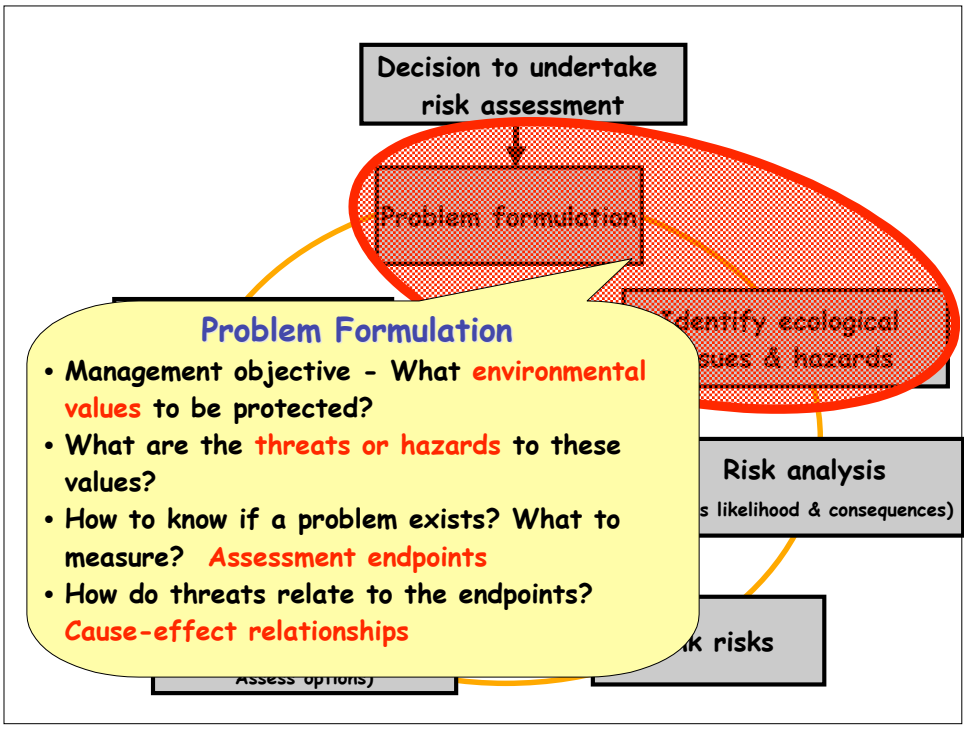
Mekong River Commission

Ecological Risk Assessment Training Program

Problem Formulation

Water Science Pty. Ltd.

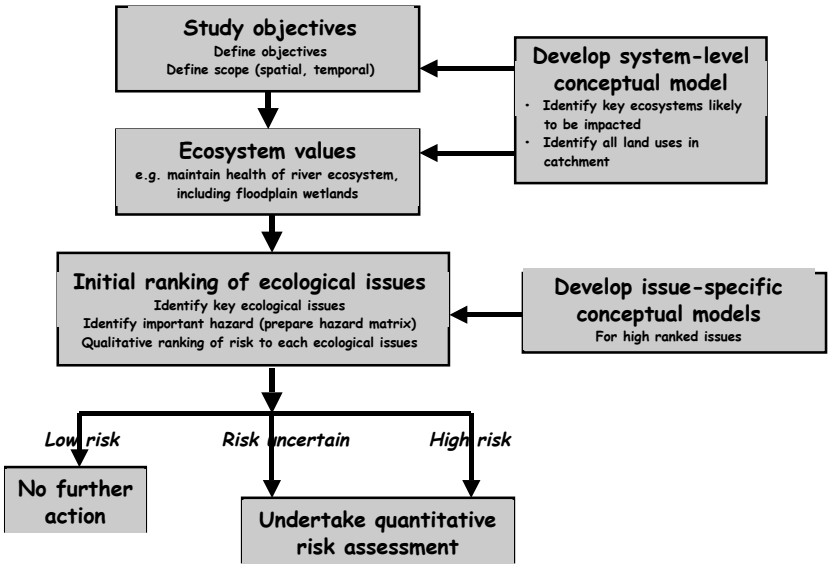
Water Studies Centre



Purpose

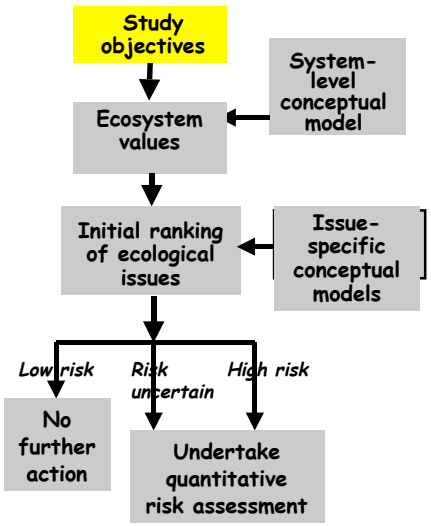
- Planning phase that establishes the goals, breadth and focus of the risk assessment
- Key outputs are:
  - identification of the ecosystem(s) to be considered
  - ecological values to be protected or maintained
  - the stressors or actions that threaten these values
  - The issues, effects or hazards that may be caused by these threats
  - the main measurement endpoint that will be used to quantify the risks
- Needs to be undertaken with *stakeholder involvement*

