:

- occurrence,
- frequency, and
- magnitude

of external events that may impact on dam safety –

earthquakes – landslides - floods

**BEST** to do this **BEFORE** dam design and construction begin

- Seismic analysis – regional – shared benefits?

# Good design investigation and hazard identification

Why is good design investigation important?

- Robust dam - get it right first time
- Avoid failure
- Avoid retrofit ($$) or compromised margins of safety
- Dam OK with natural hazards / external events

# Good design investigation

- International experience –

  site investigations budget ~ 10% of total project costs

  ➡ get the design right

- Challenge – getting the data for incorporation in design (such as earthquake occurrence, frequency and magnitude)

- Good investment in project risk management –

  future dam safety reviews

  reputational and political risk

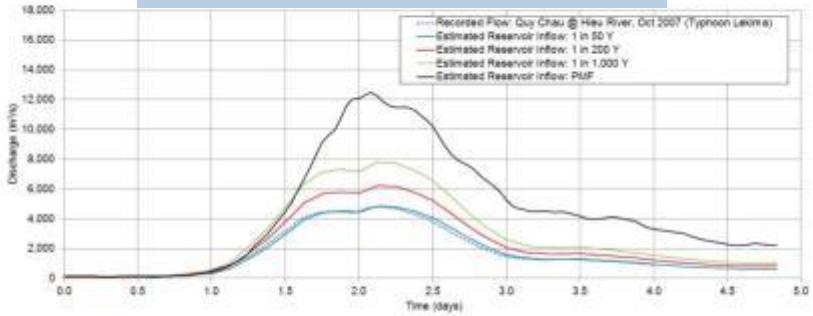
  social acceptance

# VN-NZ Dam Safety – Example Flood Hazard Outputs

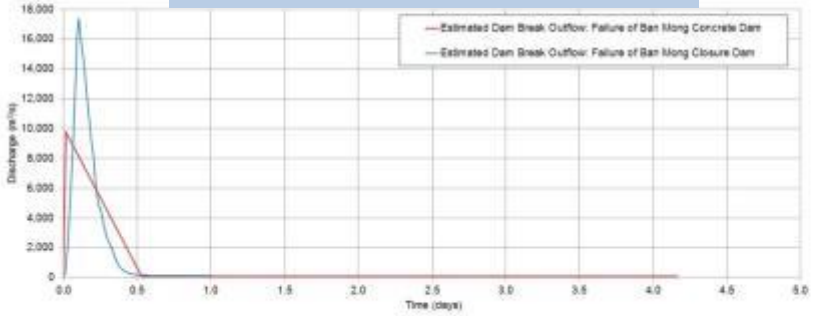
## Ban Mong Dam, Flood Hydrology

| Flood Annual Exceedance Probability (1 in Y) | Reservoir Inflow ($m^3/s$) | Spillway Outflow ($m^3/s$) | Dam Freeboard (m) |
|---|---|---|---|
| 1 in 50 | 4,890 | 4,847 | 2.3 |
| 1 in 200 | 6,273 | 6,126 | 2.2 |
| 1 in 1,000 | 7,871 | 6,964 | 0.3 |
| 1 in 5,000 | 9,486 | 8,566 | **Dam Overtopped** |
| 1 in 10,000 | 10,150 | 9,182 | **Dam Overtopped** |
| PMF | 12,460 | 10,872 | **Dam Overtopped** |

