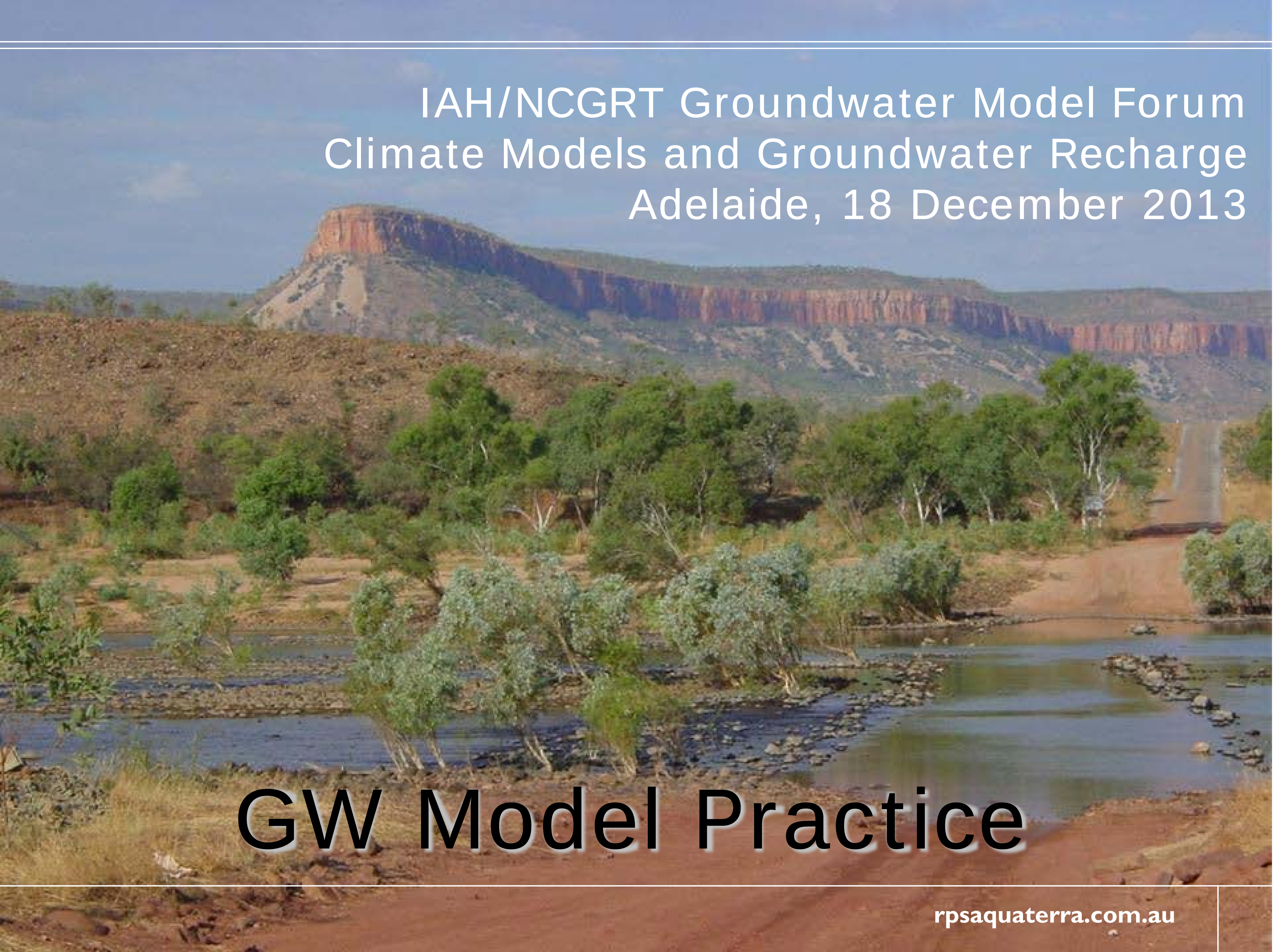


IAH/NCGRT Groundwater Model Forum
Climate Models and Groundwater Recharge
Adelaide, 18 December 2013

GW Model Practice

Guidelines basic principle

- Guiding principle ok, but we need more explicit and practical guidance
- Australian GW Model Guidelines (Barnett et al, 2012) http://archive.nwc.gov.au/library/waterlines/82
- Guiding Principle 6.2: The net impacts of future climate stresses (or changes in future climate stresses) should be obtained from the difference between predictions that include climate change assumptions and a null scenario that includes historic or current climate assumptions.

Model Uncertainties Cascade

- Climate Change scenarios give Temperature
- Transform Temperature into Rainfall and EVT
- GW models need RCH input from RF & EVT
- WAVES designed/suited to such purpose