Problem formulation steps



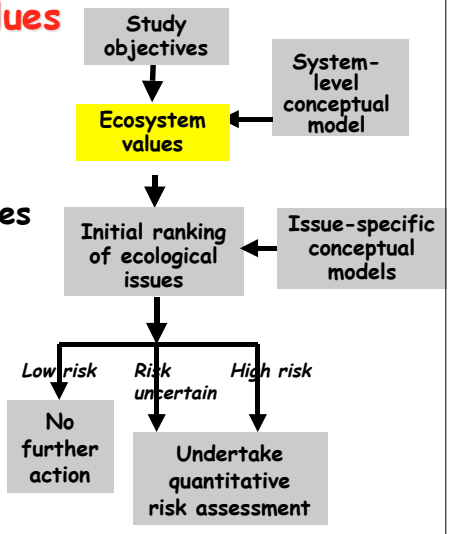
Steps

- Define study objectives
- Decide on the spatial and temporal scope of the study
  - e.g. consider in-system effects, local effects, off-site impacts, or impacts through the whole of the catchment

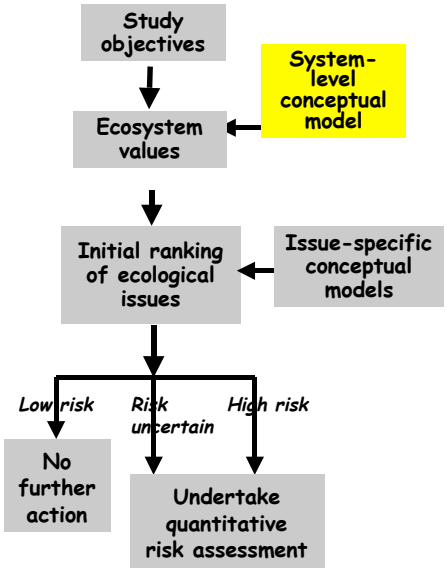


Environmental values

- Identify environmental values to be protected
- What are these?
- Examples:
  - Maintain sustainable fisheries populations
  - Maintain a healthy aquatic ecosystem
- Who establishes these?
  - Government (e.g. Vic EPA)
  - Communities

