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Groundwater yields in south-west Western Australia under climate change and development

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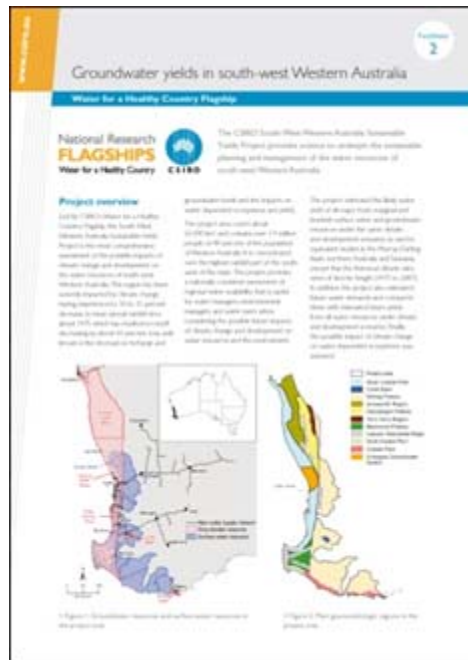


Acknowledgements

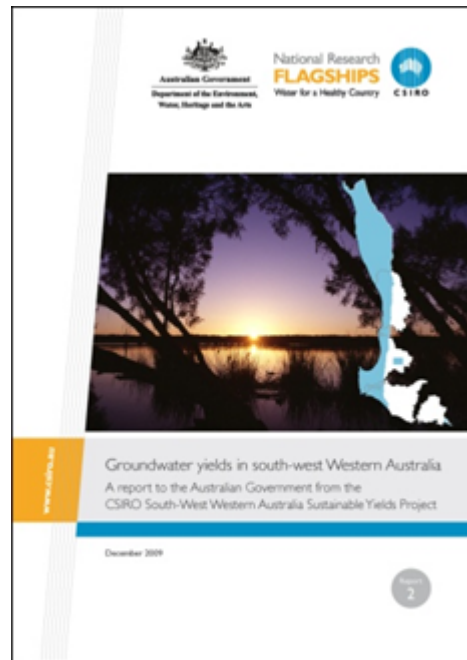
- DEWHA – funding and policy guidance
- Department of Water – data, models, researchers, report review
- Water Corporation – data, report review
- Department of Agriculture and Food WA – soils data
- Bureau of Meteorology – climate data, surface water modelling
- Queensland Department of Environment and Resource Management – SILO data
- Contracts and consultancies
 - URS – Peel Harvey groundwater model (PHRAMS)
 - CyMod Systems Pty Ltd – groundwater model calibration
- External reviewers:
 - Peter Davies (University of Tasmania); Andy Pitman (University of New South Wales); Tony Jakeman (Australian National University); Don Armstrong (Lisdon Associates) and Murray Peel (University of Melbourne)

