
IAIA22
Vancouver CANADA

# THE CONTRIBUTION OF RESILIENCE ASSESSMENT TO IMPACT ASSESSMENT

Note that an extended version of this paper has been published as a professional practice paper in IAPA. The eprint link is https://www.tandfonline.com/eprint/6I56K6HYQ8BTGDV9IYWC/full?target=10.1080/14615517.2022.2080492.

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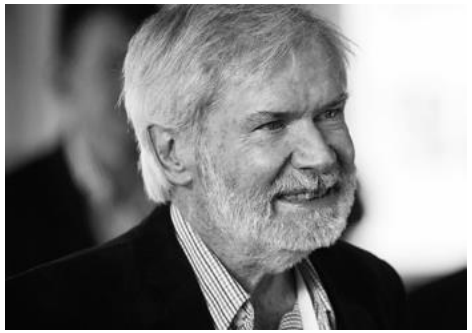

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# PRESENTATION

## *Key Elements Underpinning Resilience Assessment*

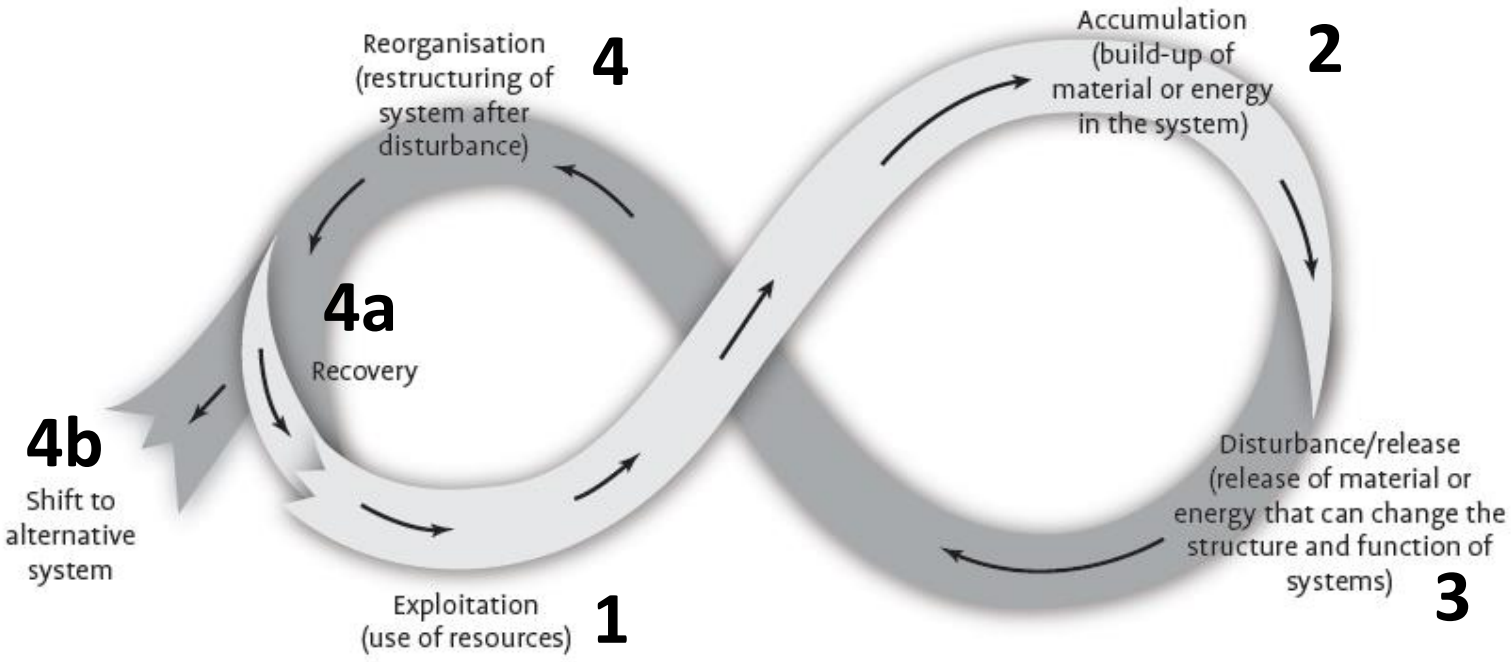
- Describing processes as adaptive cycles
- Defining failure pathways and the associated critical variables and their thresholds for system failure
- Recognising multiple spatial scales as nested adaptive systems
- Identifying management interventions to reduce system vulnerability to disturbance

