

Science behind environmental flows for the River Murray System

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Chair, Living Murray Scientific Reference Panel



COOPERATIVE RESEARCH CENTRE FOR
FRESHWATER ECOLOGY

Talk Overview

- **Summary of Scientific process**
- **Threats to health of River Murray**
- **Snapshot of River Condition**
- **Key findings from Stage 1 study**
- **Stage 2 study - ecological benefits assessment process**
- **Murray Flow Assessment Tool**



Key steps in Murray scientific process

February 2000 – First integrated scientific assessment of threats to River Murray health (Thoms et al 2001)

2001 – *Rivers as ecological systems: Murray-Darling Basin*, book by CSIRO

March 2001 – Ministerial Council decision to undertake preliminary e-flows assessment

April 2002 – Scientific Panel Mk.1 report informs decision on stage 2 analyses. Three reference points – 350, 750, 1500 GL - agreed for further analysis

November 2002 – Scientific Panel Mk. 2 working with regional scientific groups commences detailed ecological benefits analysis

August 2003 – Final ecological assessment report to be submitted to MDBC and Ministerial Council



Comparison of Stages 1 & 2

Stage 1 – 2002 Ministerial Council asked

“Flow required to deliver a healthy working River Murray according to community-based objectives”

Stage 2 – 2003 Ministerial Council asked

“Ecological benefits that could be provided by 350, 750, 1500 GL plus structural & operational improvements, compared with current (do nothing more) and 93/94 conditions”