### RESERVOIR INFLOW HYDROGRAPHS



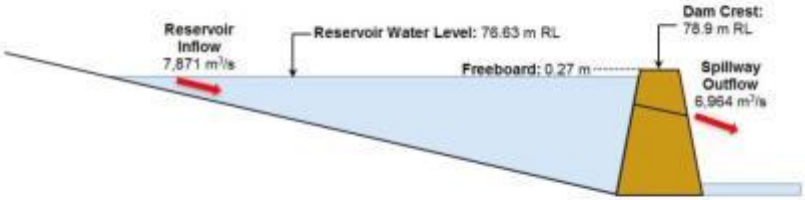

### DAM FAILURE HYDROGRAPHS



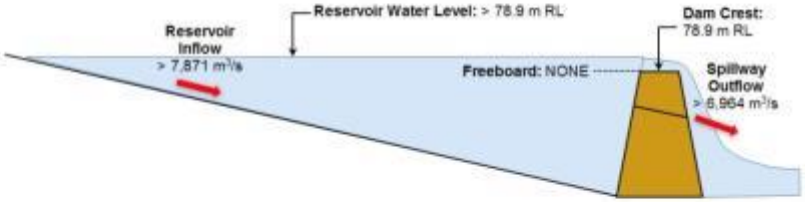

### SCHEMATIC OF RESERVOIR FLOOD LEVELS

1 in 50 AEP Flood Event


1 in 1,000 AEP Flood Event

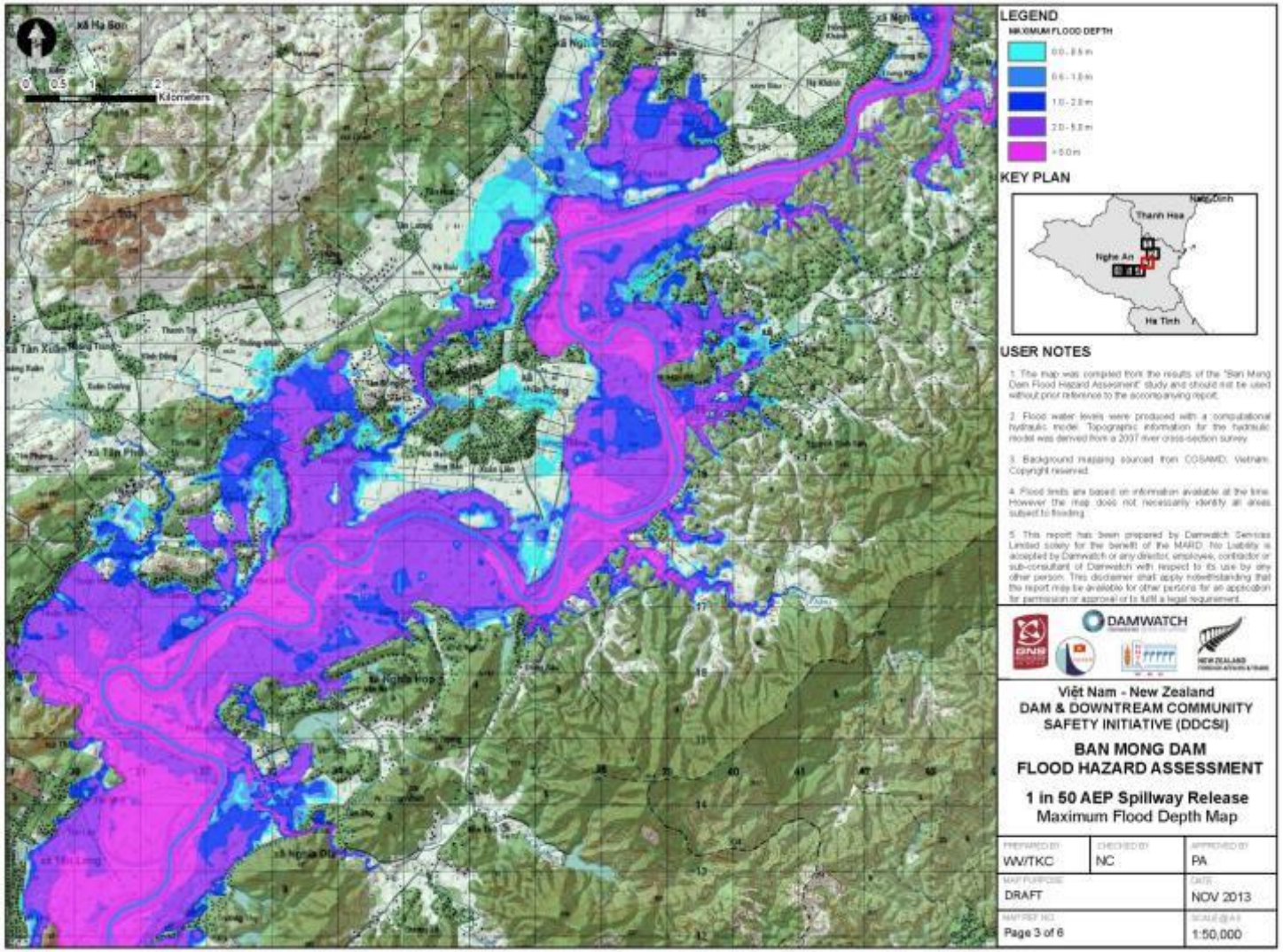