## *Examples of Resilience Assessment*

- Defining biodiversity criteria for impact assessment of Ord River Irrigation proposal
- Developing environmental programmes to maintain lake values in Wellington Region
- Designing flood protection to address impacts of levee failure - Christchurch

# ADAPTIVE CYCLE AND FAILURE PATHWAY ANALYSIS

- Interpret issues as adaptive cycles
- Identify critical variables for potential failure pathways and resilience thresholds
- Resilience - the capacity of a system to absorb disturbance and still retain its basic function and structure




Adapted from Gunderson and Holling 2002

## PHASES OF ADAPTIVE CYCLE

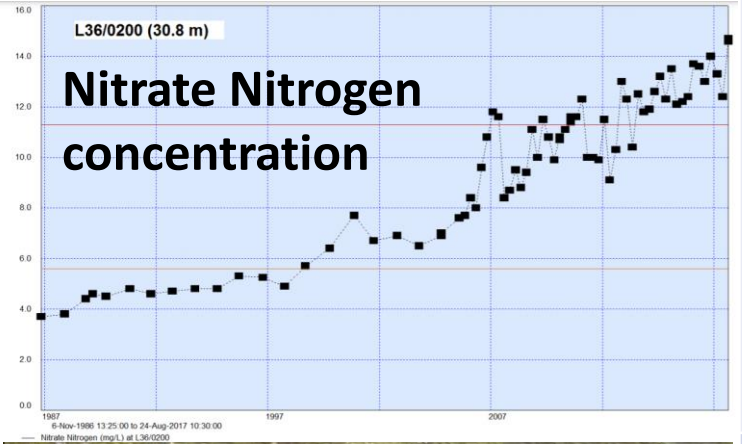
**1 Exploitation**
**- Use of resources**