Ministerial Council for Stage 2

Special focus on icon wetlands

Barmah-Millewa, Gunbower, Koondrook-
Pericoota, Hattah Lakes, Chowilla,
Coorong

...and icon species

Murray Cod, River Red Gums

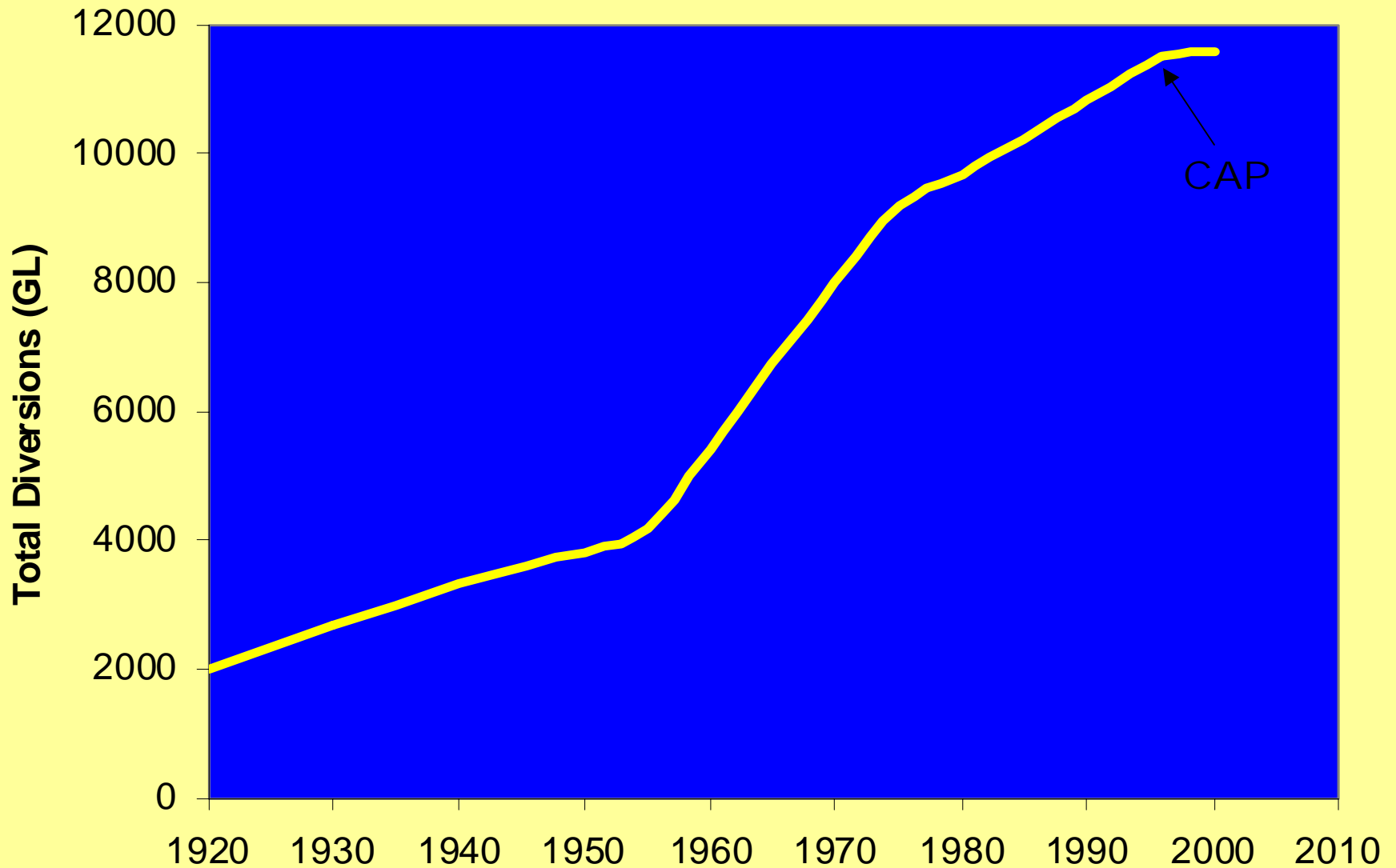




Impacts of flow regime changes on River Murray ecological condition



History of Water Use in MDB



Unseasonal flooding

High summer flow spills into floodplain forests killing trees

SA Lock 3 weir pool



Constant elevated flows



**Severe bank erosion
caused by constant
high flows**

Barmah Choke



Stable water levels

Encourages exotic species



Rigid operation of barrages & weirs



Barriers to fish passage



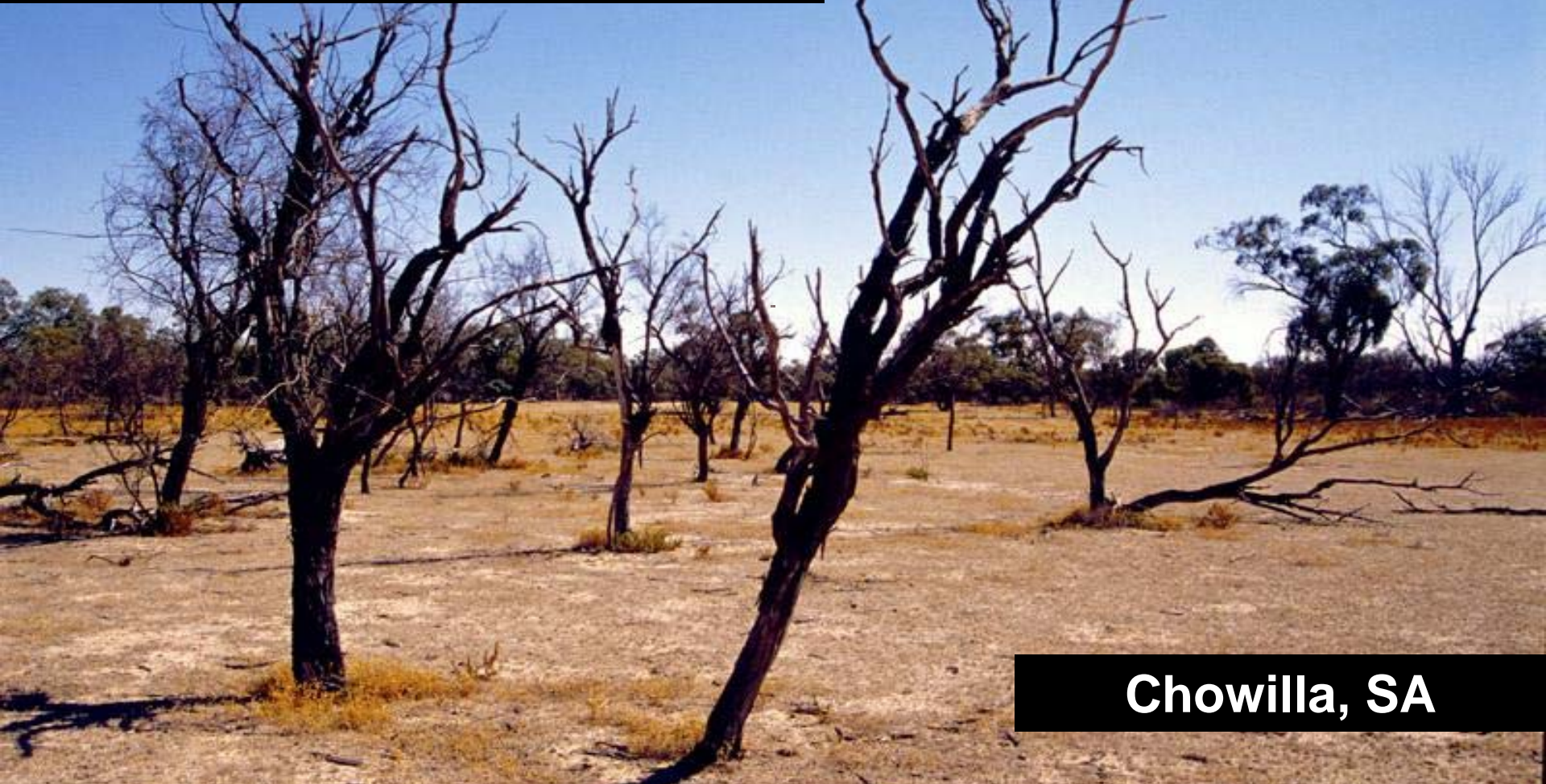
Lack of floodplain inundation

Poor health and death of Red Gum and Black Box forests



Lack of floodplain inundation

Impacts worse when trees
already stressed by salinity



Chowilla, SA



Reduced flow volume



**Increased
likelihood of
Murray Mouth
closure**



Reduced flow volume ...

Increased risk of
toxic algal blooms





Impacts of non-flow changes on River Murray ecological condition



Land management practices



Salinity – threat for wetlands








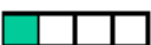


Pest species such as Carp












Snapshot of River Murray Condition*

Zone 4 Torrumbarry Lock 26 to Lock 11

Biotic Features





Feature	Condition	Trend
Macroinvertebrates 		=
Fish 		■
Riparian Vegetation 		■
Wetlands 		■

Environmental Features




Feature	Condition	Trend
Hydrological Condition		■
Wetland Inundation		■
Nutrient and Sediment Loads		■
Nutrient Concentrations		■
In-stream Salinity (EC)		■
(Loads)		=/■
Riverine Habitat		■
Bank Condition		■
Catchment Impacts on River		■



Condition

	Good
	Poor
	Very Poor
	Extremely Poor

Recent Trend

	Degrading		Improving		No Condition Measure or No Trend Available	=	Stable	/	Indicates a trend change within a zone
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* Norris et al. 2001

Snapshot of River Murray Condition*

Zone 5 Lock 11 to Lock 3

Biotic Features		Condition	Trend
Macro invertebrates			=
Fish			■
Riparian Vegetation			■
Wetlands			■
Environmental Features		Condition	Trend
Hydrological Condition			■
Wetland Inundation			■
Nutrient and Sediment Loads			■
Nutrient Concentrations			■
In-stream Salinity (EC) (Loads)			=
Riverine Habitat			■
Bank Condition			■
Catchment Impacts on River			■



Condition	Recent Trend
Good	Degrading
Poor	Improving
Very Poor	No Condition Measure or No Trend Available
Extremely Poor	Stable
	Indicates a trend change within a zone