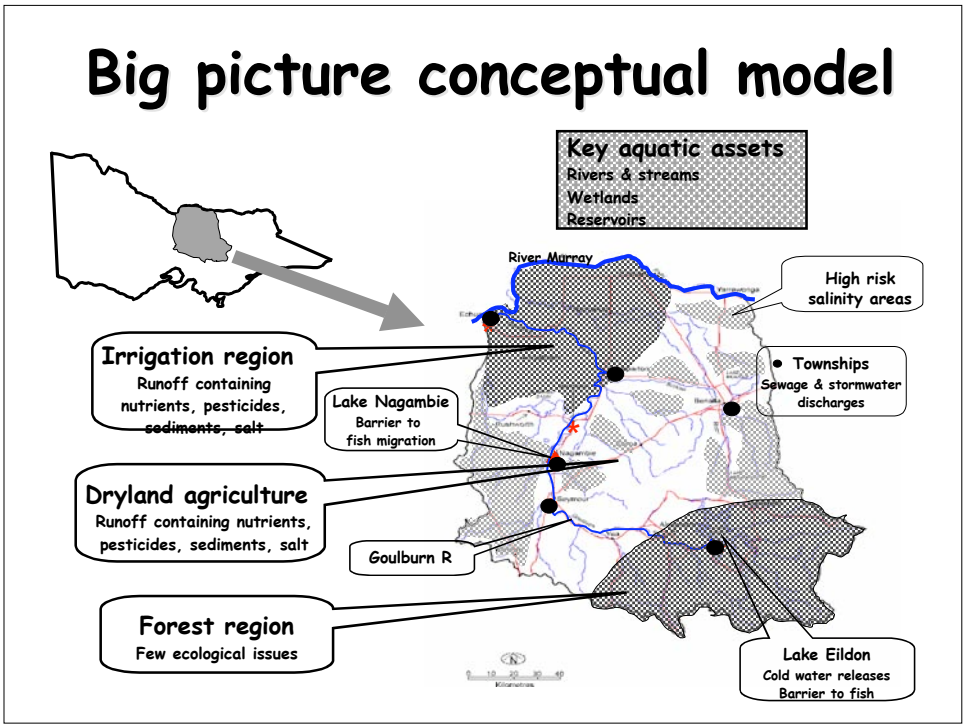


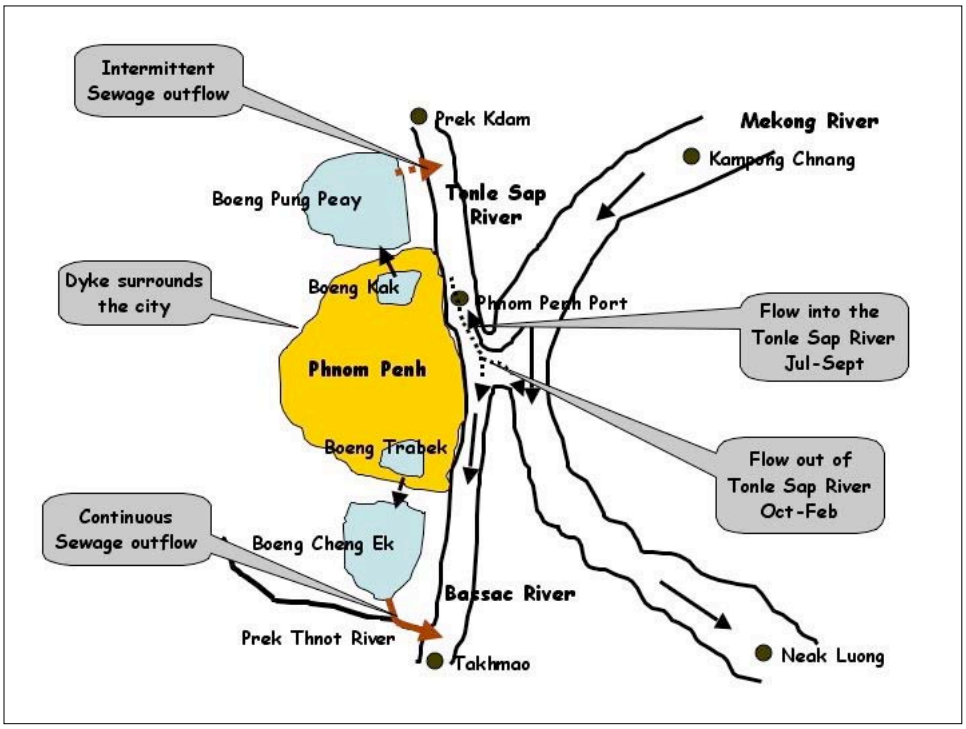
- Develop an overall conceptual model for the system within its catchment
  - identify all major land uses within the catchment
  - identify the ecosystems likely to be at risk
  - identify the key stressors likely to be associated with the irrigation systems and with other land uses within the catchment