**2 Accumulation**
**- Build-up of material or energy**

**3 Disturbance**
**- Release that can change system**

**4 Reorganisation**
**- 4a Recovery, or**
**- 4b Shift to alternative system**

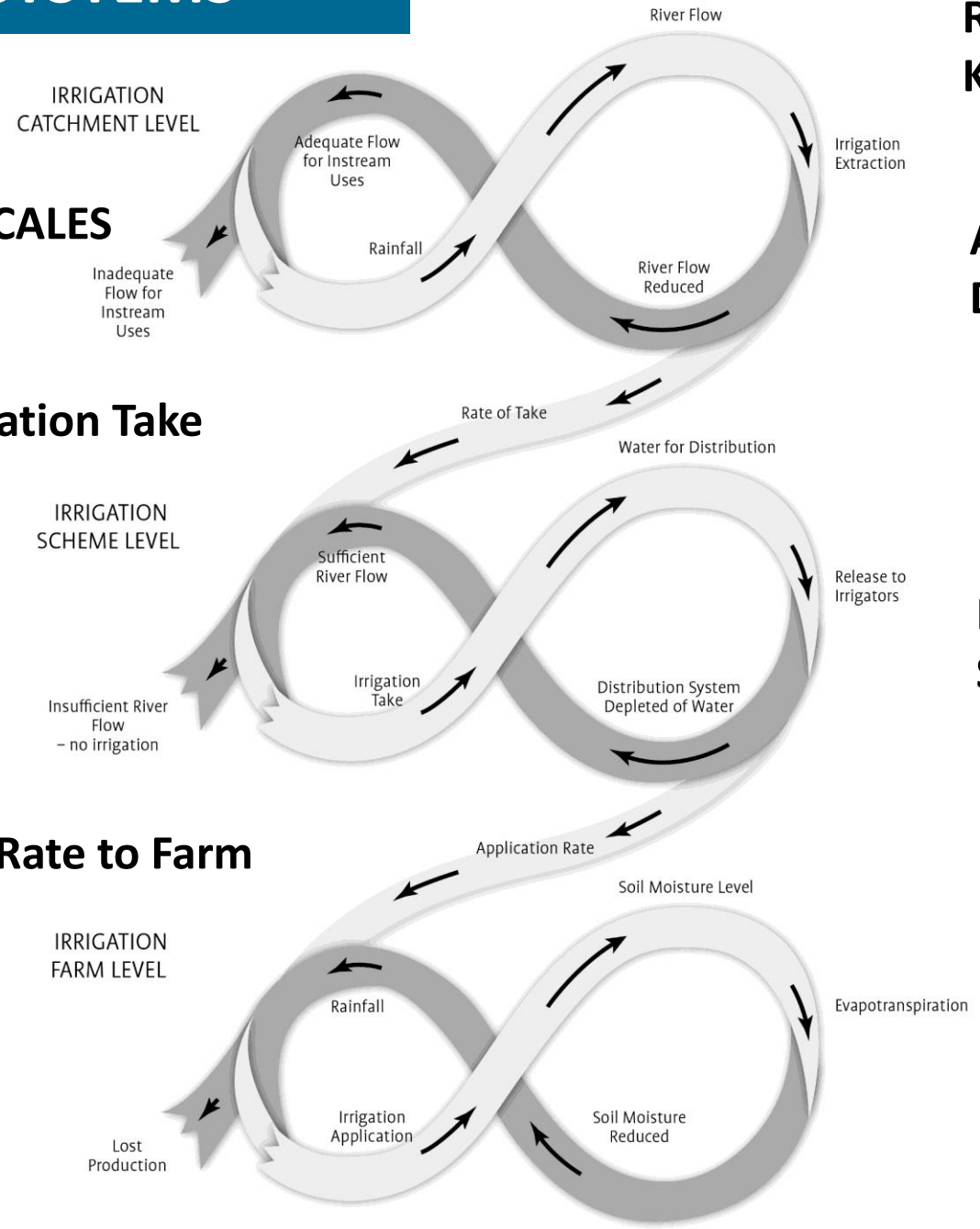
# FAILURE PATHWAYS

| | *Key Elements* | *Eutrophication* |
|---|---|---|
|   | **Failure Pathways**<br>- Disturbances that have potential to cause system failure and a shift to a degraded state | **Nutrient Enrichment**<br>- Land use intensification |
|   | **Critical Variables**<br>- Measures that characterise the processes on failure pathways | **Nitrate Nitrogen**<br>- Key parameter in determining adverse effects |