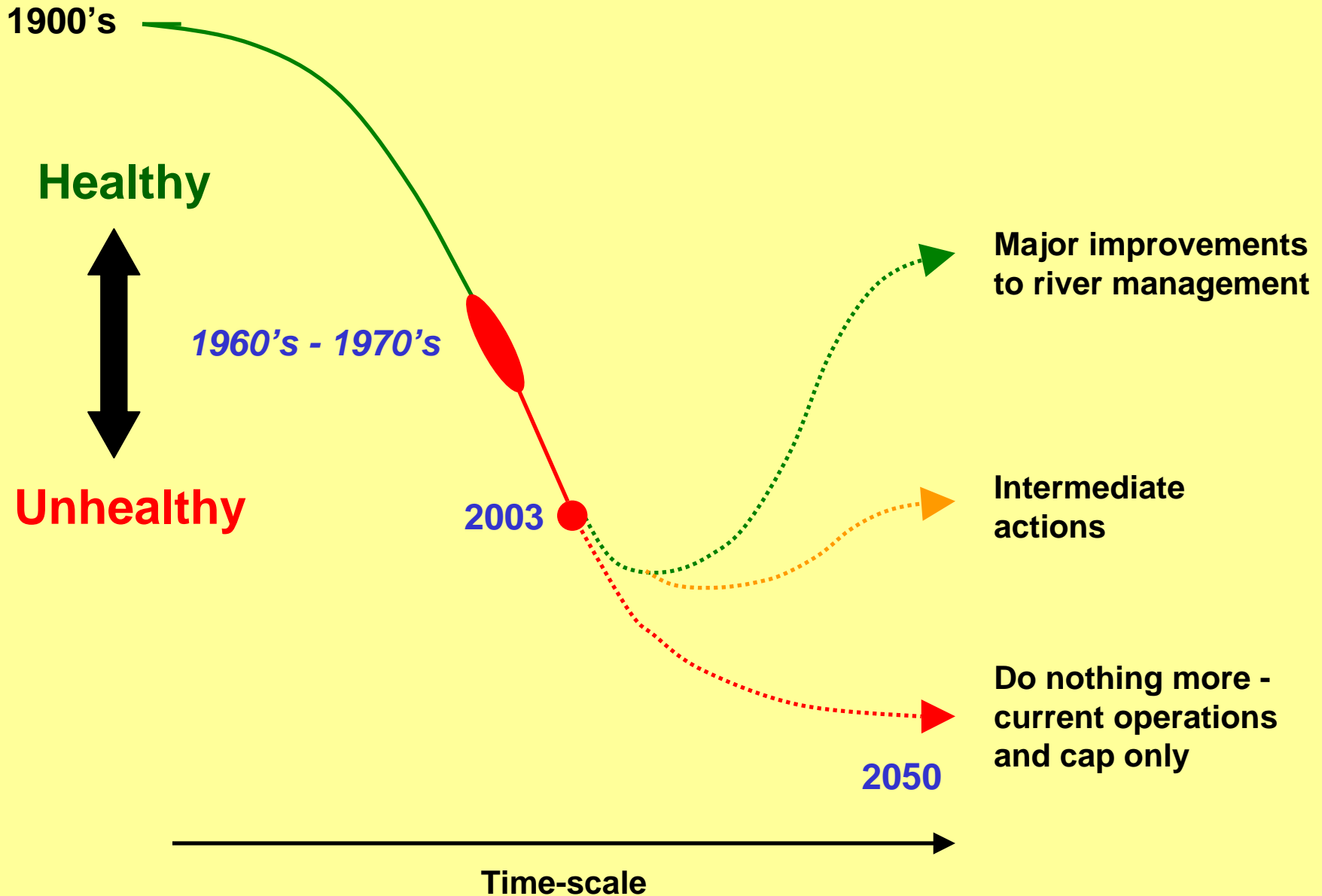
* Norris et al. 2001

CSIRO Stakeholder Survey*

- **93% of survey group (n=320) believe River Murray has serious health problems**
- **95% support e-flow allocation**
- **support drops to <70% if some people's livelihoods badly affected**
- **and further to <40% if local people not involved in decision making**

* Syme et al. 2001

History of River Murray Health





How much
e-flow is
needed to
ensure a
healthy
working
River Murray?



Stage 1 Scientific Panel – April 2002

Aim: Healthy Working River Murray system:

> Two-thirds
natural flow

High likelihood

> Half
natural flow

Moderate likelihood

< Half
natural flow

Low likelihood



Stage 1: Range-finding process

- Based on non-optimised flow operations and modelling
 - Whole of River focus, and on overall ecological condition
 - Indications of likelihood or risk
 - Qualitative approach based largely on expert opinion
 - Non-flow benefits not directly considered, though noted as constraints
- * All these issues addressed in Stage 2**



Stage 2 - Scientific Panel 2003

- **Regional and ‘whole of system’ benefits**
- **Specific biota & groups: Fish, Birds, Floodplain & Wetland Vegetation, Toxic Algae**
- **Includes Murrumbidgee & Goulburn (to be confirmed)**
- **Smarter flow operations & modelling**
- **Quantitative indices of ecological condition**



Stage 2: Ecological benefits analysis

Assessing benefits from operational & structural improvements & volumes:

- Operational improvements to flow regime
- New structures to improve connectivity & better manage flow regime
- Physical habitat improvements (eg. re-snagging, cold water)
- Possible increased flow volumes



Fish passages

Improved fish movements

Fish ladder on
Torrumbarry Weir



Floodplain regulators



Minimise unnatural flooding



Re-snagging

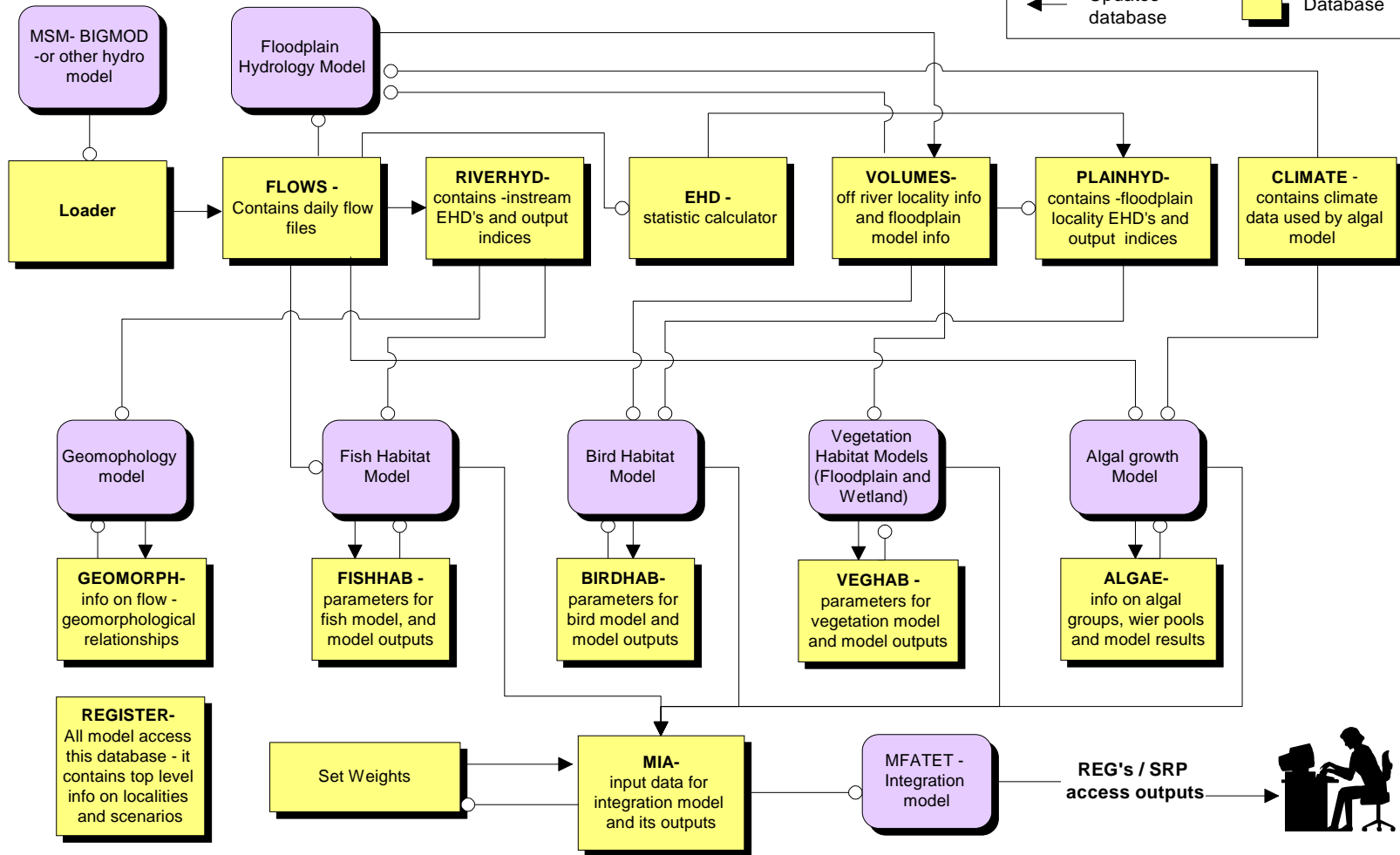
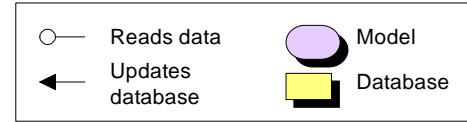