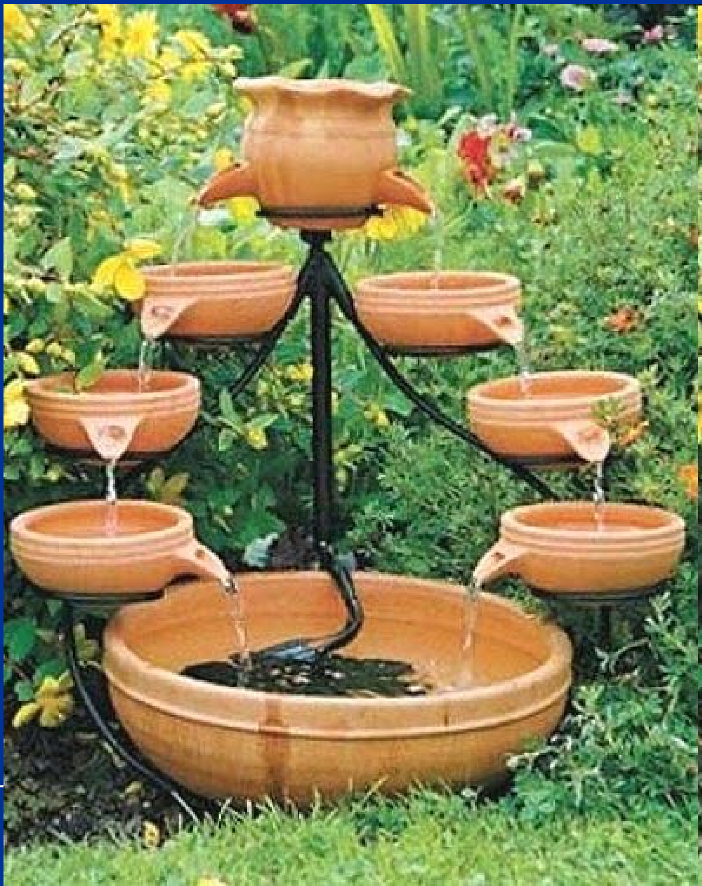
GG emissions

GCM temperature

Rainfall & EVT, scaling issues

Recharge model (WAVES)

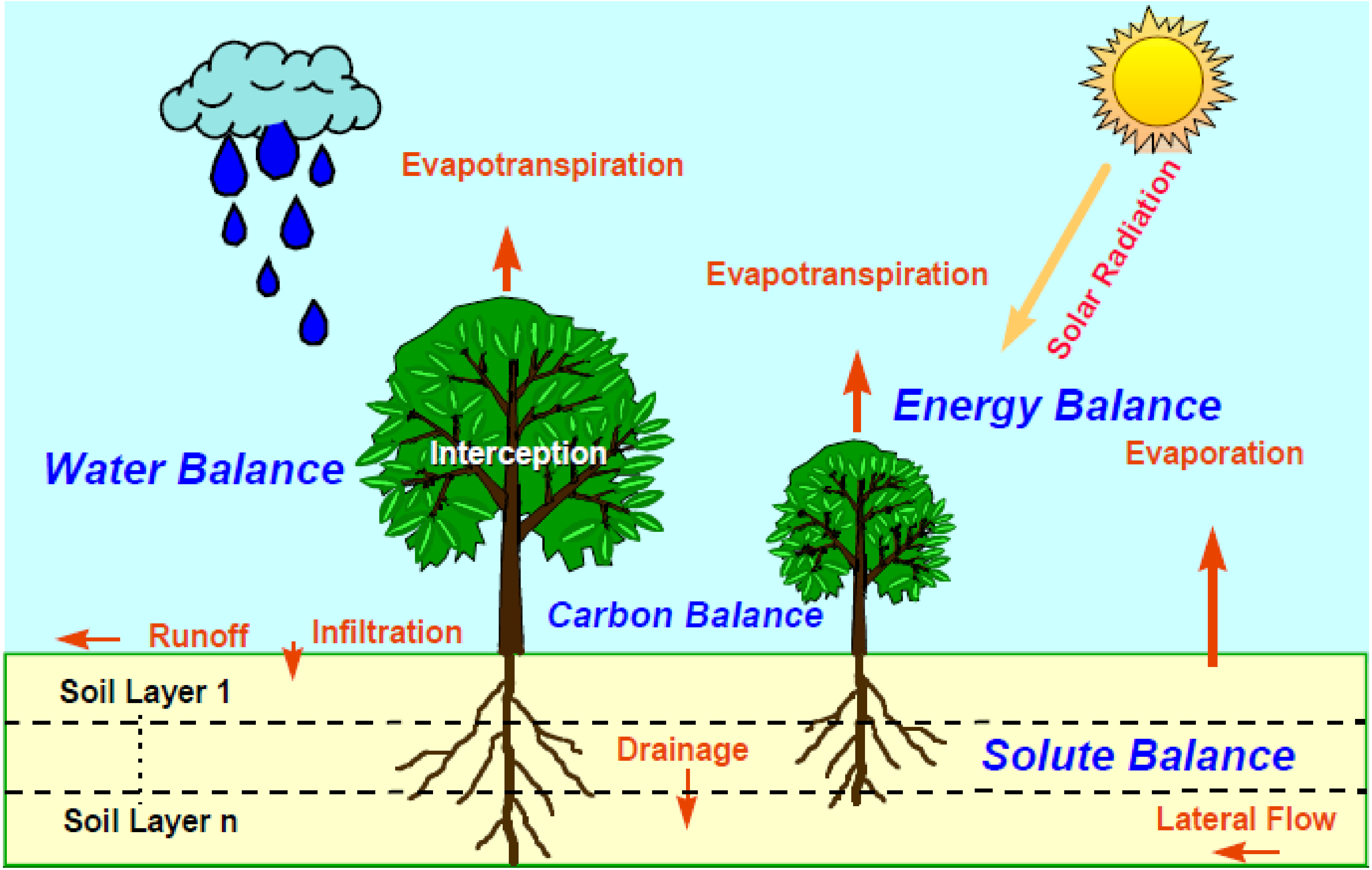
Groundwater model RCH & EVT



Premise: CC RCH to GW model

- WAVES designed/suited to provide RCH, but
- WAVES must be calibrated (not default), and
- GW model response to WAVES RCH must be validated to history of GW system responses of pre/post climate change signal/character
- Need to evaluate uncertainty for decisions

Water Vegetation Energy and Solute Modelling (WAVES)



Models Support Decisions

- Decision makers are eager for certainty
- Models/Modellers **cannot provide certainty**
- Models affected by uncertainties in terms of:
  - concepts/structure
  - parameters
  - calibration and prediction
- Cannot predict future events with certainty
  - all predictions will be wrong in some way