|   | **Thresholds**<br>- Tipping points for critical variables that change the state or function of a socio-ecological system | **Algal Blooms**<br>- Change in status of the river to a degraded state |

# NESTED SYSTEMS

**LINKAGE BETWEEN SCALES**

**RESILIENCE KEY ISSUE**




**Adequacy of Downstream Flow**

**Reliability of Supply to Scheme**

**Lost Production from Inadequate Soil Moisture**

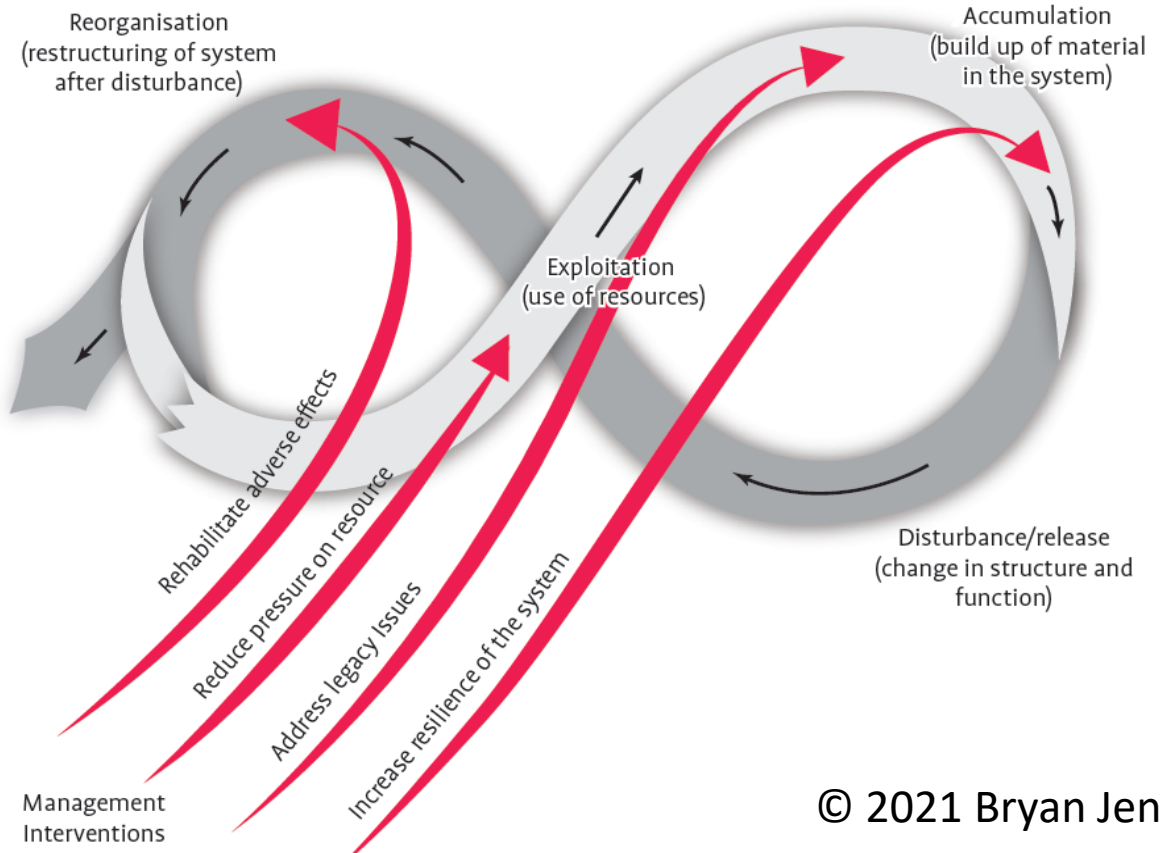
Systems operate at different spatial and time scales with linkages between different scales