MFAT Decision Support System

- **Links modelled flow data to ecological conceptual models to assess benefits**
- **Produces annual ecological condition indices**
- **Indices can be aggregated by spatial or ecological scale**
- **Optional weightings of components according to significance and certainty**
- **Captures all evidence and confidence levels**
- **Transparent - allows all scientific evidence to be viewed in one location**



MFAT Conceptual Structure



- Splash
- Credits
- About



- Concept Map
- Setup
- Explore

Setup

- Configure Floodplain Hydrology
- Set Up Weights and Connections

Ecological Assessment Models

- Native Fish Habitat Condition
- Algal Growth Model
- Floodplain Vegetation Habitat Condition
- Wetland Vegetation Habitat Condition
- Waterbird Habitat Condition

MFAT has been written in good faith but the authors accept no responsibility for any errors or omissions it may contain or any liability or damage that may result from its use.

- Splash
- Credits
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- Explore

Exit

A product of collaborative research between CRCFE, MDBC and CSIRO to support the Living Murray Initiative.

v 1.0b (2003-02-13)



Edit Pipe

Config ID : 002 Pipe ID : 206

Name : Pipe 206

Regulation

Regulated Closed from start of : January
Closed until end of : April

Input Source

Storage Flow file Shedding Floodplain

Storage : Lock 6 Partitioning storage

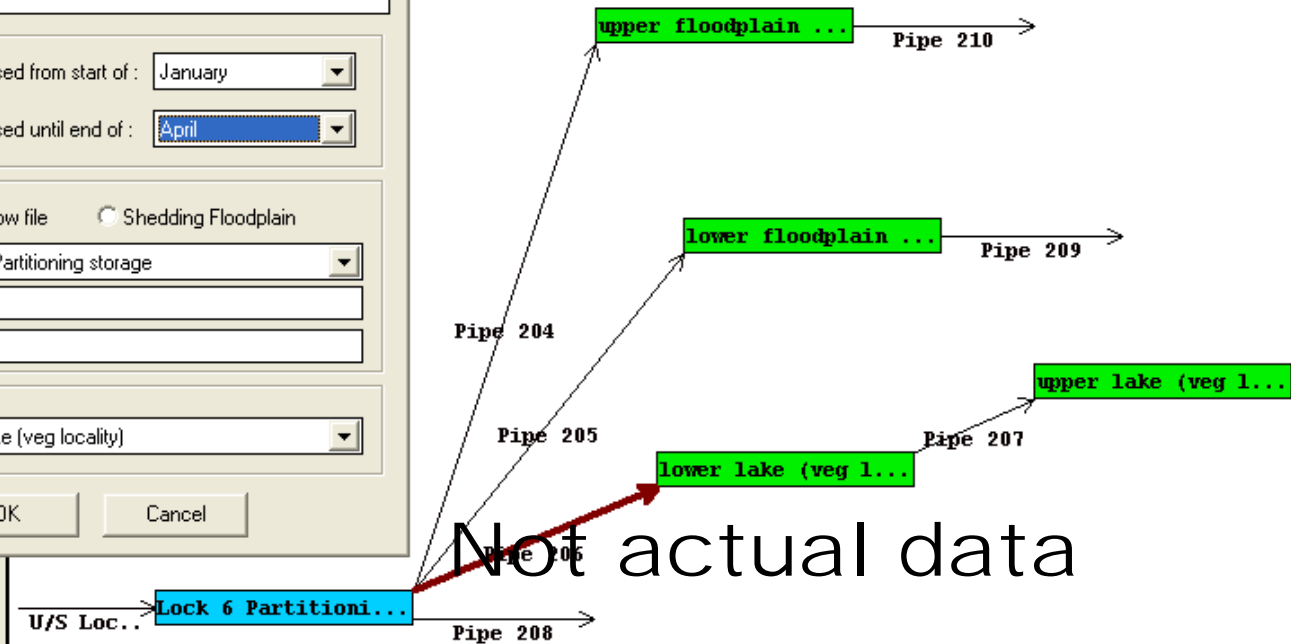
Pmax (ML) : 40500

Pmin (ML) : 40000

Output Storage

Storage : lower lake (veg locality)