> 1 in 1,000 AEP Flood Event



# VN-NZ Dam Safety Methodology – Example Outputs

## Ban Mong Dam, Flood Inundation Maps (1 in 50 AEP Spillway Release)

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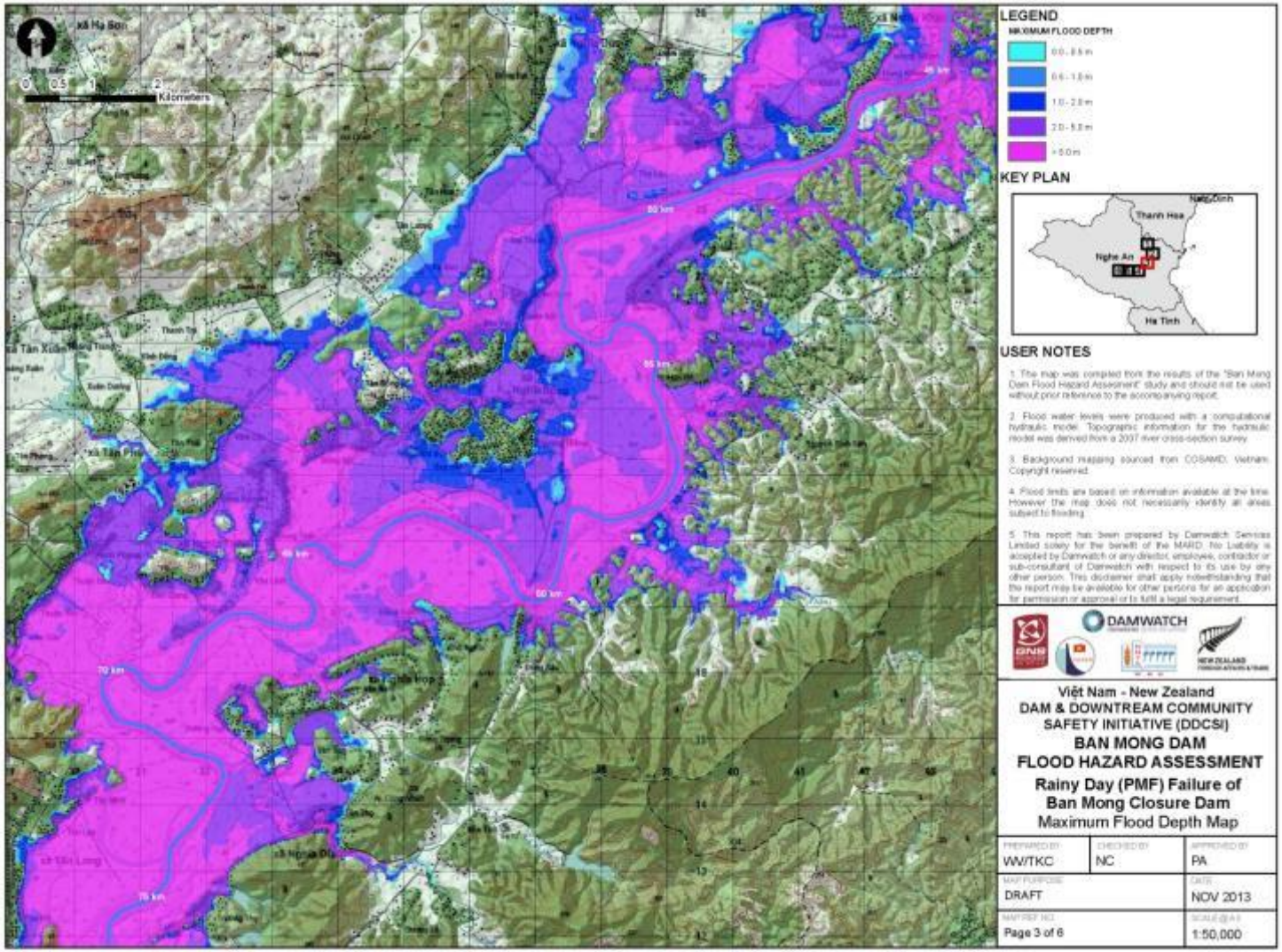
# VN-NZ Dam Safety Methodology – Example Outputs