GW Model Uncertainty

- Conceptual / Structural (critical)
  - physical framework; hydrological processes
  - most important; recent studies confirm
  - structural uncertainty cannot be quantified
- Calibration
  - GW models calibrate ratio of thruflow/Kh
  - non-uniqueness; constrain with measurements, especially flow volumes (RCH?); include hydrological variability
  - Trad. or PU sensitivity/uncertainty methods
- Parameterisation (ask John Doherty)
  - Predictive Uncertainty (www.pesthomepage.org)

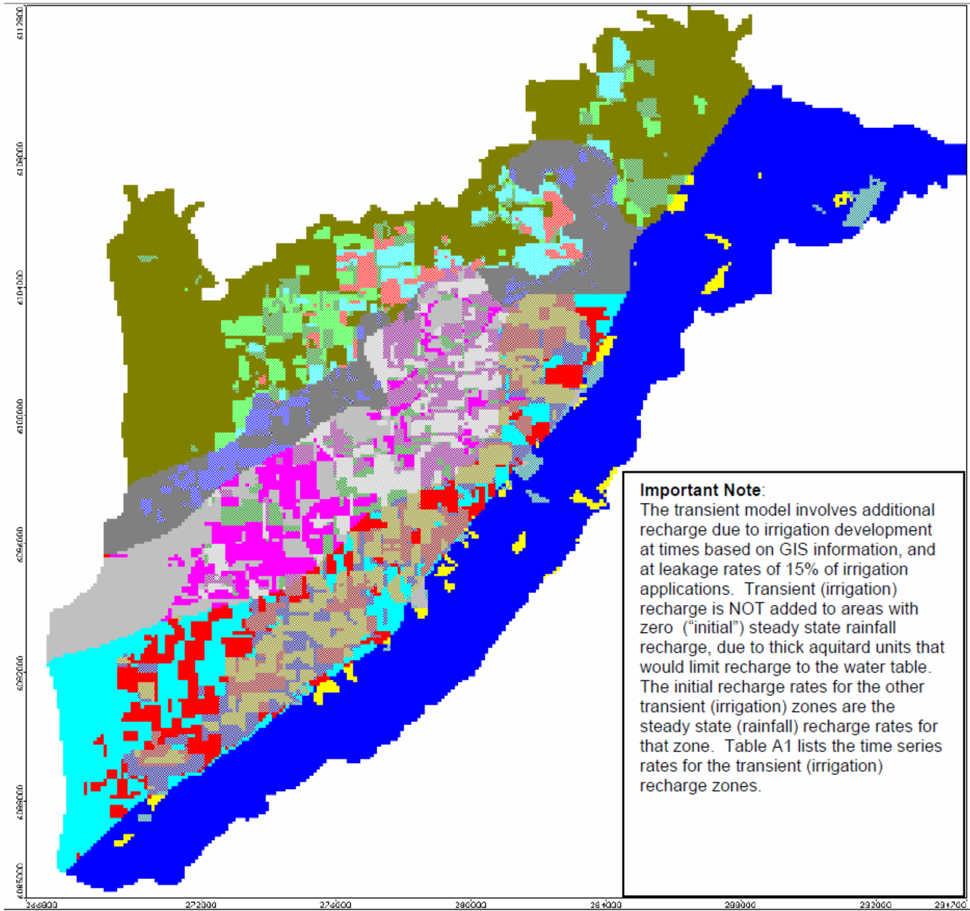
Structural/Conceptual Uncertainty

- Due to simplification of complex reality
- Multiple model conceptualisations helpful
- Ye et al, Yucca Mtn; Ground Water, vol.48/5, 2010
  - (5xRCH)*(5xGeology) = 25 model realisations
  - Parametric uncertainty using Monte Carlo
  - Structural error uses 2 model averaging methods
  - Structural: major effect on predictive uncertainty
  - Calibration observations do not discriminate model
- Eastern Snake (www.idwr.idaho.gov)
  - Consensus approach with all parties involved in model development, from concepts to scenarios
  - "social approach" to address model uncertainty

McLaren Vale –> 2 models

- High/Low Recharge
- Two K distributions
- Scenarios run for each model to identify envelope of aquifer response
- Used to inform Water Allocation Planning (2006)