Example of Irrigation Scheme

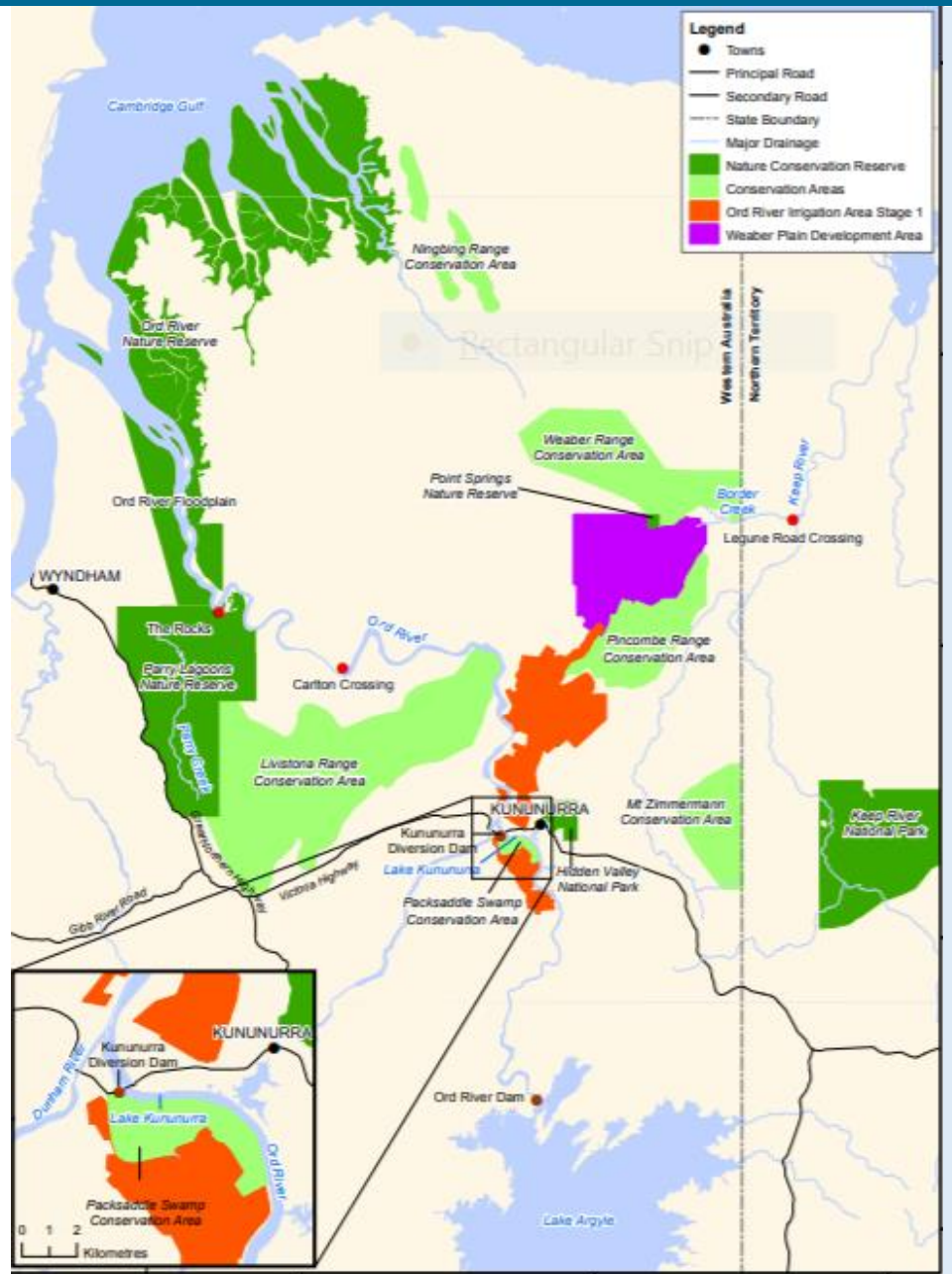
- Higher spatial scale: catchment of the irrigation intake
- Lower spatial scale: farms being irrigated