Publications

Factsheet



Groundwater main report



Executive summary



Web: www.csiro.au/partnerships/SWSY.html

Talk outline

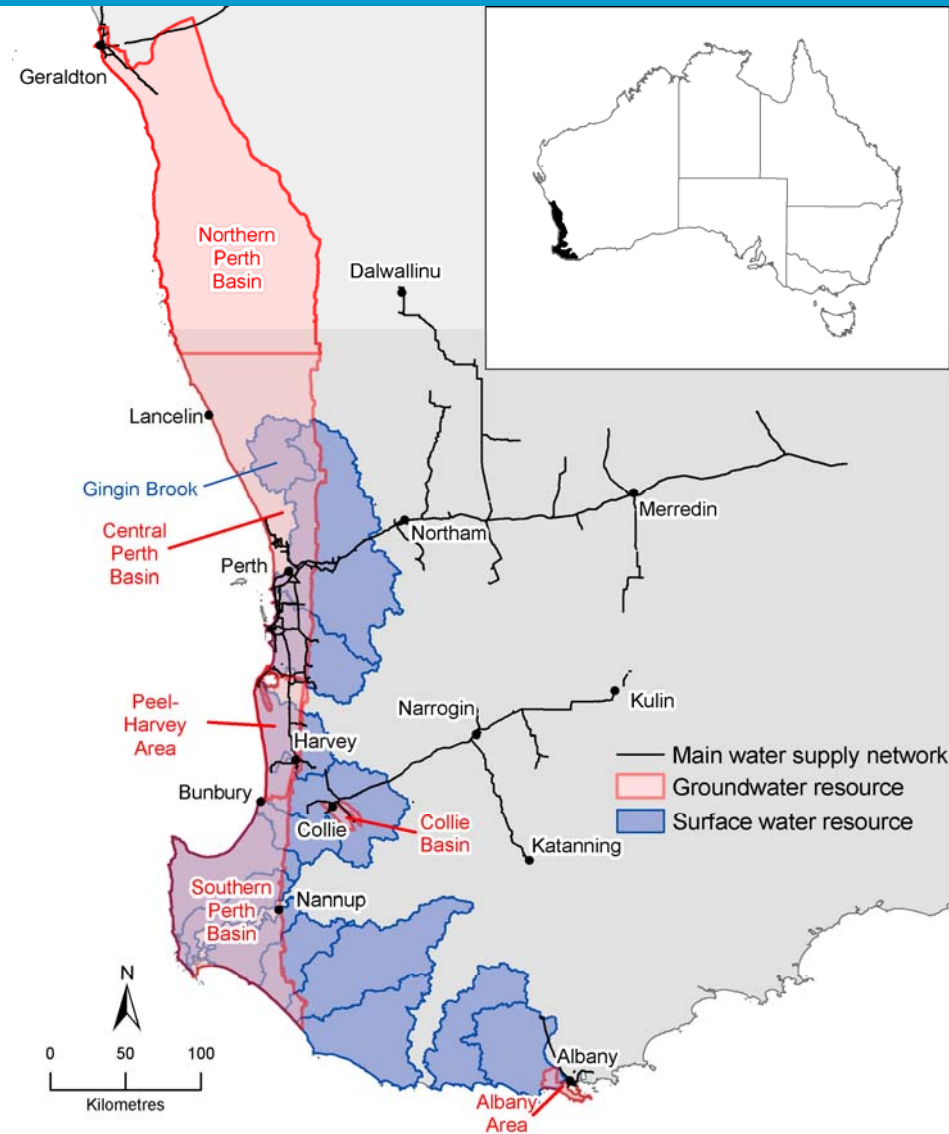
- Climate and background to scenarios
- Climate scenarios
- Methods and model inputs
- Results
 - Groundwater levels
 - Groundwater recharge
 - Water balance
 - HARTT projected future groundwater levels
 - Surface – groundwater interactions
 - Confidence in model predictions
 - Key findings

Objectives – Groundwater

- Project groundwater levels in 2030 under future climate and development scenarios
- Understand why some areas and aquifers may be less sensitive to climate change than others
- The groundwater results are later used to:
 - assess the impacts of levels on groundwater dependent ecosystems (GDEs); and
 - estimate future groundwater yields