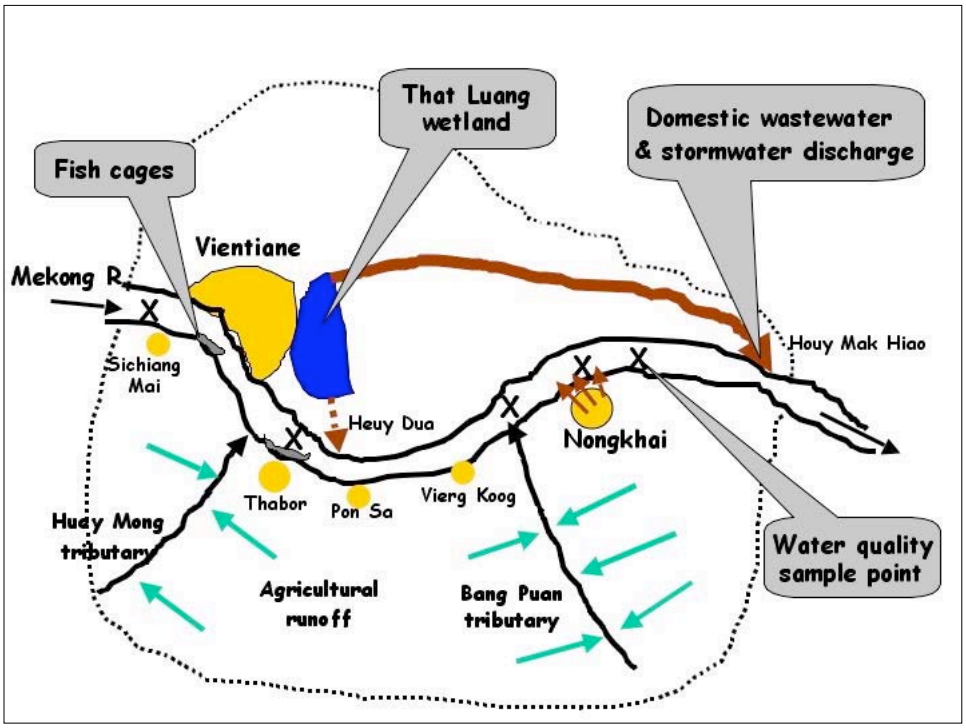


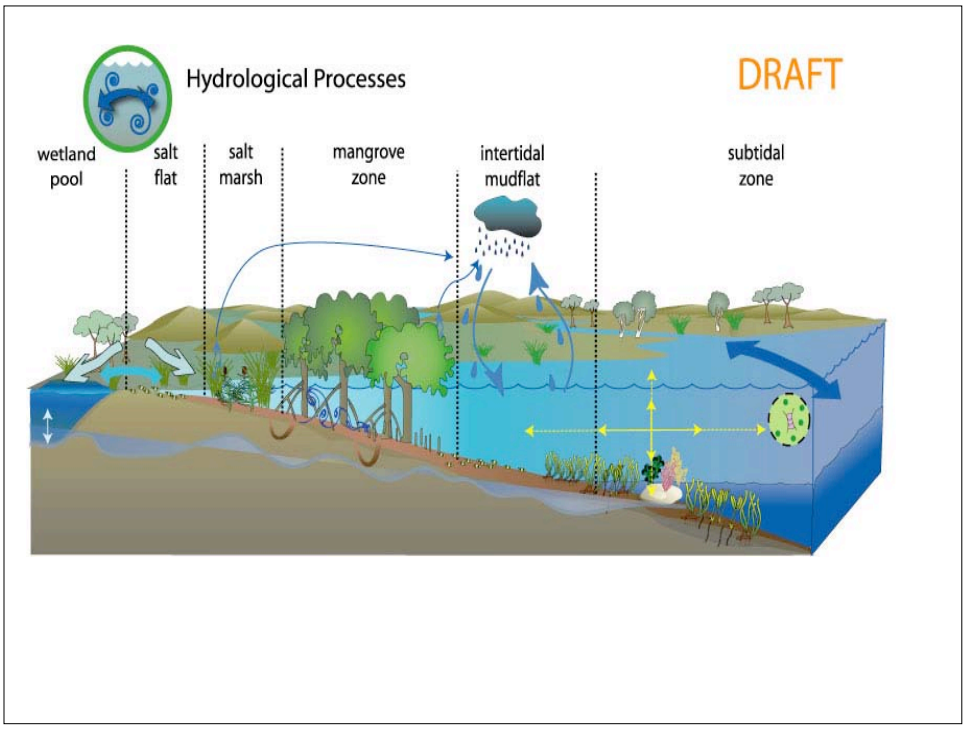
Conceptual Models

- Purpose of system conceptual model
  - To identify all major areas & factors that may contribute to the ecological issues
  - To look at the whole system first
  - To ensure you don't miss some important factors

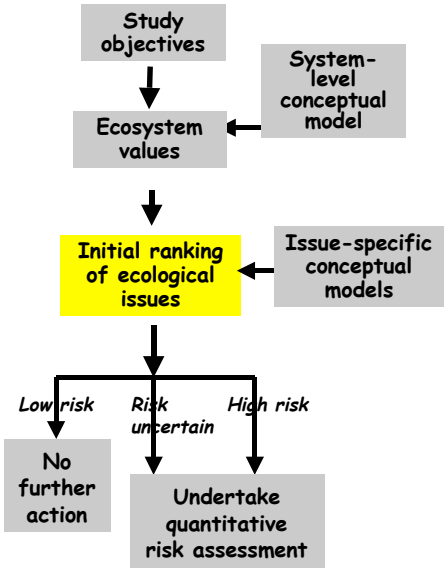

Big picture conceptual model
Key aquatic assets
Rivers & streams
Wetlands
Reservoirs
River Murray
High risk salinity areas
Irrigation region
Runoff containing nutrients, pesticides, sediments, salt
Lake Nagambie
Barrier to fish migration
Townships
Sewage & stormwater discharges
Dryland agriculture
Runoff containing nutrients, pesticides, sediments, salt
Goulburn R
Forest region
Few ecological issues
Lake Eildon
Cold water releases
Barrier to fish


Intermittent Sewage outflow
Prek Kdam
Mekong River
Kampong Chnang
Tonle Sap River
Boeng Pung Peay
Dyke surrounds the city
Boeng Kak
Phnom Penh Port
Flow into the Tonle Sap River Jul-Sept
Phnom Penh
Boeng Trabek
Flow out of Tonle Sap River Oct-Feb
Continuous Sewage outflow
Boeng Cheng Ek
Bassac River
Prek Thnot River
Takhmao
Neak Luong