# MANAGEMENT INTERVENTIONS TO ADDRESS FAILURE PATHWAYS

- Exploitation phase:
  ***Reduce pressure on resource***
- Accumulation phase
  ***Address legacy issues***
- Disturbance phase
  ***Increase resilience of the system***
- Reorganisation phase
  ***Rehabilitate adverse effects***



# ORD RIVER IRRIGATION SCHEME Stage 2

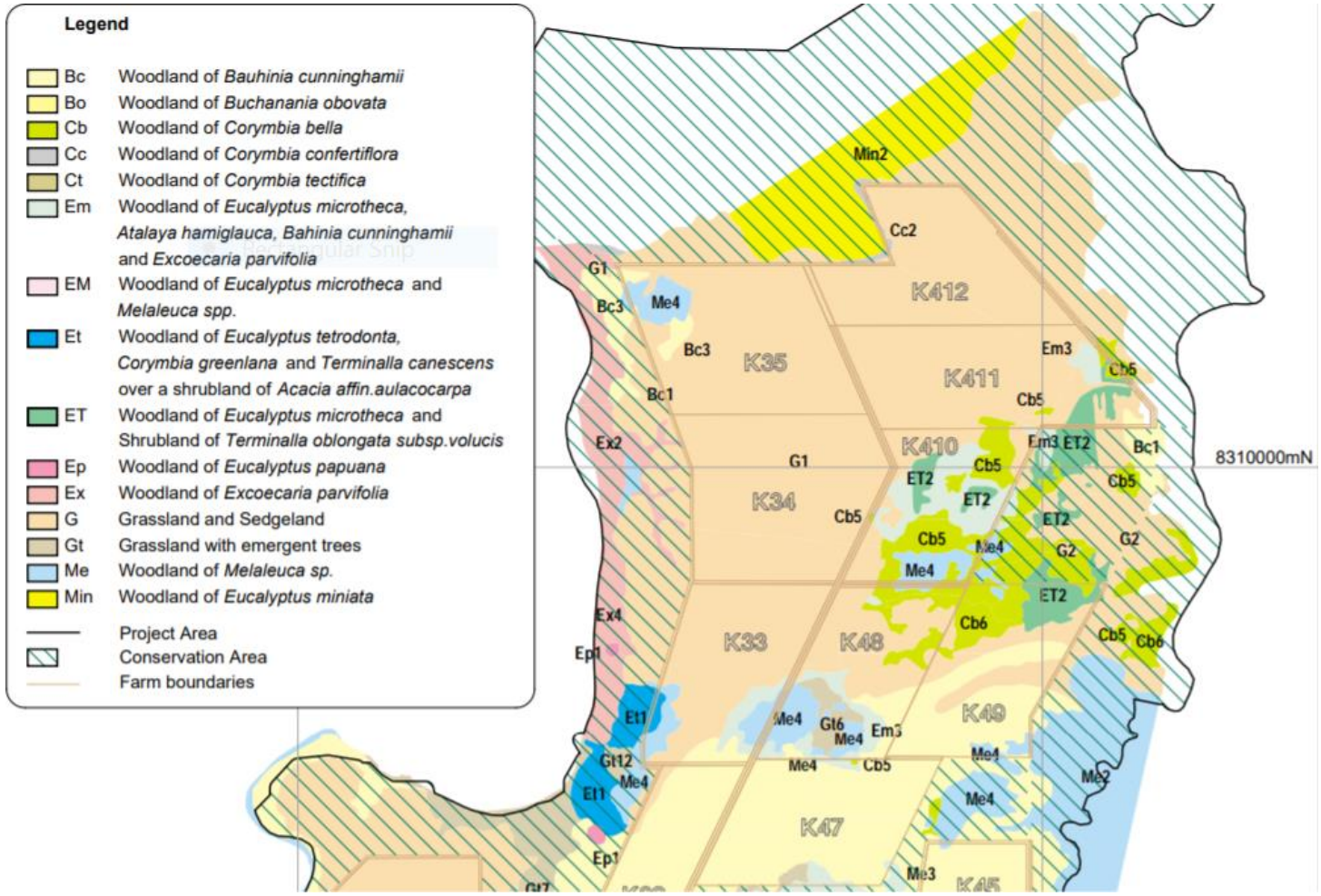



- 36,000 ha of irrigated farms
- 400,000 t sugar mill
- Two stage assessment process
- Regional significance of flora and fauna in project area
- Biodiversity of cracking soil plains
- Only limited areas of bioregion in conservation reserves

# RESILIENCE ASSESSMENT FOR BIODIVERSITY CRITERIA

- Regional scale resilience assessment
- Objective to avoid system failure of extinction of any flora and fauna species
- Retain at least 30% of each vegetation association
- Conservation strategy for bioregion and project
- Retention of representative associations
- Designation of buffer areas
- Connections between conservation areas

## Project Area Conservation Area



# RESILIENCE ASSESSMENT OF ENVIRONMENTAL PROGRAMMES

Resilience assessment of lakes in Greater Wellington Region to identify environmental programmes to maintain lake values