OK Cancel



[Werta Wert - Coombool complex] 206

Configuration

New Open

Delete Properties

Save

Storage

New Graph

Delete Properties

Pipe

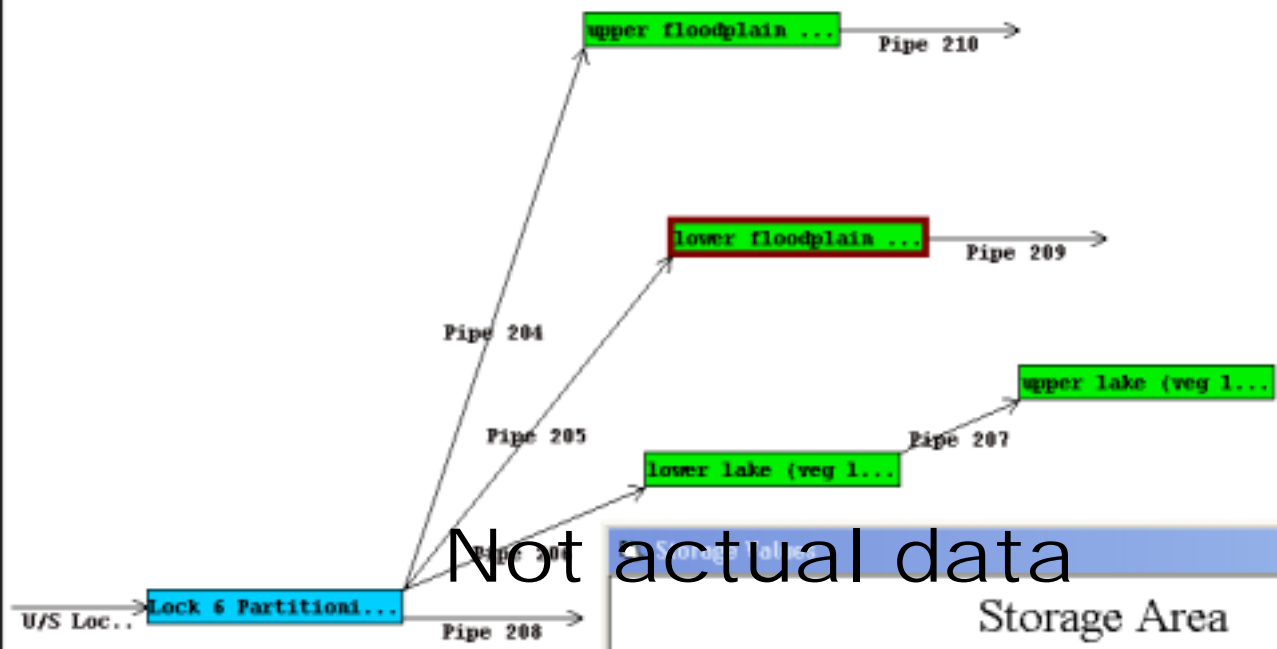
New Graph

Delete Properties

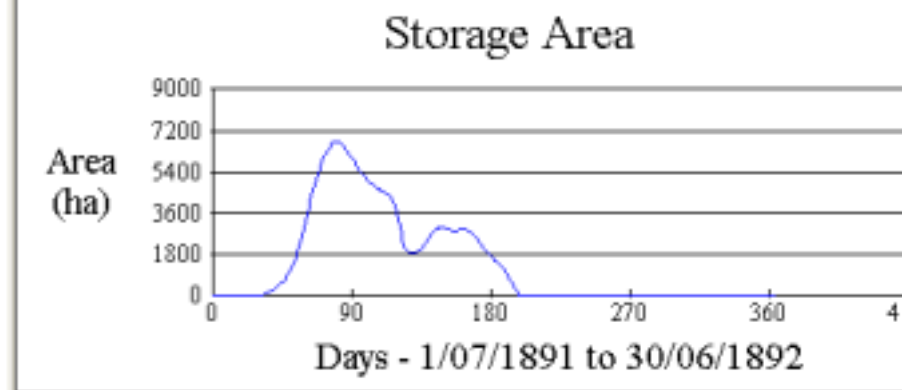
Model

Run Batch Run

EXIT



Not actual data



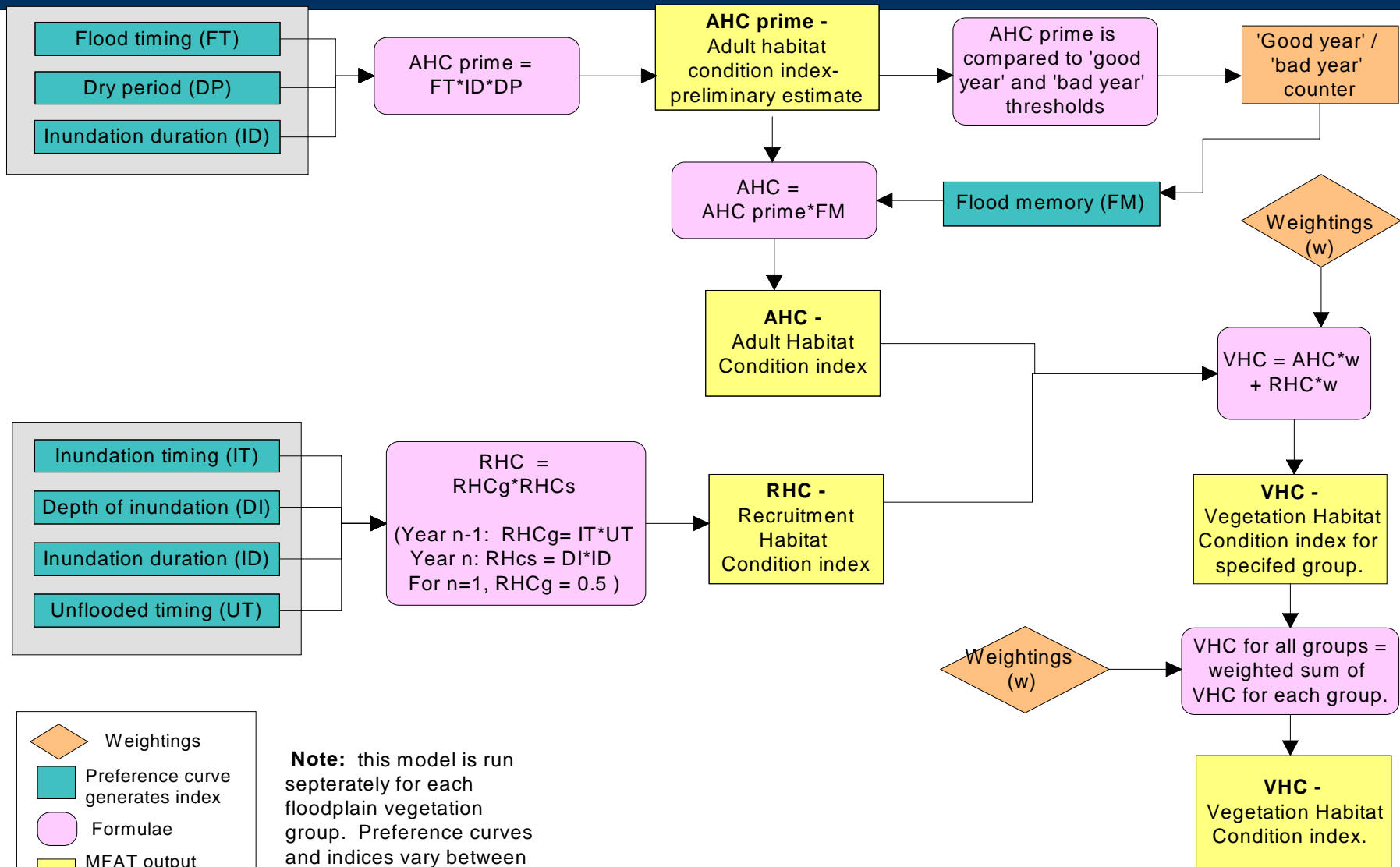
Volume Year: Scenario:

Area [] Natural

[101] lower floodplain (veg locality)

[Werta Wert - Coombool complex] 101

Floodplain Vegetation Habitat Condition Model - conceptual structure and process



- Prepared by Bronwyn Rennie CRCFE 24/1/03 -

locality

- Werta Wert - floodplain 1
- Werta Wert - floodplain 2
- Merreti - floodplain
- Spectacle Lakes - floodplain

group

- All groups
- River red gum forest
- River red gum woodland
- Lignum shrubland
- Rats Tail Couch grassland

Overall Confidence

Storage "lower floodplain (veg locality)" (101) in "Werta Wert - Coorabool complex" (002)

scenario

- All scenarios
- 001: Natural
- 002: Current
- 003: Reference
- 004: 350GL-Cap

Run

Batch Run

Exit

Cancel

v 1.1 (2003-03-11)

Vegetation Habitat Condition equation

$$VHC = w_1 AHC + w_2 RHC$$

Vegetation Habitat Condition (VHC) weights

Adult Maintenance Habitat Condition (AHC)