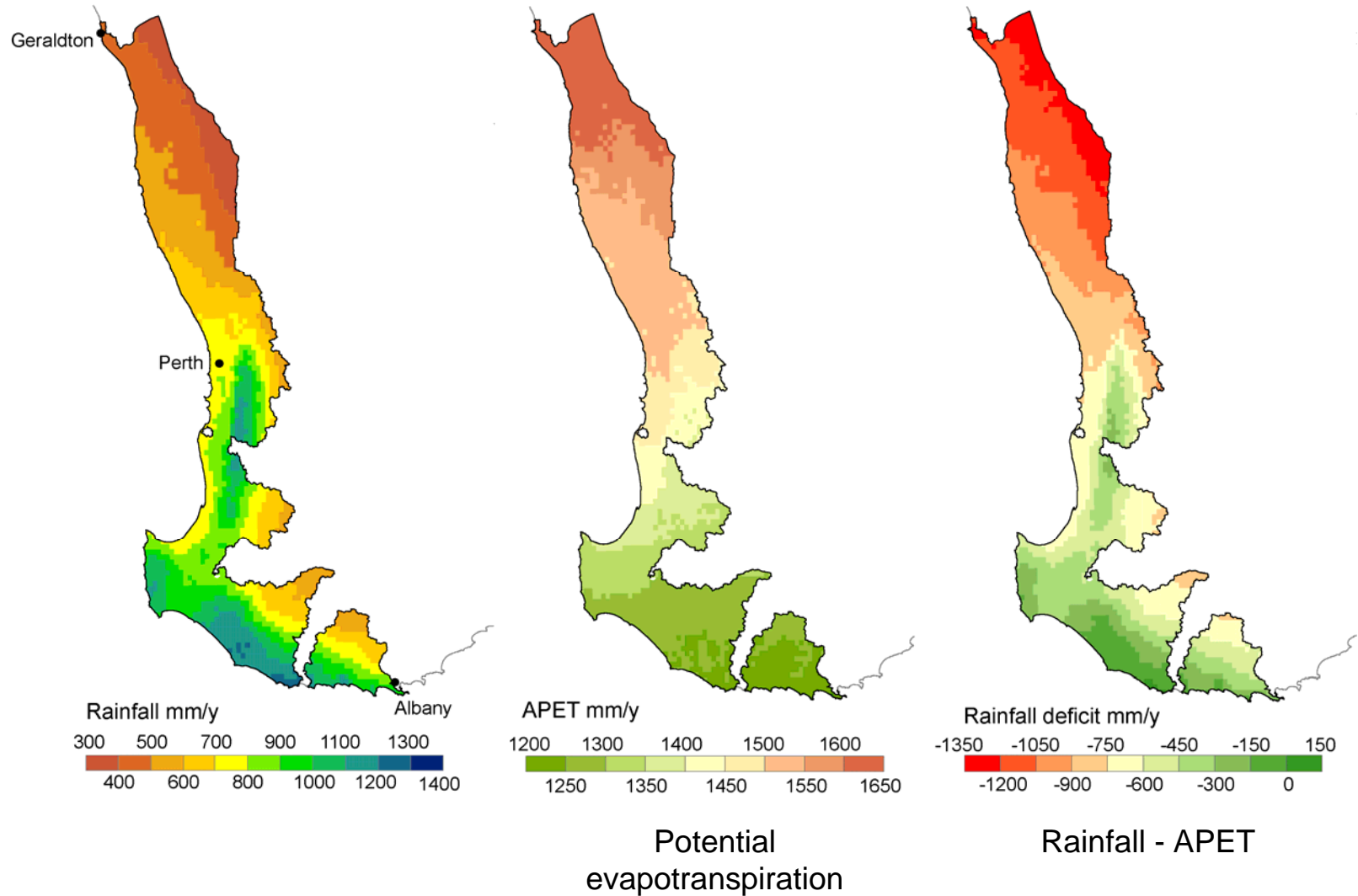
Project area location

- All aquifers within the Perth and Collie basins, plus the western Bremer Basin
- Area = 37,186 km²