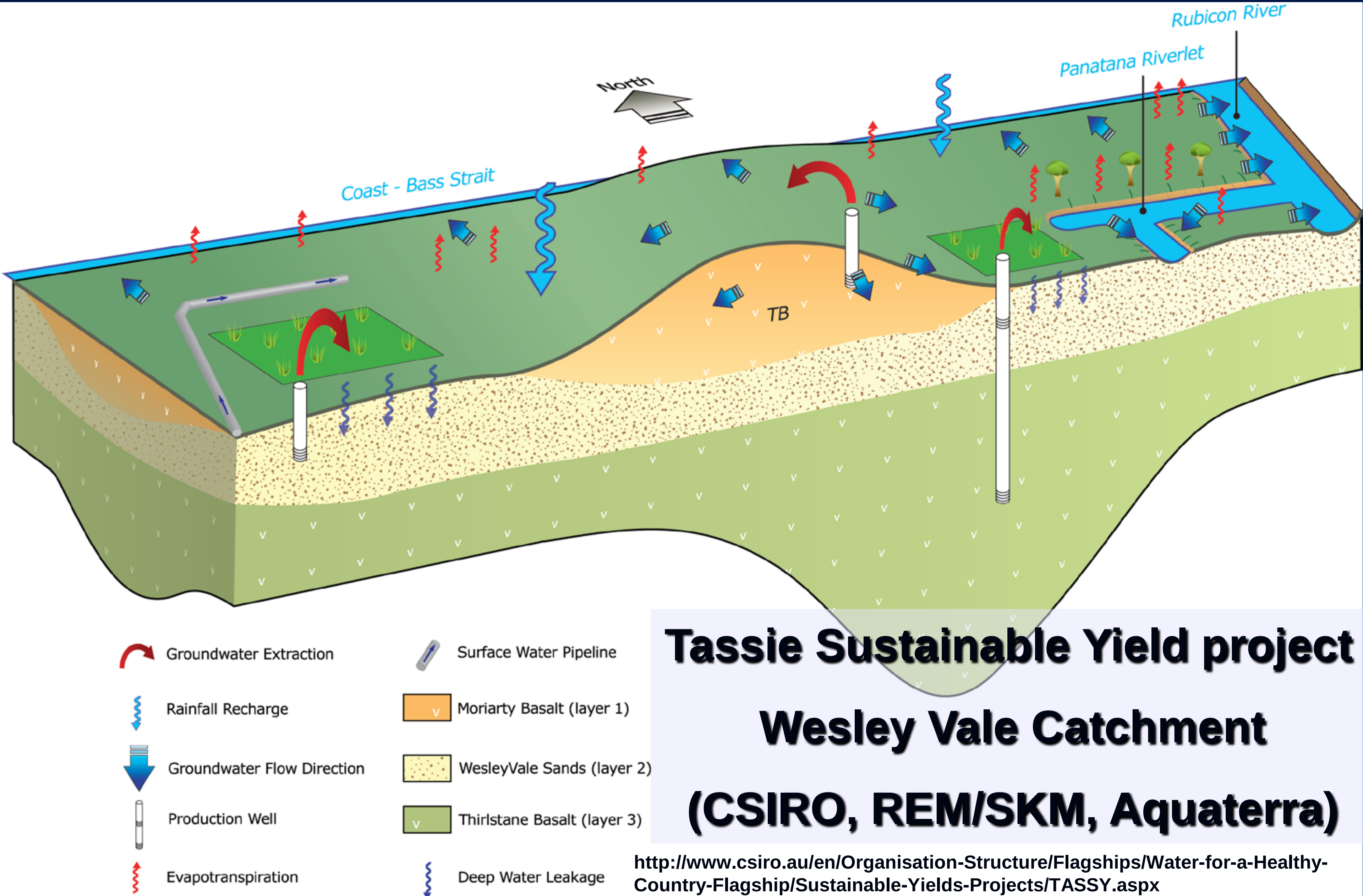
Figure A1 - Transient Model Recharge Zones



Legend	Zone Number	Zone Type	MV1 Rate (mm/yr)	MV2 Rate (mm/yr)	Legend	Zone Number	Zone Type	MV1 Rate (mm/yr)
	1	Steady Sate	7	12		11	Transient	0
	2	Steady Sate	0	0		12	Transient	10
	3	Steady Sate	10	15		13	Transient	17
	4	Steady Sate	0	5		14	Transient	0
	5	Steady Sate	17	20		15	Transient	10
	6	Transient	0	5		16	Transient	17
	7	Transient	10	15		17	Transient	0
	8	Transient	17	20		18	Transient	7
	9	Transient	0	5		19	Transient	7
	10	Transient	10	15		20	Transient	7

Aquaterra (2006)