Recruitment Habitat Condition (RHC)

Adult Maintenance Habitat Condition equation

$$AHC = \sqrt[3]{FT \times FD \times DP \times FM}$$

Adult Maintenance Habitat Condition (AHC)

Flood Timing (FT)

Inundation Duration (FD)

Annual Drying Period (DP)

Flood Memory (FM)

Good years Increment

Bad years Decrement

Recruitment Habitat Condition equation

$$RHC = \sqrt[3]{ID \times DD \times GT_{n-1}}$$

Recruitment Habitat Condition (RHC)

seedling establishment: current year

Inundation Depth (ID)

Inundation Duration (DD)

germination: previous year

Germination Timing (GT)

Not actual data

About
Model
Diagnostics
Conceptual Map

Floodplain Vegetation Habitat Condition Model

locality

- Werta Wert - floodp
- Werta Wert - floodp
- Merreti - floodplain
- Spectacle Lakes - f

group

- All groups
- River red gum fores
- River red gum wood
- Lignum shrubland
- Rats Tail Couch gre

Overall Confic

Storage "lower floodplai

locality" (101) in "Werta

Coombool complex" (0

scenario

- All scenarios
- 001: Natural
- 002: Current
- 003: Reference
- 004: 350GL-Cap

Run

Exit

SRP

Reset to SRP

Save

Close

germination: previous year

Germination Timing (GT) Edit

Preference Curve

Inundation Duration for River red gum forest

Days: Value: Add Delete

Days	Value
0	0.0
100	1.0
200	1.0
625	0.0

Not actual data

start

SR... Pu... Mu... Fl... Pr... EN

7:33 AM

Floodplain Vegetation Habitat Condition Model

locality

Werta Wert - floodp
Werta Wert - floodp
Merreti - floodplain
Spectacle Lake

group

All groups
River red g
River red g
Lignum shr
Rats Tail C

Over

Storage "lowest
locality" (101)
Coombooloo

scenario

All scenario
001: Nature
002: Current
003: Refere
004: 350GL-

Run

Exit

Preference Curve

Inundation Duration for River red gum forest

Evidence

Inundation Duration Preference Curve for River red gum forest

Author: Gary Jones

Date: Sunday, 9 March 2003

Confidence Level: (A) Expert judgement supported by data and consensus knowledge from published papers and reports

Evidence:

- (A) Expert judgement supported by data and consensus knowledge from published papers and reports
- (B) Expert judgement supported by unpublished data and knowledge, which can be made available for public consideration
- (C) Expert judgement based on general scientific experience or anecdotal information

To be assigned by SRP in the near future

Sources: Young et al 2001 Rivers as Ecological Systems: Murray Darling Basin, CSIRO Land & Water, p. 215

Table: EvidenceKeyedByZoneGroup

Save Close

Not actual data

start

7:37 AM

Floodplain Vegetation Habitat Condition Model

locality

Werta Wert - floodp
Werta Wert - floodp
Merreti - floodplain
Spectacle Lake

group

All groups
River red g
River red g
Lignum shr
Rets Tail C

scenario

All scenari
001: Nature
002: Current
003: Refere
004: 350GL

Run

Exit

Vegetation Habitat Condition equation

Preference Curve

Inundation Duration for River red gum forest

Evidence

Inundation Duration Preference Curve for River red gum forest

Author: Gary Jones

Date: Sunday, 9 March 2003

Confidence Level: (A) Expert judgement supported by data and consensus knowledge from published papers and reports

Evidence: Several published papers and extensive forestry research as summarised in Young et al (2001)

Sources: Young et al 2001 Rivers as Ecological Systems: Murray Darling Basin, CSIRO Land & Water, p. 215

Table: EvidenceKeyedByZoneGroup

Save Close

start

7:38 AM

Not actual data

locality
 Lock 7 weirpool (or Mulluroo Ck)

group
 2 Macquarie perch
 3 Wetland specialists
 4 Freshwater catfish
 5 Main channel generalists
 6 Main channel specialists

Overall Confidence

Murray Cod, Trout cod, River blackfish, Two-spined blackfish

scenario
 All scenarios
 001: Natural
 002: Current
 003: Reference
 004: 350GL-Cap

Run Batch Run

Exit Cancel

v 1.1.1 (2003-03-19)

Adult Habitat Condition equation

$$AHC = w_4WD + w_5WT + w_6CC + w_7FP + w_8MF$$

Locality Parameters (not group-specific)

Woody Debris (WD)

Woody debris at natural levels - no desnagging View Values

Water Temperature (WT)

No thermal pollution - natural thermal regime View Values

Channel Condition (CC)

View Initial Values Table View Index Reductions

- Channel has undergone significant straightening -0.2
- Signs of bank erosion or riparian tree loss -0.2
- In-channel sedimentation -0.2
- Absence of Macrophyte beds for Catfish -0.2

Fish Passage (FP)

Flow threshold for effective passage (ML/day) 0 View Values

Migration period Jul to Jun

Maintenance Flow (MF)

Flow Percentile (Adult) (FPA) Edit

Flow Timing (FT) Edit

Not actual data

About
 Model Weights
 AHC
 SHC
 LHC
 Diagnostics
 Conceptual Map

locality
 Lock 7 weirpool (or Mulluroo Ck)

- group**
- 3 Wetland specialists
 - 4 Freshwater catfish
 - 5 Main channel generalists
 - 6 Main channel specialists
 - 7 Low flow specialists

Overall Confidence

Murray Cod, Trout cod, River blackfish, Two-spined blackfish

- scenario**
- All scenarios
 - 001: Natural
 - 002: Current
 - 003: Reference
 - 004: 350GL-Cap

Run Batch Run

Exit Cancel

v 1.1.1 (2003-03-19)

Adult Habitat Condition equation

$$AHC = w_4WD + w_5WT + w_6CC + w_7FP + w_8MF$$

Locality Parameters (not group-specific)

Woody Debris (WD)

Woody debris at natural levels - no desnagging View Values

Water Temperature (WT)

No thermal pollution - natural thermal regime View Values

- Channel Modifications
- Channel has undergone significant straightening -0.2
 - Signs of bank erosion or riparian tree loss -0.2
 - In-channel sedimentation 0.2
 - Absence of Macrophyte beds (or Cattfish) 0.2

Fish Passage (FP)

Flow threshold for effective passage (ML/day) 40000 View Values

Migration period Jul to Dec

Maintenance Flow (MF)

Flow Percentile (Adult) (FPA) Edit

Flow Timing (FT) Edit

Not actual data

About
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locality

- Werta Wert - floodplain 1
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- Merreti - floodplain
- Spectacle Lakes - floodplain

group

- All groups
- River red gum forest
- River red gum woodland
- Lignum shrubland
- Rats Tail Couch grassland