## Ban Mong Dam, Flood Inundation Maps (Dam Failure Scenario)

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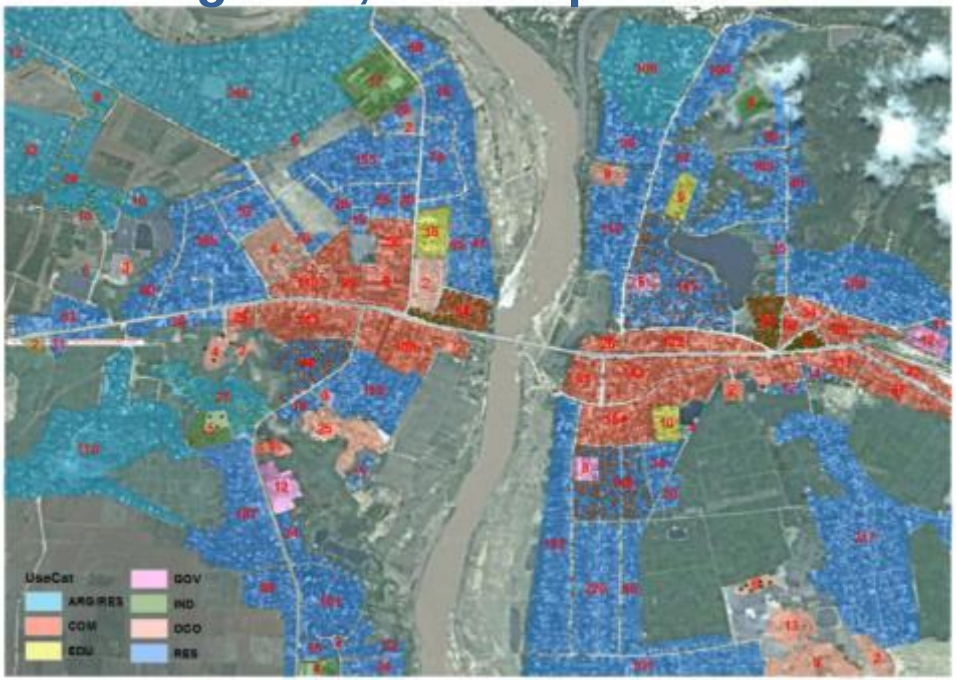
# VN-NZ Dam Safety – Consequence Identification

Consequence analysis tool that provides information about what could happen to people, buildings, agricultural activities and infrastructure in a natural hazard event / disaster

## Ban Mong Dam, Consequence Assessment




**GIS Layers:**

What can it be used for?:

- Evacuation/response planning
- Building approvals
- Evacuation exercise planning
- Mitigation priorities
- Risk / impact analysis
- Basis for cost-benefit analysis
- Land-use planning
- Education / Information

# Example - Identification of Potential Improvements

## Examples of Dam Safety & CBDRM Recommendations after using DSM

| Dam Safety Recommendation #1 | |
|---|---|
| Dam Safety Issue | Risk of overtopping and failure of closure dam in extreme flood events |
| Dam Upgrade Recommended | Construct Parapet Wall on Closure Dam |
| Risk Reduction Achieved | Significantly reduce risk of overtopping failure of Closure Dam |