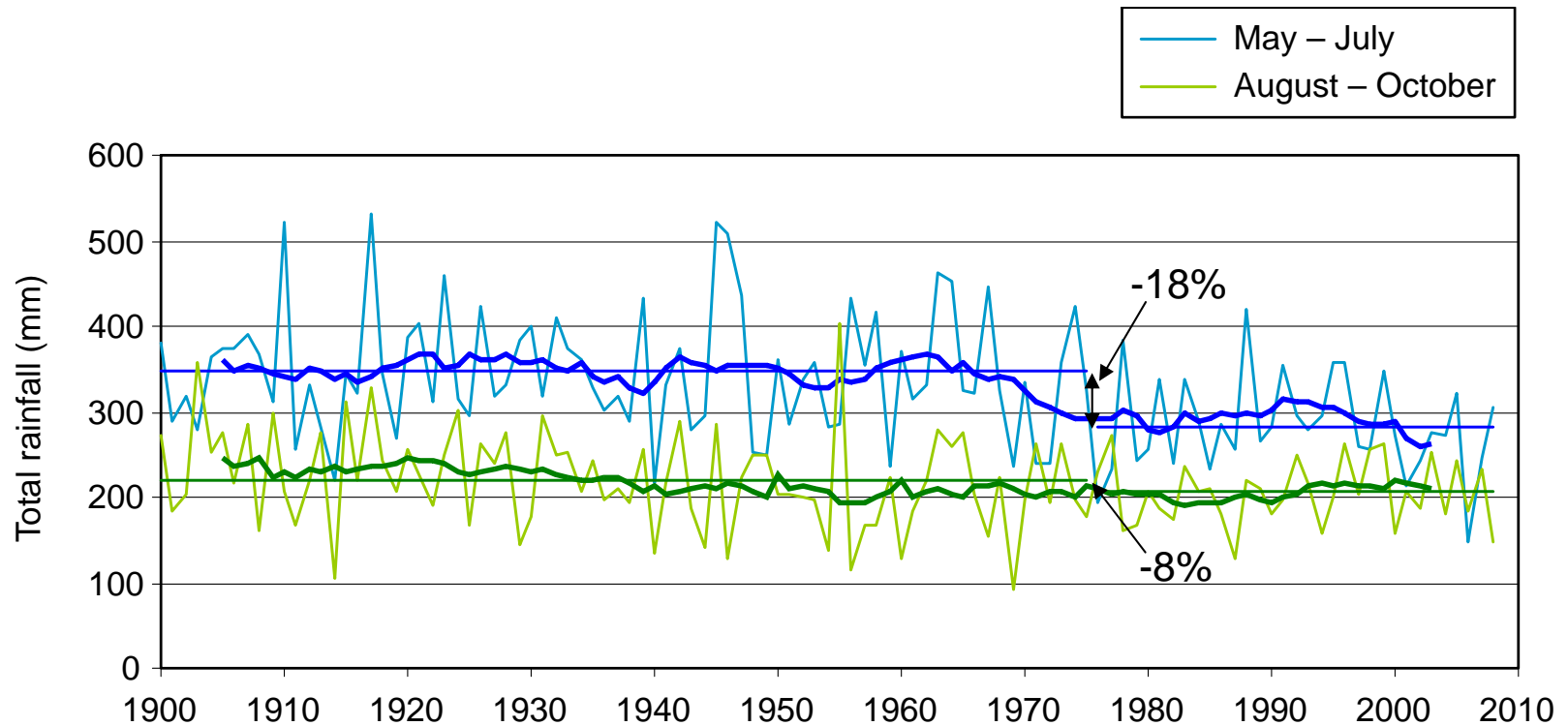


Climate and Background to Scenarios

Climate – annual averages, 1975 to 2007

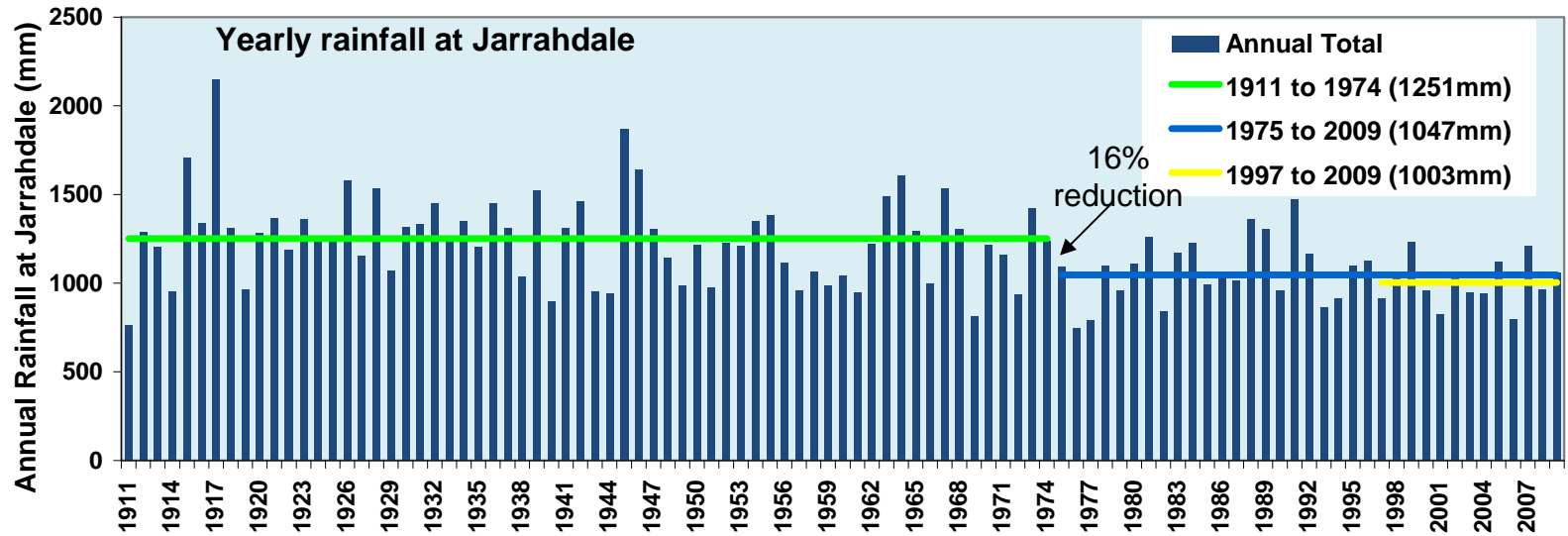


South-west WA has had reduced rainfall since 1975

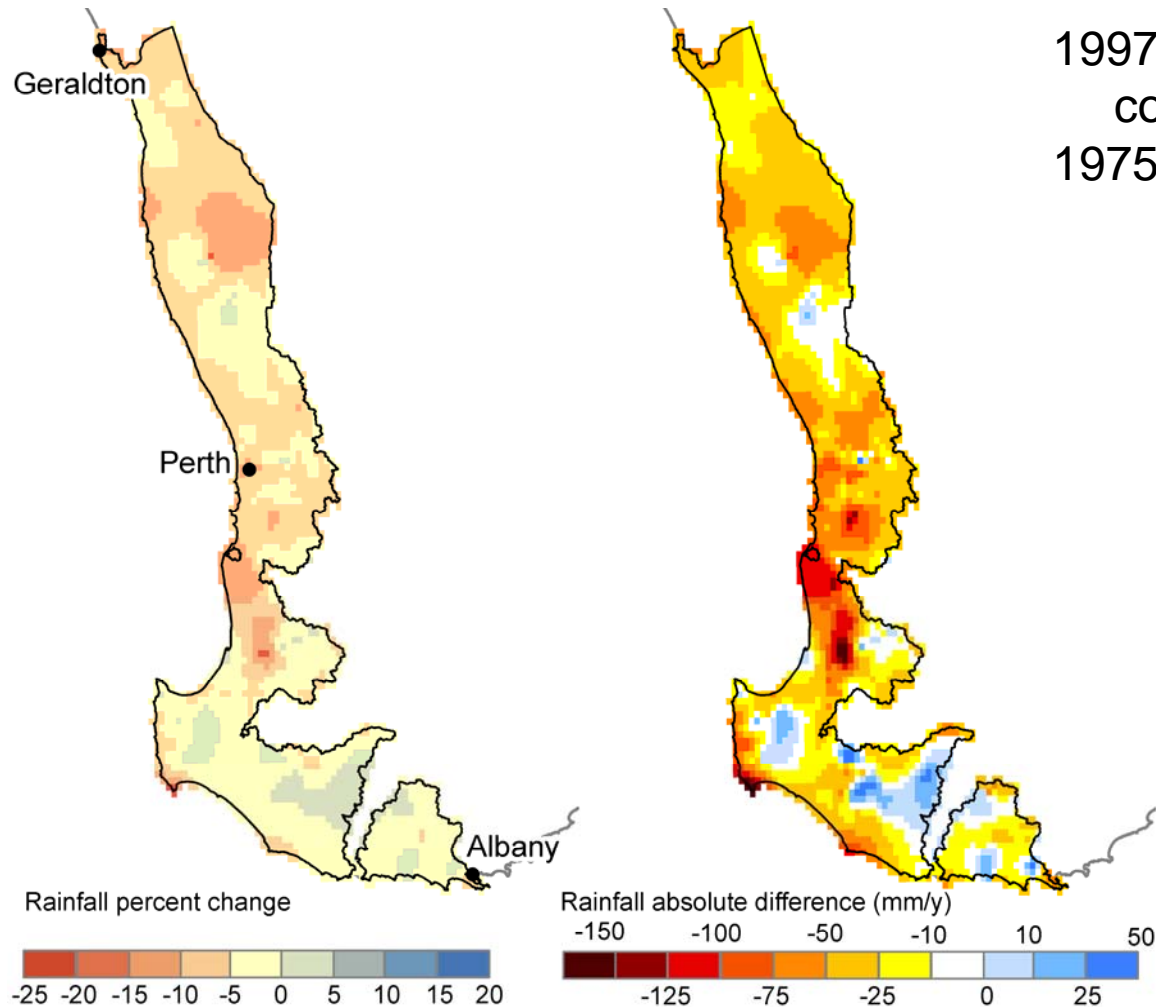


The 1975 to 2007 period is the baseline for all subsequent comparisons

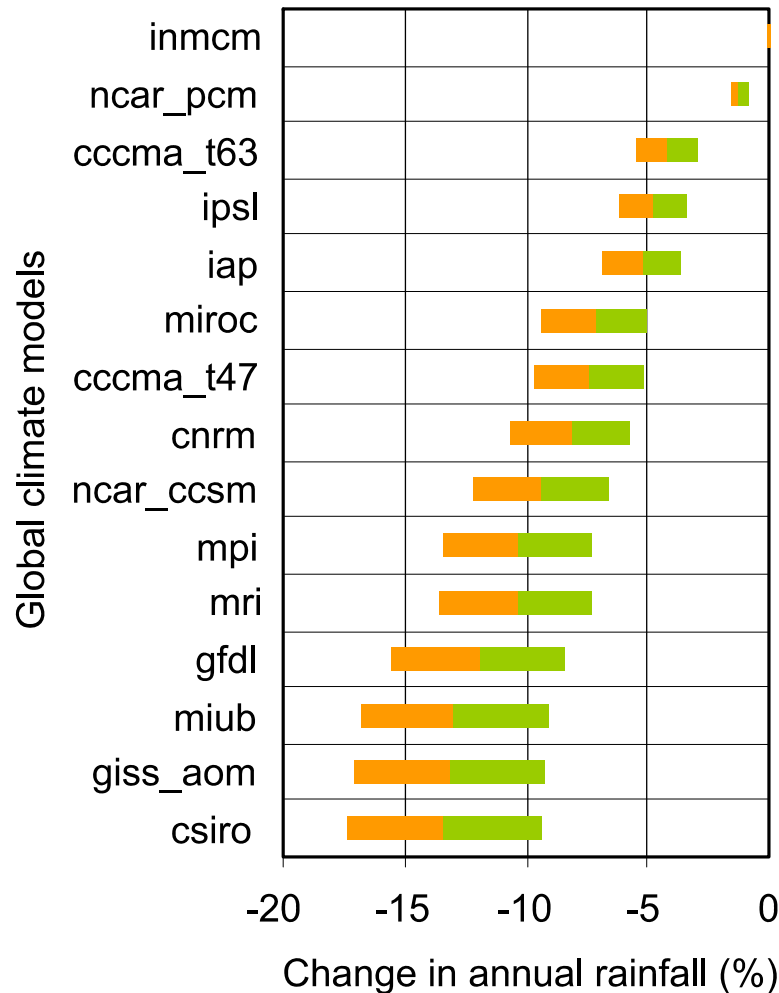