Overall Confidence

Storage "lower floodplain (veg locality)" (101) in "Werta Wert - Coombool complex" (002)

scenario

- All scenarios
- 001: Natural
- 002: Current
- 003: Reference
- 004: 350GL-Cap

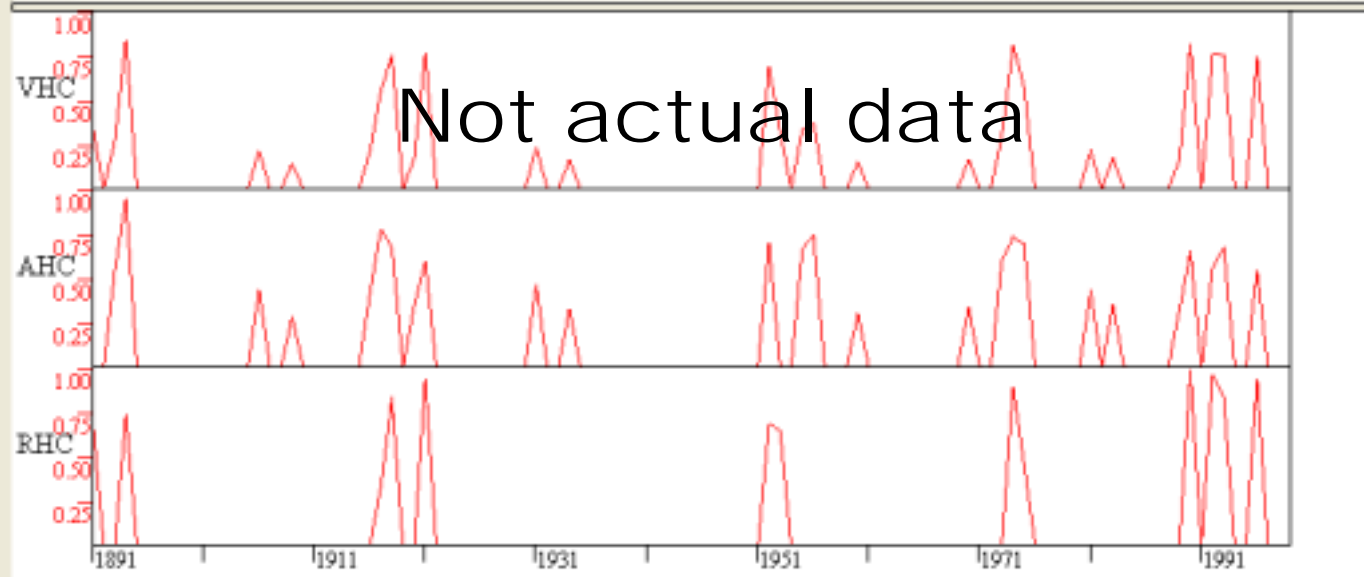
Run Batch Run

Exit Cancel

Diagnostic Mode

annual output series daily input/output series for year: 1891

- VHC_VegetationHabitatCondition
 - AHC_AdultHabitatCondition
 - FT_FloodTiming
 - FD_InundationDuration
 - DP_AnnualDryingPeriod
 - FM_FloodMemory
 - RHC_RecruitmentHabitatCondition
 - GT_GerminationTiming
 - ID_InundationDepth
 - DD_InundationDuration



- within zone comparison
- between zone comparison
- floodplain investigation

zone (one or all)

E: Lock 11 to Lock 3
Murray River

locality (one, all or several)

Werta Wert - billabong/lagoon
Werta Wert - lake
Werta Wert - floodplain 2
Werta Wert - floodplain 1
Werta Wert - Coombool

assessment type

Floodplain Vegetation Habitat Con
Inundation Volume
Inundation Area

test scenario (>)

001: Natural
002: Current
003: Reference
004: 350GL-Cap
005: 750GL-Cap

reference scenario

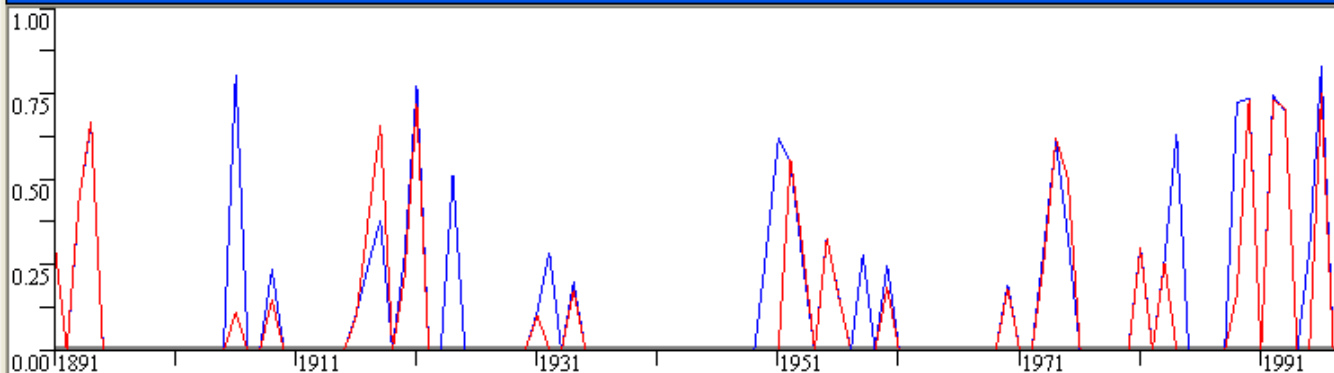
003: Reference
004: 350GL-Cap
005: 750GL-Cap
006: 1500GL-Cap
013: Actual

threshold value index time unit

threshold duration years

time series CDF log scale seasonal average

Yearly Time Series for Floodplain Vegetation Habitat Condition at Werta Wert - floodplain 1 (Year 1 July - 30 June)



Yearly Statistics for Floodplain Vegetation Habitat Condition at Werta Wert - floodplain 1 with threshold 0.01 index a

	scenar	mean	median	min	max	S80	CV	% above	spells	above: m	above: lon	below: me	below: lo
	001	0.34	0.31	0	0.9	2.57	0.95	55	26	2.35	26	1.76	25
▶	002	0.1	0	0	0.75	Infinity	2.05	25	18	1.56	18	4.44	18
	003	0.12	0	0	0.76	Infinity	1.94	26	18	1.61	18	4.39	18
	004	0.12	0	0	0.76	Infinity	1.81	30	19	1.74	19	3.95	19
	005	0.14	0	0	0.83	Infinity	1.71	32	20	1.75	20	3.65	20
	006	0.14	0	0	0.85	Infinity	1.7	32	19	1.84	19	3.84	19
	013	0.26	0	0	0.84	Infinity	1.29	44	6	2	6	2.14	7

Not actual data

- within zone comparison
- between zone comparison
- floodplain investigation

zone (one or all)

E: Lock 11 to Lock 3
Murray River

locality (one, all or several)