That Luang wetland
Domestic wastewater & stormwater discharge
Fish cages
Vientiane
Mekong R.
Houy Mak Hiao
Sichiang Mai
Heuy Dua
Nongkhai
Thabor
Pon Sa
Vierg Koog
Huay Mong tributary
Agricultural runoff
Bang Puan tributary
Water quality sample point


Hydrological Processes
DRAFT
wetland pool
salt flat
salt marsh
mangrove zone
intertidal mudflat
subtidal zone

- Identify the key ecological issues for the system being studied
- Typical
  - Increase in the frequency of blue-green algal blooms
  - Increase in the number of fish kills
  - Adverse effect of toxicants on fish or macro-invertebrate population
  - Reduced primary production caused by increase in turbidity



Typical stressors/hazards

- Toxicants (Biocides - herbicides, pesticides, Heavy metals)
- Nutrients (P, N)
- Organic matter (BOD)
- Salt or salinity
- Turbidity/suspended solids
- Physical changes (e.g. flooding)
- Modification of habitat
- Lack of adequate flows
- Introduced species (e.g. carp, weeds)

Table 1: Checklist of potential off-site ecological issues associated with irrigation systems. * Acceptance criteria would need to be developed to determine what level of reduction in biodiversity is acceptable.

Activity	Hazard/Threat/Stressor	Potential ecological effect
Flow-related	• Changed flow regimes & reduced flows • Barrier (weirs, dams) • Poor water quality (low temperature, low dissolved oxygen)	• Reduced biodiversity* - interferes with breeding cycles, loss of habitat • Reduced biodiversity - interferes with fish migration • Toxicity to fish, alien species take over (e.g. trout)
Contaminants	• Increased nutrients (P, N) • Increased toxicants (biocides, heavy metals) • Increased turbidity and suspended particulate matter	• Increased frequency of algal blooms • Reduced biodiversity - due to toxic effects • Reduced primary production, smothering of benthic habitat
Salinity	• Increased salinity	• Reduced biodiversity due to toxic effects on aquatic biota and terrestrial plants

For each ecological issue

- identify measurable assessment endpoints for the ecological effect
- identify hazards, stressors, threats
- develop a conceptual model linking the key hazards (or drivers) with the ecological effect

Assessment endpoints

- Needed to focus the assessment
- Examples
  - Decreases in fish or benthic macroinvertebrate populations
  - Adverse changes in phytoplankton populations
  - Adverse changes in aquatic macrophyte community structure (in wetlands)
  - Toxicant-induced impacts on human health due to the consumption of contaminated aquatic biota
  - Unacceptable water quality as perceived by rowers, canoers, kayakers, motorboat enthusiasts, swimmers and tourists

Table 2: Examples of different ecological effects and assessment endpoints used to assess the risks to ecosystem values. * Desirable at this stage to also nominate how the particular change will be measured (see Section 4.3 and Box 12).

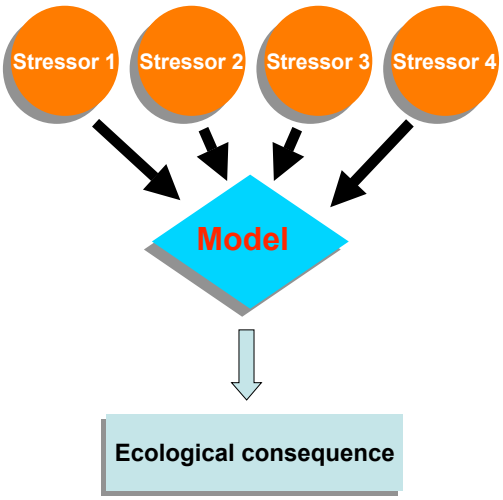
Ecosystem values	Ecological effects	Assessment endpoints*
Protection of wetland health	• Loss of biodiversity due to increased salinity	• Reduction in the abundance and diversity of macroinvertebrates • Reduction in the abundance and diversity of fringing macrophyte vegetation
	• Loss of aquatic macrophytes due to changes to the flow	• Reduction in the abundance and diversity of macrophytes
Protection of river health	• Reduction in native fish numbers due to cold water releases from a reservoir	• Reduction in the abundance and diversity of native fish
	• Toxicity to biota due to pesticide runoff	• Reduction in the abundance and diversity of native fish • Reduction in the abundance and diversity of macroinvertebrates
	• Blue-green algal blooms due to increased nutrient release from an irrigation area	• Increased frequency of cyanobacterial blooms, measured as the number of days the cyanobacterial cell numbers were >15,000 cells/mL
	• Loss of a threatened species due to loss of in-stream and riparian habitat	• Decline in the population size of the threatened species