GW model with WAVES RCH



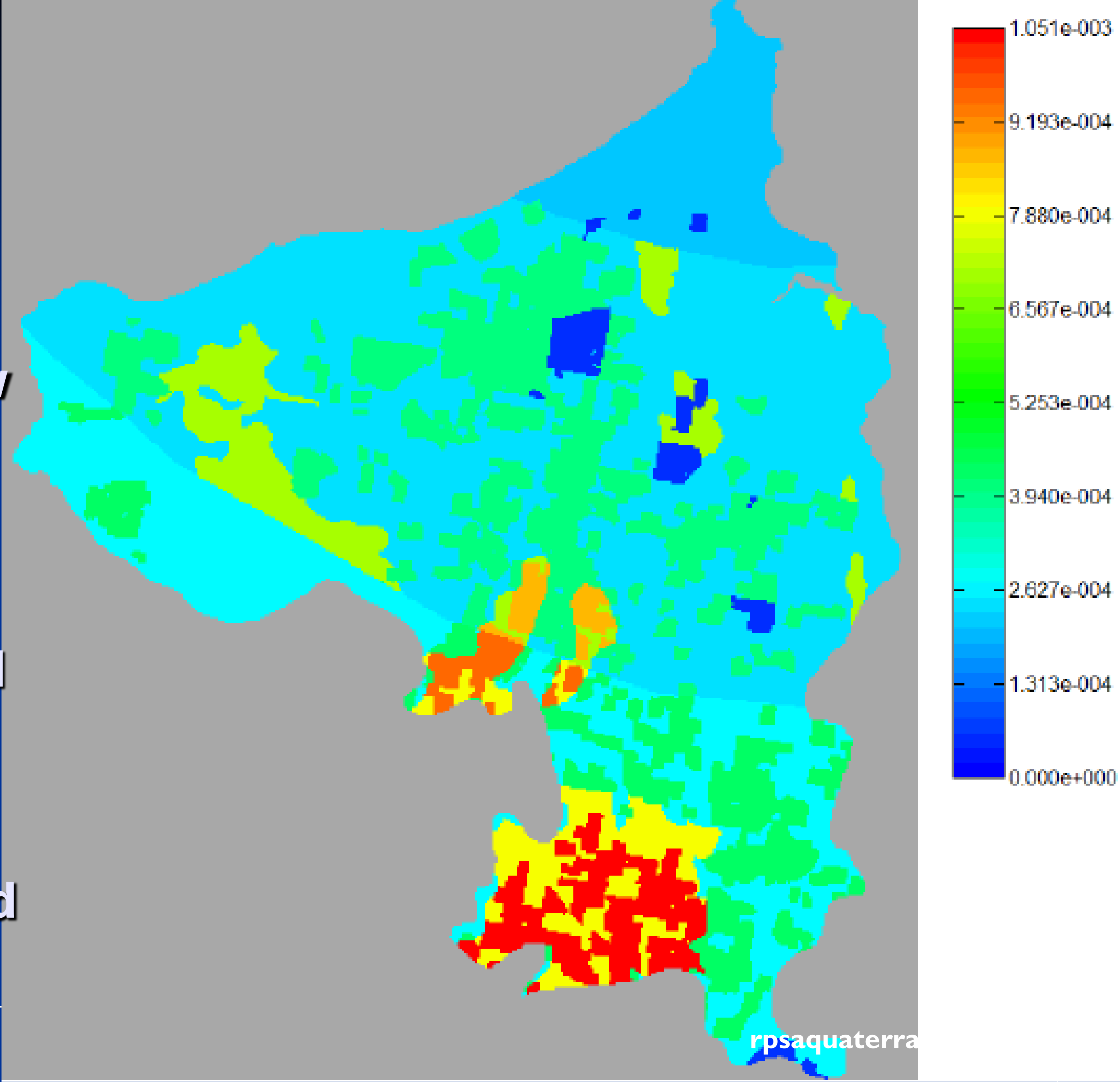
Tassie Sustainable Yield project

Wesley Vale Catchment

(CSIRO, REM/SKM, Aquaterra)

http://www.csiro.au/en/Organisation-Structure/Flagships/Water-for-a-Healthy-Country-Flagship/Sustainable-Yields-Projects/TASSY.aspx

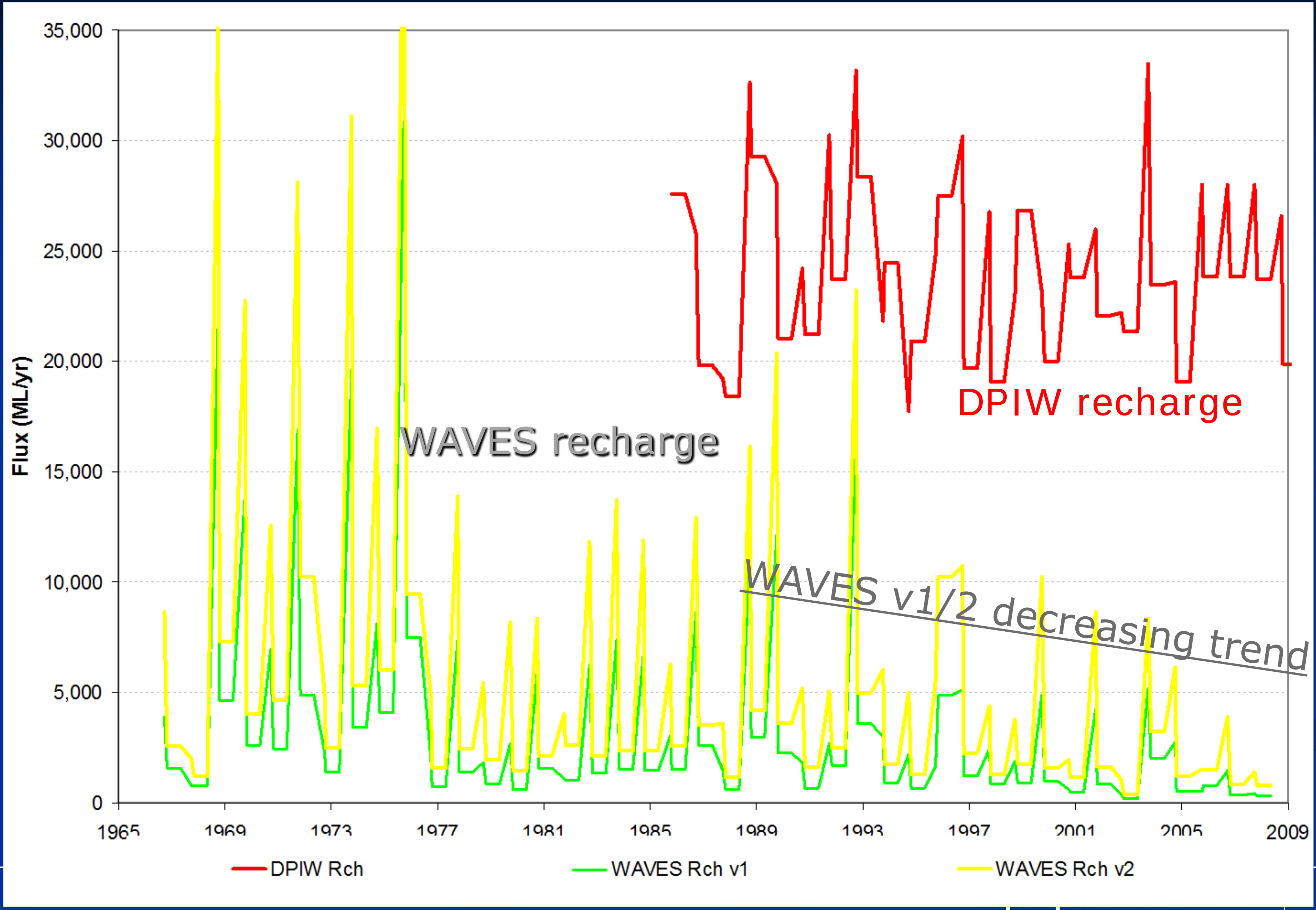
Pre-TasSY: DPIW model developed: rainfall recharge for Modflow model at 10%-20% of annual rainfall, with spatial variability for rainfall isohyets, geology and land use