- Werta Wert - billabong/lagoon
- Werta Wert - lake
- Werta Wert - floodplain 2
- Werta Wert - floodplain 1**
- Werta Wert - Coombool

assessment type

- Floodplain Vegetation Habitat Cor**
- Inundation Volume
- Inundation Area

test scenario (▶)

- 001: Natural
- 002: Current**
- 003: Reference
- 004: 350GL-Cap
- 005: 750GL-Cap

reference scenario

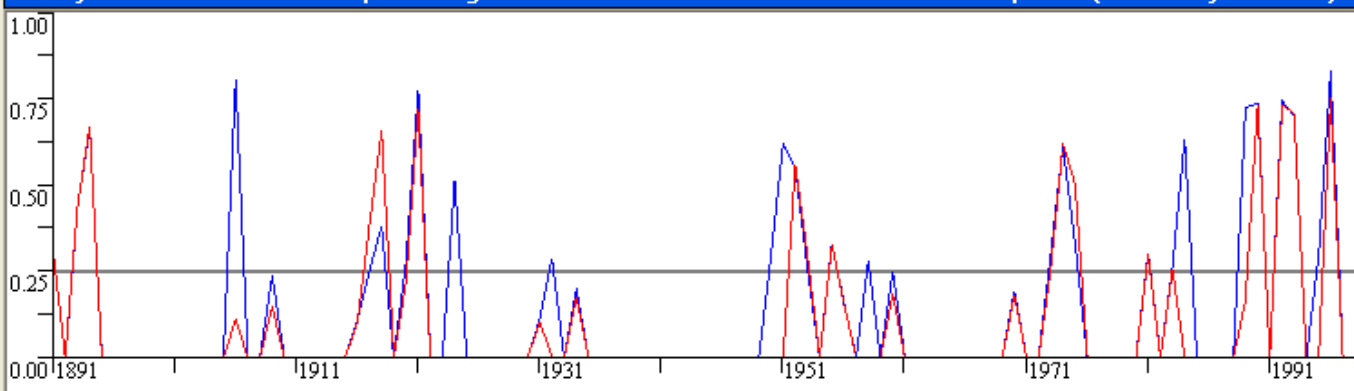
- 003: Reference
- 004: 350GL-Cap
- 005: 750GL-Cap**
- 006: 1500GL-Cap
- 013: Actual

threshold value index time unit

threshold duration years

time series CDF log scale seasonal average

Yearly Time Series for Floodplain Vegetation Habitat Condition at Werta Wert - floodplain 1 (Year 1 July - 30 June)



Yearly Statistics for Floodplain Vegetation Habitat Condition at Werta Wert - floodplain 1 with threshold 0.25 index a

scenari	mean	median	min	max	S80	CV	% above	spells	above: mean	spell duratio	above: long spells
001	0.34	0.31	0	0.9	2.57	1.95	56	20	2.26		27
002	0.1	0	0	0.75	Infinity	2.05	16	12	1.5		12
003	0.12	0	0	0.76	Infinity	1.94	18	12	1.67		12
004	0.12	0	0	0.76	Infinity	1.81	19	13	1.62		13
005	0.14	0	0	0.83	Infinity	1.71	26	17	1.71		17
006	0.14	0	0	0.85	Infinity	1.7	25	16	1.69		16
013	0.26	0	0	0.84	Infinity	1.29	40	6	1.83		6

Not actual data

Scientific Assessment Summary

- **Integrated hydrological and ecological analysis, with benefits compared with current (do nothing more) and 93/94 conditions (to assess recent improvements)**
- **3 reference volumes x 3 operational scenarios (for better use of available water) + structural improvements**
- **Zone based assessments by REGs integrated to whole of river scale by SRP**
- **Levels of certainty explicitly represented**
- **Non-flow constraints to recovery identified**
- **All supporting scientific evidence captured in one location – MFAT**



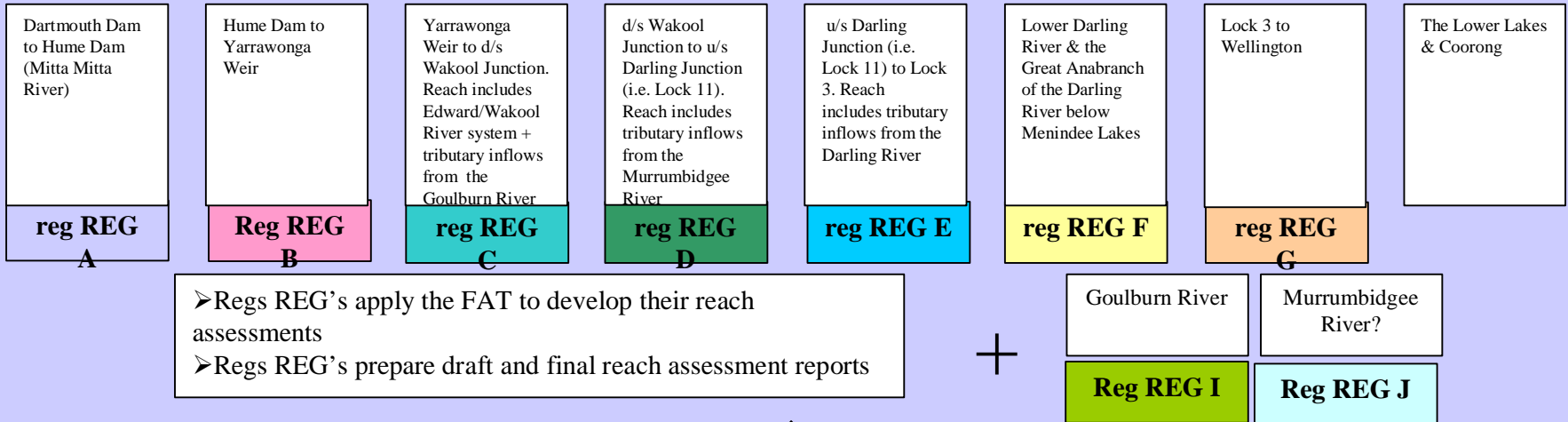
Scientific Reference Panel (SRP)

➤ Develop River Murray Flow Assessment Tool (MFAT)

- Establishment of regs REG's
- Regs REG's assemble ecological data required to run the FAT
- FAT training workshops for REG's regs

Interaction with MDBC Project Team (modelling, ecologist)
➤ Model optimisation: 350, 750 & 1500GL & the 'Do Nothing' benchmark

River Murray reaches and regional evaluation groups (regs)



- Regs REG's apply the FAT to develop their reach assessments
- Regs REG's prepare draft and final reach assessment reports

Interaction with MDBC Project Team (modelling, ecologist)

- SRP integrate and synthesise final reg REG reach assessments
- SRP prepare final report to the Project Board

Murrumbidgee REG

- **Led by Dr. Robyn Watts, CSU**
- **Scientific specialists in hydrology & geomorphology, fish & bird biology, vegetation, wetlands, algae & water quality**
- **Scientists from CSU, UNE, VDSE, DLWC, NSW Fisheries**



Advice not advocacy