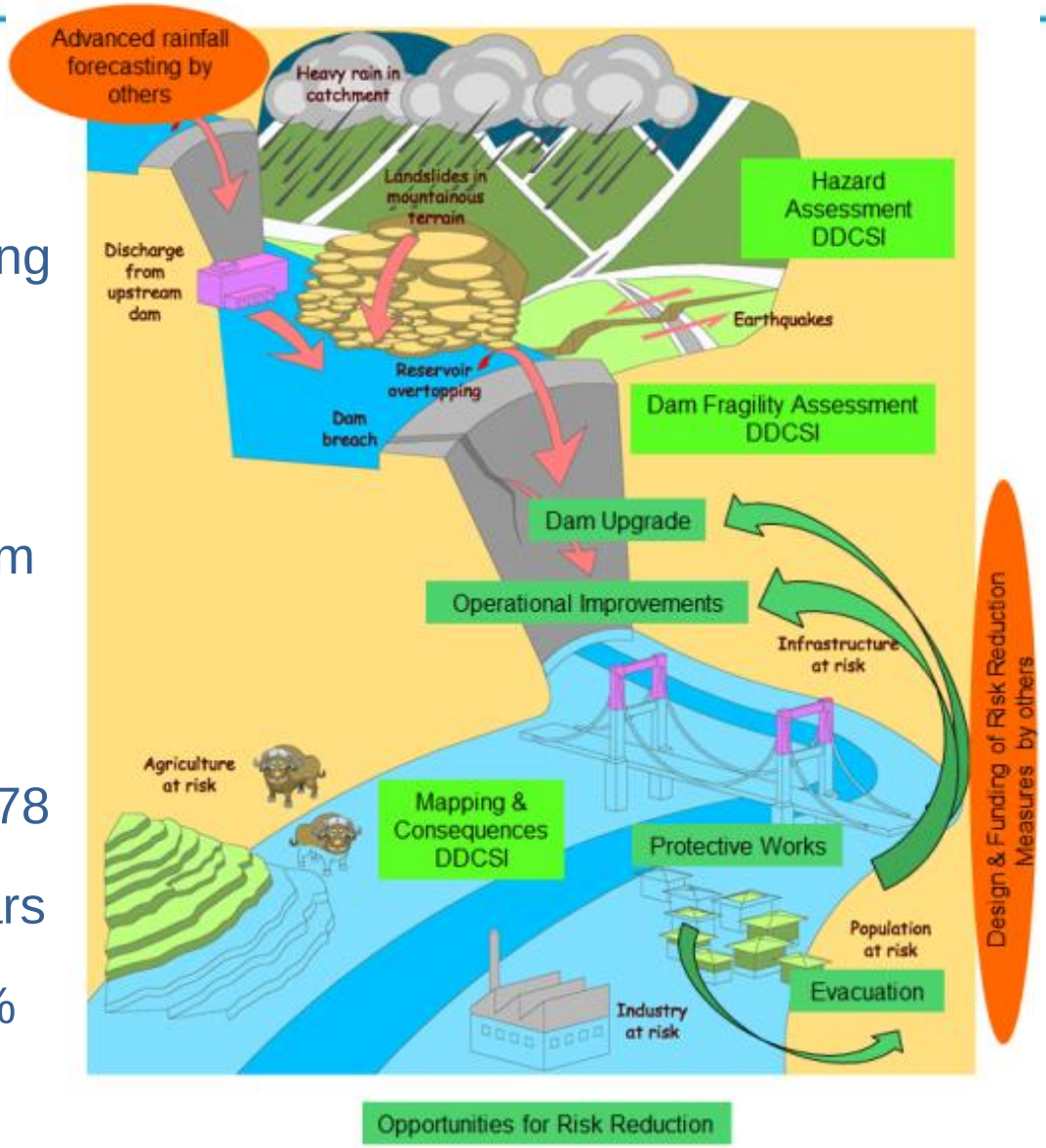
| Dam Safety Recommendation #2 | |
|---|---|
| Dam Safety Issue | High risk of overtopping and failure of Closure Dam during construction |
| Dam Upgrade Reccomended | Improve flood passage during construction |
| Risk Reduction Achieved | Reduce risk of dam failure during construction |

| CBDRM Improvement Recommendation #1 | |
|---|---|
| Dam Safety Issue | No flood inundation maps for dam failure and spillway release events |
| Dam Upgrade Reccomended | Integrate DSM flood maps into emergency response and evacuation planning |
| Risk Reduction Achieved | Reduce impact of flood hazard on downstream communities. |

# VN-NZ Dam Safety Methodology Summary

Methodology:

- Delivers Evidence based Decision Making in Dam Safety for whole river basin
- Phase 1 Trialled successfully in Nghe An Province, Viet Nam
- 2016 – Phase 2 - Application of Tool in major river basin system – 1000km, 978 dams (905 small, 58 med, 15 large), 5 years – design complete, funding approval 95% ….



# Summary – Project Benefits

- **DDCSI provides dam owners/managers an understanding of:**
  - The potential risks related to their dams
  - The natural hazards that can affect dams
  - The reasons why dams fail, and
  - Improvements that can be made to mitigate these risks

Phase 2 includes development of a prioritisation tool – identify where investment is best spent to reduce risk

# Summary – Project Benefits

- **River-basin approach to dam safety assessment:**
  - Comprehensive approach that considers both upstream hazards **and** impacts on downstream communities
  - Provides solutions to improve dam safety and Disaster Risk Management practices

- Provides tools for compliance with aspects of (most) national regulations

# Using VN-NZ Dam Safety Methodology Outputs

## Engineers and Planners can use outputs to design projects, such as:

**Dam safety improvements**

- Dam upgrade/structural improvements
- Dam operational improvements/flood peak mitigation options
- Multiple reservoir operation rules
- Early warning systems for dam operators and authorities

**Community disaster risk management**

- Improved downstream community resilience
- Early warning systems for communities
- Improved evacuation planning

**Physical works**

- Protective measure locations (e.g. dykes)
- Road and bridge improvements to improve evacuation routes and flow paths
- Infrastructure upgrades

**Land use planning**

- Identification of areas to restrict future development