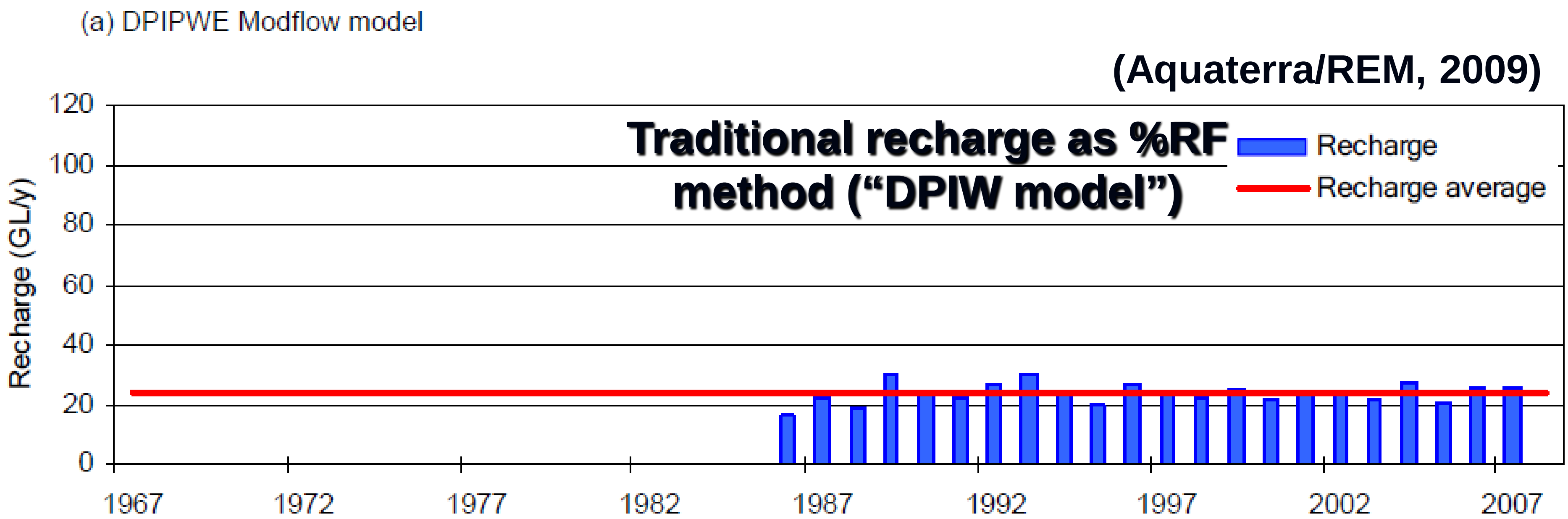
WAVES benchmarking

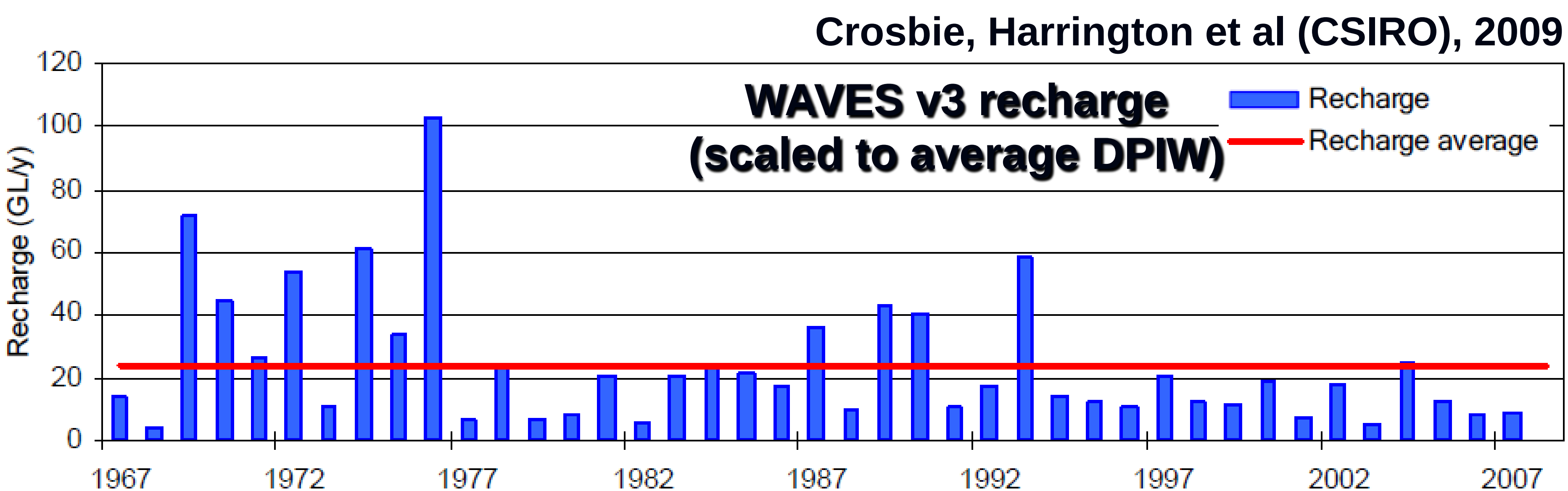
- DPIW models: assumed recharge at 10-20% of rainfall isohyet zones; peer reviewed (Ray Evans); established GW model parameters, “cannot change” (no predictive uncertainty)
- TasSY (2009-10): apply WAVES recharge to Wesley Vale model (has most bore data)
- WAVES RCH 10%-50% of DPIW rates (even after adjusting WAVES parameters)
- WAVES decreasing trend with recent time
- But no definitive evidence of long term trend downwards in measured water table levels
- Scaled WAVES to match traditional RCH mean