**Lake Waitawa**

Small (16ha), shallow (<7m) coastal lake

Small catchment (278ha), pastoral cover 94%

Treated wastewater from Forest Lakes Camp

Discharges to Waitohu Stream

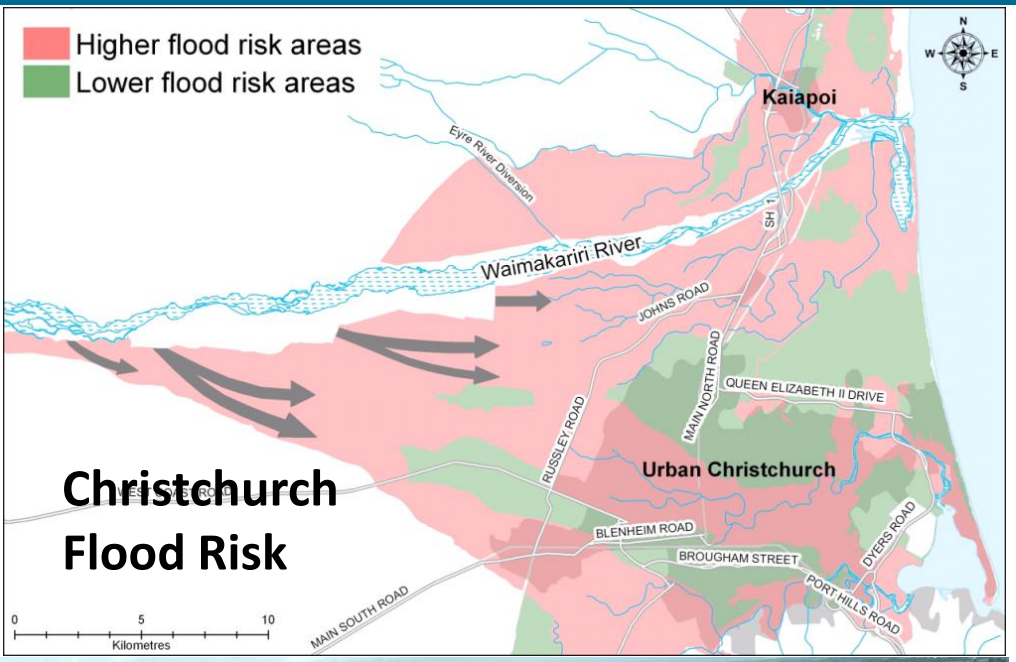
# CRITICAL VARIABLES AND THEIR THRESHOLDS FOR LAKE WAITAWA

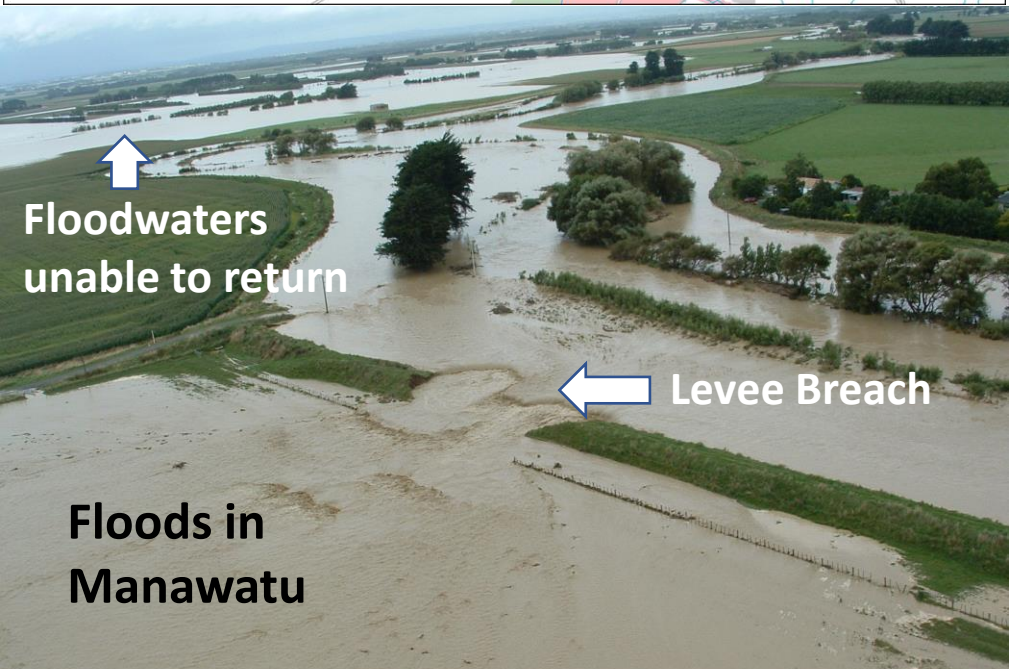
| *CRITICAL VARIABLES* | *THRESHOLDS* |
|---|---|
| Water quality<br>***Nutrient levels*** | **Trophic Level Index 5.8**<br>Compared to national average 4.8 |
| Aquatic Ecology<br>***Phytoplankton blooms*** | **Frequent blooms** compared to "low frequency of nuisance blooms" |
| Aquatic Ecology<br>***Invasive plants*** | **70% hornwort** compared to 30% naturally available area with natives |
| Aquatic Ecology<br>***Pest fish*** | Over **80% bullies** compared to "indigenous fish resilient" |
| Recreational Values<br>***Bacteriological quality*** | Max **4cfu/100mL** compared to 540cfu/100mL (95$^{th}$ percentile) |
| Recreational Values<br>***Cyanobacteria levels*** | **8.7 mm$^3$/L** compared to 1.8 mm$^3$/L toxic cyanobacteria |
| Fish Ecology<br>***Dissolved oxygen levels*** | At depth regularly below **2 mg/L** threshold detrimental to fish |

# CATCHMENT RUNOFF FAILURE PATHWAY & MANAGEMENT INTERVENTIONS

| *FAILURE PATHWAY* | *INTERVENTION* |
|---|---|
| **EXPLOITATION (catchment)**<br>Nutrient intensive farming | **Nutrient reduction; Stock exclusion from waterways** |
| **ACCUMULATION (catchment)**<br>Build up of nutrients in soil & water | **Riparian planting** |
| **RELEASE (catchment)**<br>Discharge from tributaries to lake | **Re-establish wetlands** |
| **EXPLOITATION (lake)**<br>Nutrients into lake | |
| **ACCUMULATION (lake)**<br>Build up in water column & sediments | **Flocculation; Freshwater mussels; dredging; lock sediments in place** |
| **RELEASE (lake)** Anoxic sediments release nutrients; Algal growth in water | **Destratify lake** |
| **REORGANISATION (catchment)** | **Reduce nutrient intensity of farms** |