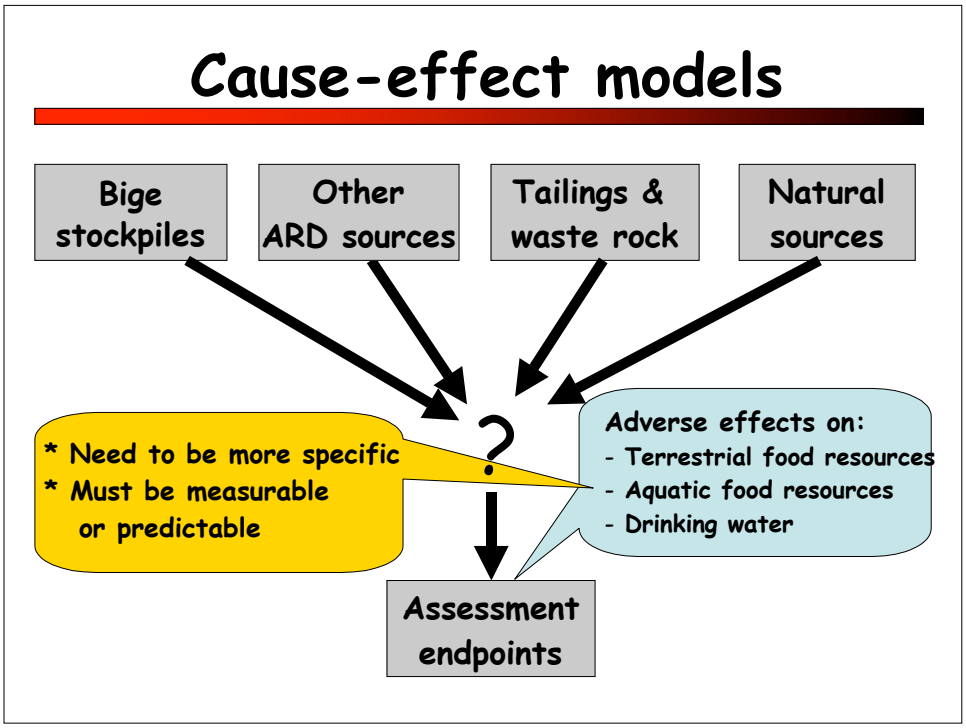
Table 3: Hazard-effect matrix showing the environmental values for Hattah-Kulkyne National Park and the potential threats (hazards) to those values (Carey et al., 2004). Cross denotes possible interaction between value and threat, with 'X' indicating strong interaction and 'x' weak. Highlighted cell denotes interaction considered in the next stage of the assessment.

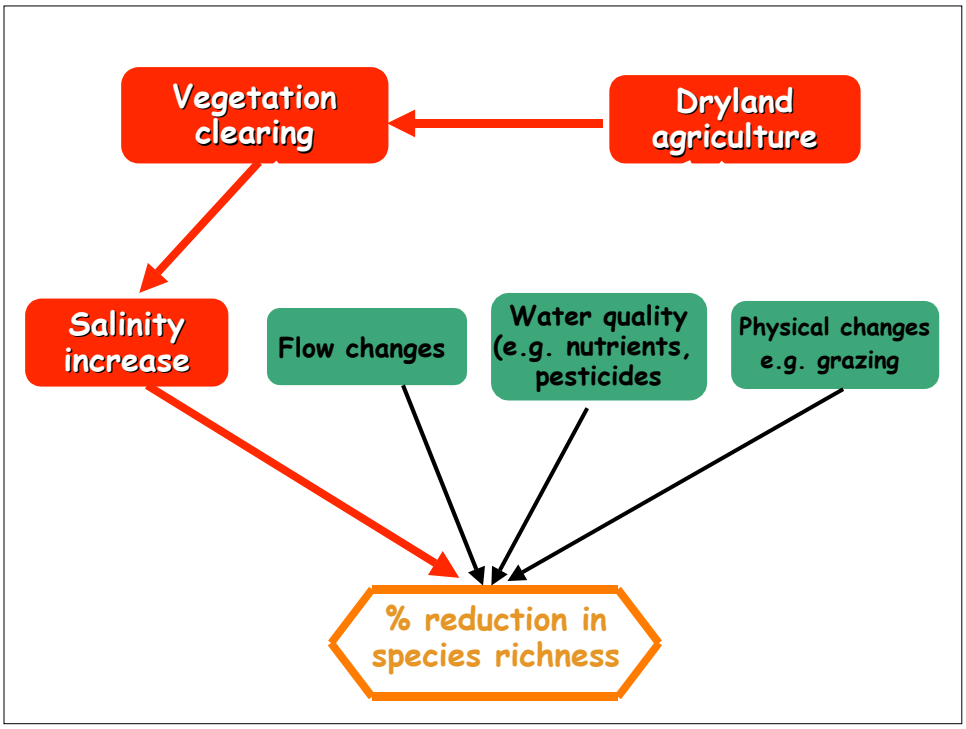
Environmental Values	Potential Threats											
	Trespass or re-introduction of cattle	Overgrazing by kangaroos	Grazing by rabbits and goats	Inappropriate environmental flows	Irrigation impacts on groundwater	Predation by feral cats	Predation by foxes	Feral bees	Presence of weeds	Fragmentation of landscape	Inappropriate fire regime	Drought severity/frequency
Riverine woodlands	X	X	X	X	X		x	X	X		X	X
Four listed communities in Pine/Buloke/Belah complex	X	X	X		X		x	X	X		X	X
Mallee fowl	x	X	X			X	X			X	X	X
Regent parrot	X	x	X	X	X	X	X	X		X	X	X
Lizards	X	X	X			X	X			X	X	X
Mallee bird community	X	X	X	X	x	X	X	X	X	X	X	X
Wilderness values	X	X	X		X	X	X	X	X		X	X
Wetlands	X	X	x	X	X	X	X	X	X		X	X
Old growth/young mallee mosiac	x	X	X		x			X	x		X	
Availability of hollow-bearing trees	X	X	X	X	X			X		X	X	X