TasSY – WAVES early trials

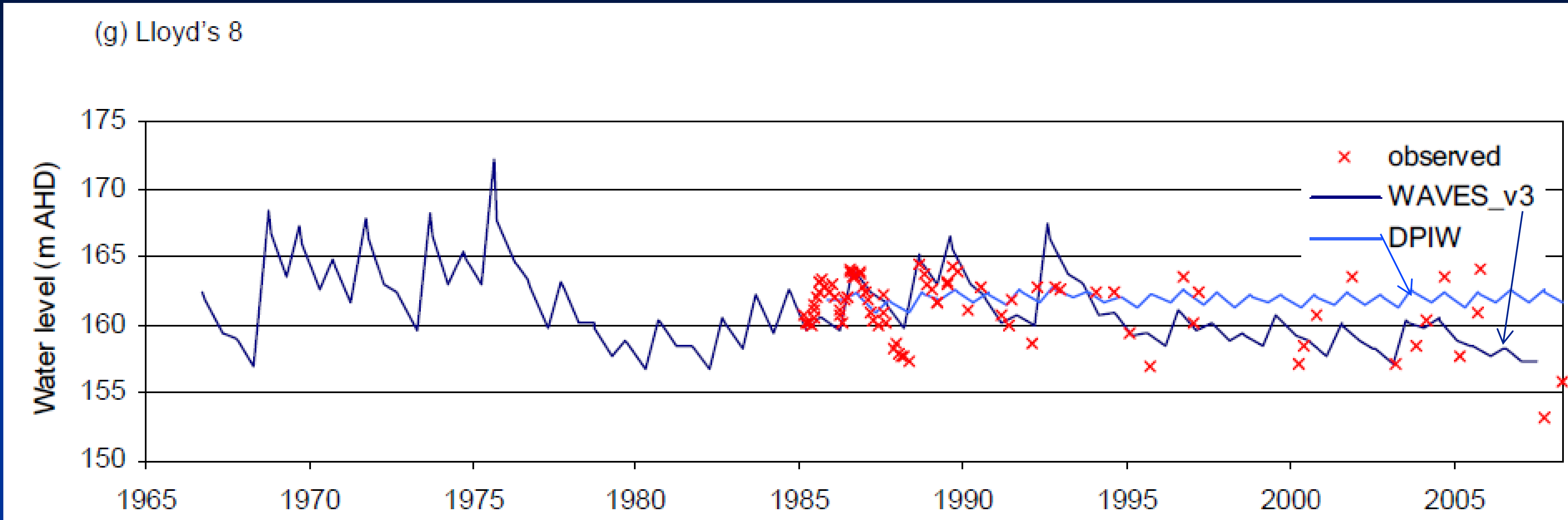


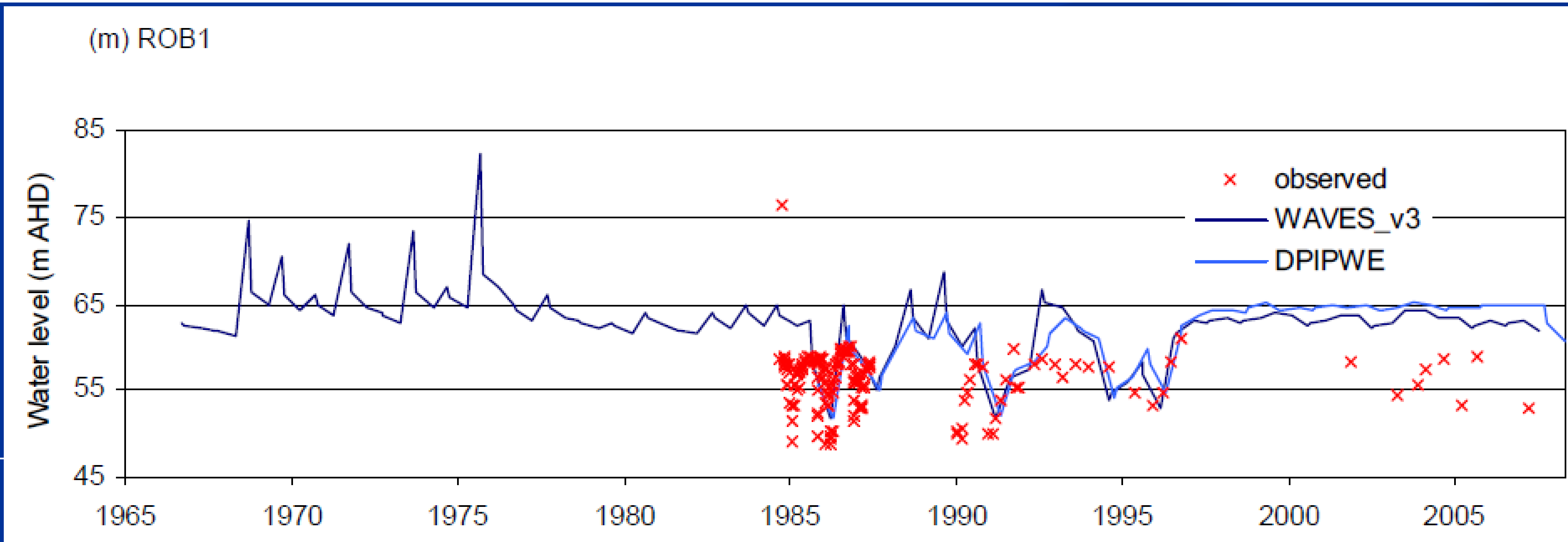
TasSY – WAVES final v3 scaled





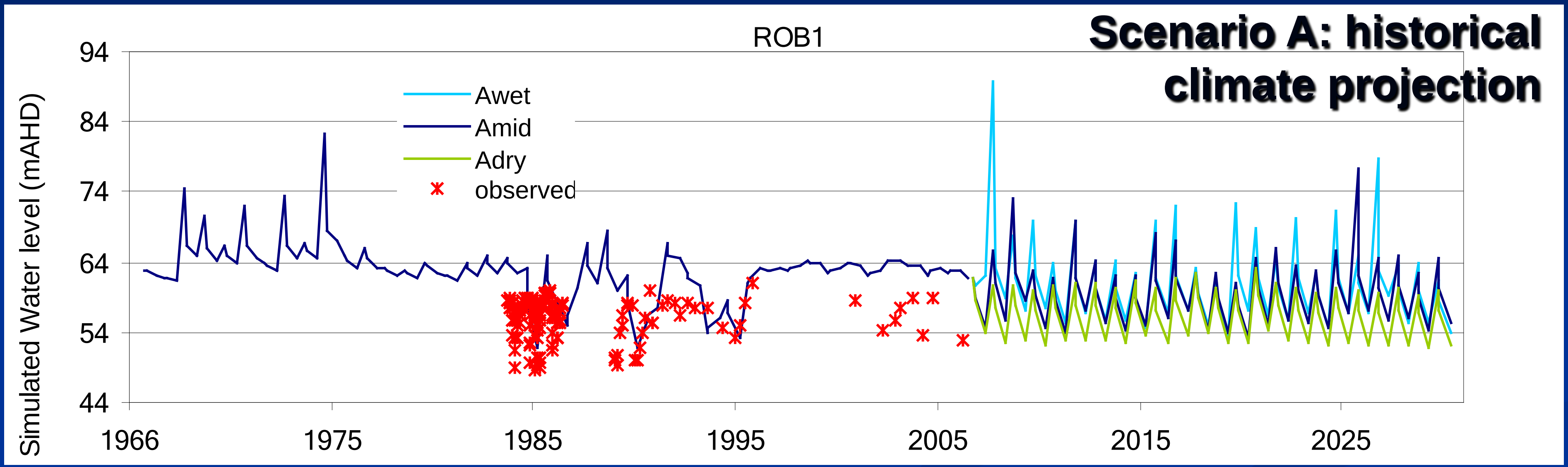
TasSY – model calibration

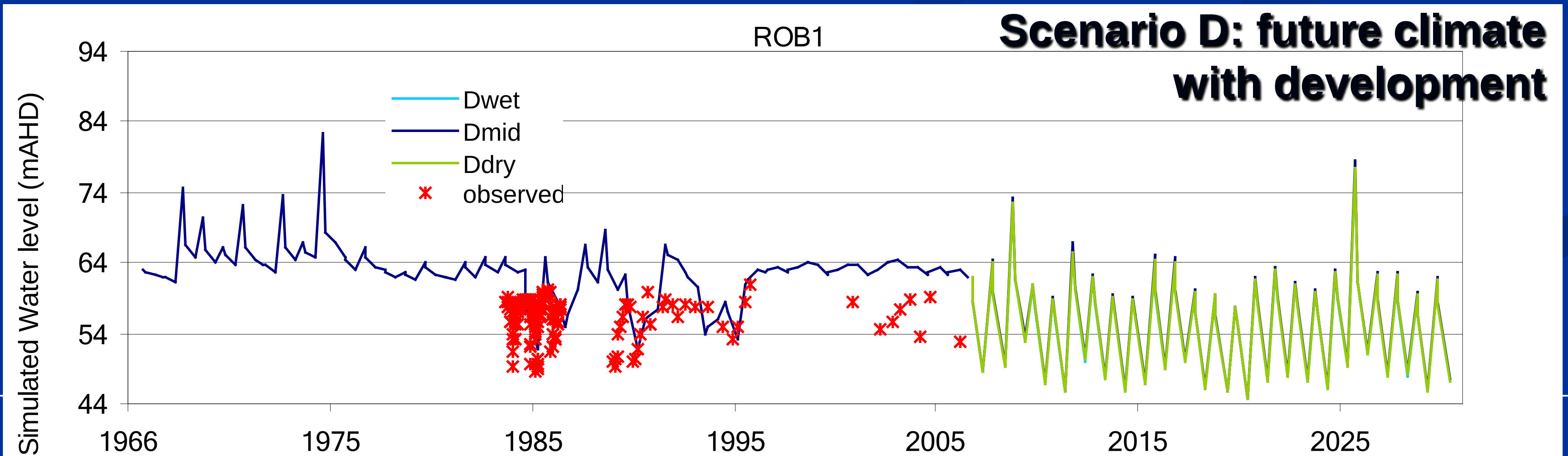




TasSY – model predictions

Despite data/model/climate/demand uncertainties, an adaptive water resource mgt objective of further irrig & forestry development is achievable





Premise: PU4CC

- Predictive Uncertainty (PU) approach required for climate change (CC) scenarios (PU4CC)
  - historical & climate change RCH dataset (WAVES)
  - multiple GW model parameter sets (PEST-PU)
  - all equally calibrated to pre- and post-climate change hydrological analogues (addresses non-uniqueness)
  - demonstrate predictive skill to a variable climate
  - Predictive Uncertainty scenarios to provide information for decision making

- What timeframe to calibrate/benchmark?

Premise: PU4CC

- GW model validated with WAVES RCH:
  - 1961-1990 pre-climate change processes
  - 1991-2011 climate change/variability processes

- WMO: “normal period” 1961-1990
- WASY: 1974-2005 (excludes wet pre-1970s in WA)
- NASY: 1930-2007 (captures variability, inc wet recent)
- SA DoW 2011: 1961-2010 (captures variability)