# FLOOD PROTECTION MANAGEMENT FOR CHRISTCHURCH



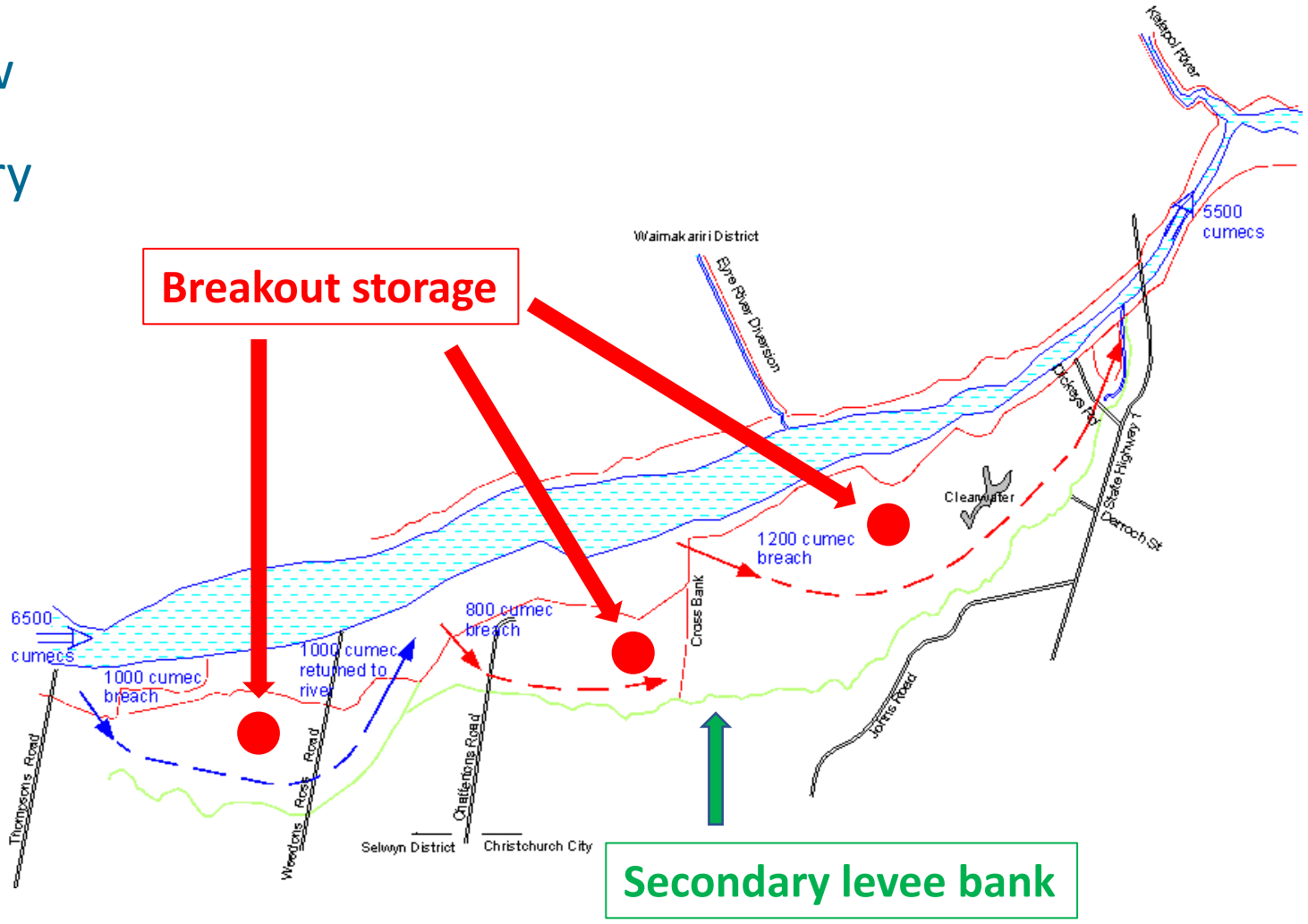

## *Traditional Approach To Flood Protection*

- Provide protection for event of specified return period
- For Christchurch – levees designed for 1-in-500-year flow on Waimakariri River
- North Island experience of levee bank failure leading to flooding of “protected areas” and inability of floodwaters to return to the river because of downstream levee banks
- Need to address the consequences of flood flows greater than the design flow

# RESILIENCE ASSESSMENT IN PROJECT DESIGN

***Resilience assessment addresses the consequences of system failure***

- Secondary levee provided along alignment of natural terrace to accommodate 1-in-10,000 year flow
- Storage of breakouts between primary secondary levees
- Return of breakout flows to main channel after flood peak passed
- If 1-in-10,000-year flow exceeded then flood warning and evacuation plan for low-lying areas: breakout storage provides 3 days for preparation



# CONCLUSION: VALUE ADDED BY RESILIENCE ASSESSMENT

- Ord River Irrigation Impact Assessment
  - criteria for limiting biodiversity impacts and basis for bioregional conservation
- Environmental programmes for maintaining lake values
  - identification of critical variables, failure pathways and management interventions
- Project design for impacts of levee failure
  - address consequences of impacts when threshold for system failure exceeded

# Let’s continue the conversation!

Post questions and comments via chat in the IAIA22 platform.

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