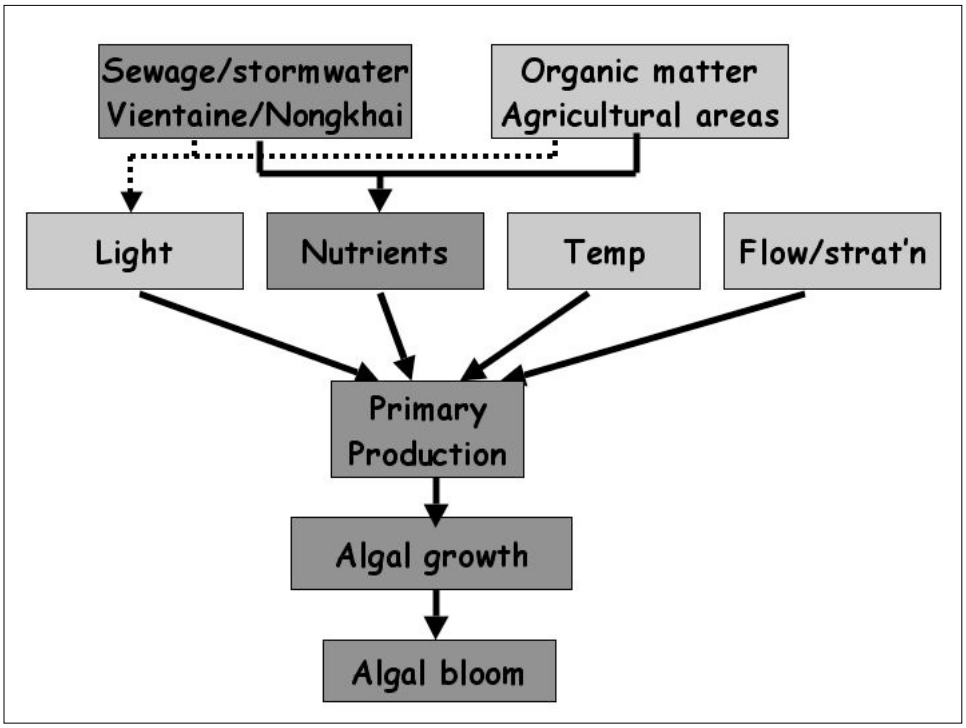
Issue-specific conceptual models

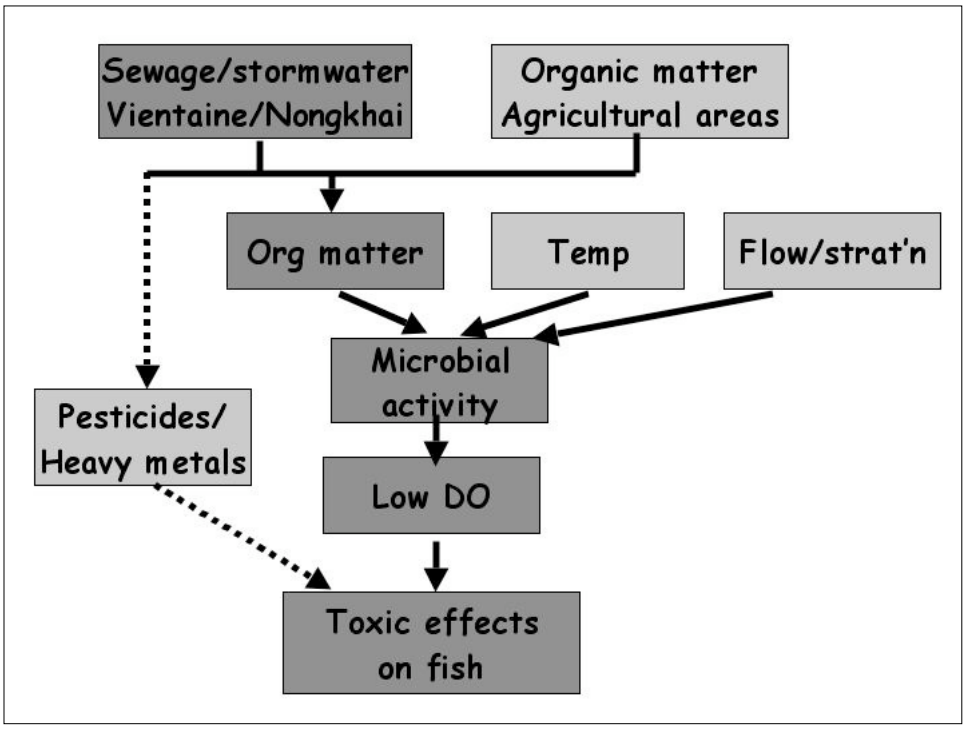
- Conceptual model
  - Linking stressors & ecological consequences
  - Cause and effect relationships

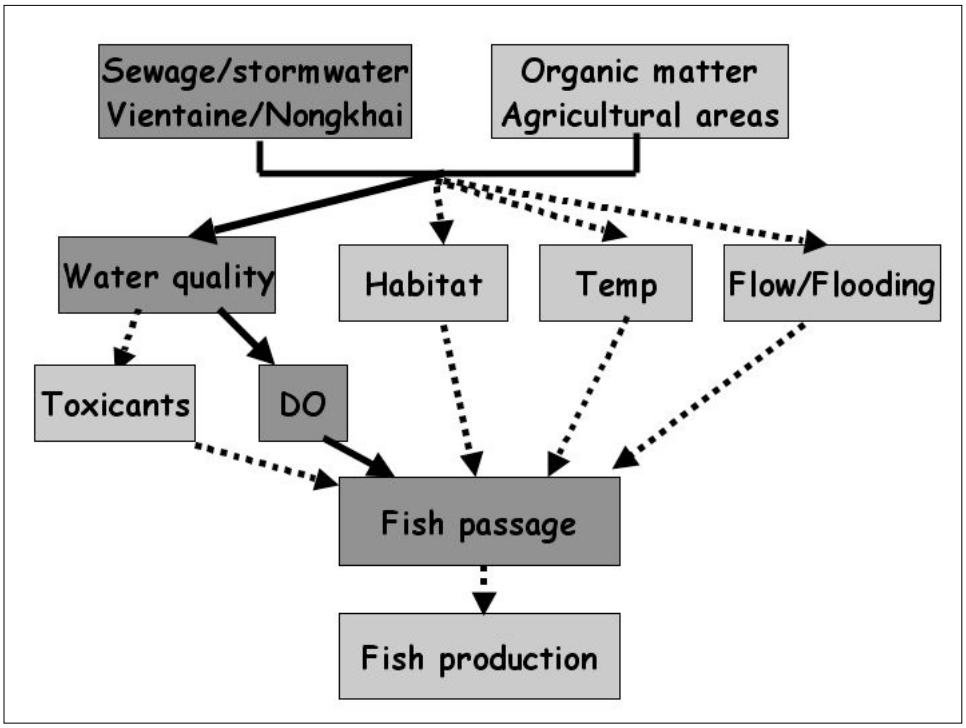



Cause-effect models
Bige stockpiles
Other ARD sources
Tailings & waste rock
Natural sources
?
* Need to be more specific
* Must be measurable or predictable
Adverse effects on:
- Terrestrial food resources
- Aquatic food resources
- Drinking water
Assessment endpoints


Vegetation clearing
Dryland agriculture
Salinity increase
Flow changes
Water quality (e.g. nutrients, pesticides
Physical changes e.g. grazing
% reduction in species richness


Sewage/stormwater
Vientaine/Nongkhai
Organic matter
Agricultural areas
Light
Nutrients
Temp
Flow/strat'n
Primary
Production
Algal growth
Algal bloom


Sewage/stormwater
Vientaine/Nongkhai
Organic matter
Agricultural areas
Org matter
Temp
Flow/strat'n
Microbial
activity
Pesticides/
Heavy metals
Low DO
Toxic effects
on fish



Key messages

- Problem formulation phase establishes the goals, breadth and focus of the risk assessment
- Key outputs are:
  - identification of the ecosystem(s) to be considered
  - ecological values to be protected or maintained
  - the stressors or actions that threaten these values
  - the main measurement endpoint that will be used to quantify the values (and hence risks)
  - the cause-effect relationships (conceptual models) between threats/hazards and endpoints
- Needs to be undertaken with *stakeholder involvement*