Rainfall at Jarrahdale



Annual rainfalls have been even drier since 1997

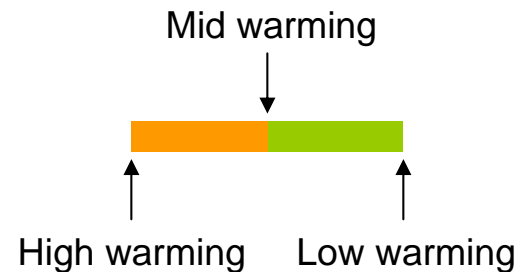


14 of 15 GCMs project it will get drier



Change in annual rainfall

- Median future climate -7%
- Wet extreme future climate (90 percentile) -1%
- Dry extreme future climate (10 percentile) -14%



Scenarios

- The 'historical climate' assumed that the climate of the last 33 years (1975 to 2007) would continue. This was used as a base case for comparison of other climate scenarios
- The 'recent climate' assumed that the climate of the last 11 years (1997 to 2007) would continue
- The 'future climate' used 15 GCMs with 3 GHG emission levels which would result in 0.7, 1.0 and 1.3°C of warming by 2030 = 45 possible climates. They are reported as:
 - wet future climate
 - median future climate, and
 - dry future climate

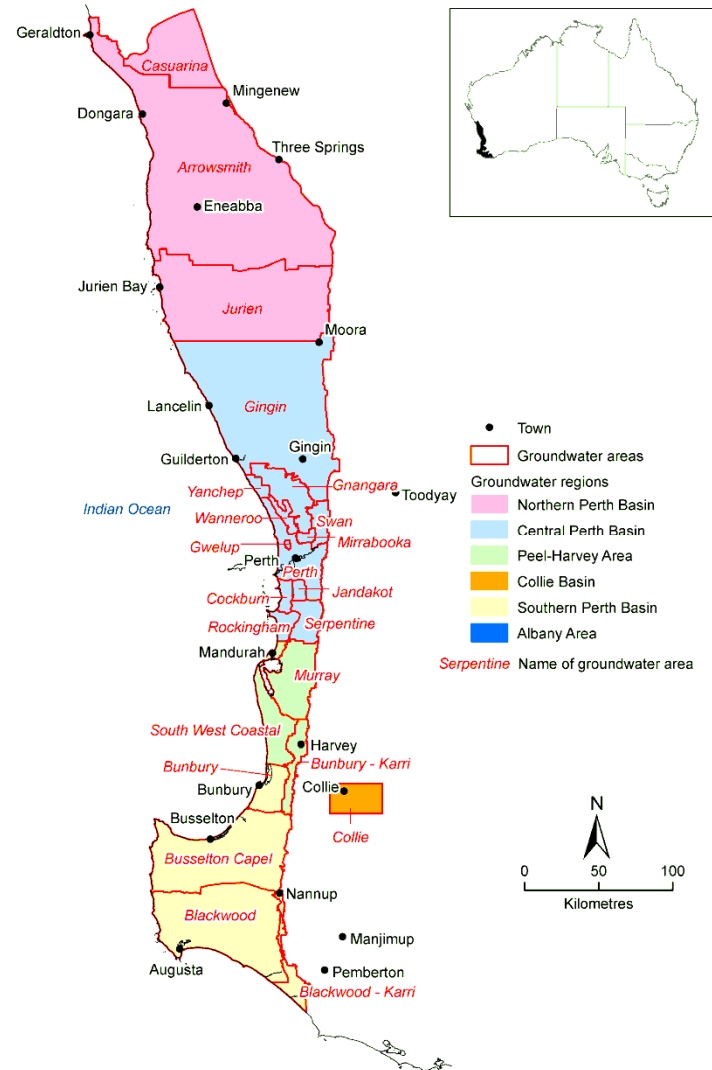
Scenarios

- Current levels of abstraction and land use were assumed to continue for all scenarios above
- The 'future climate and development' assumed a median future climate and full groundwater abstraction

Methods and Model Inputs

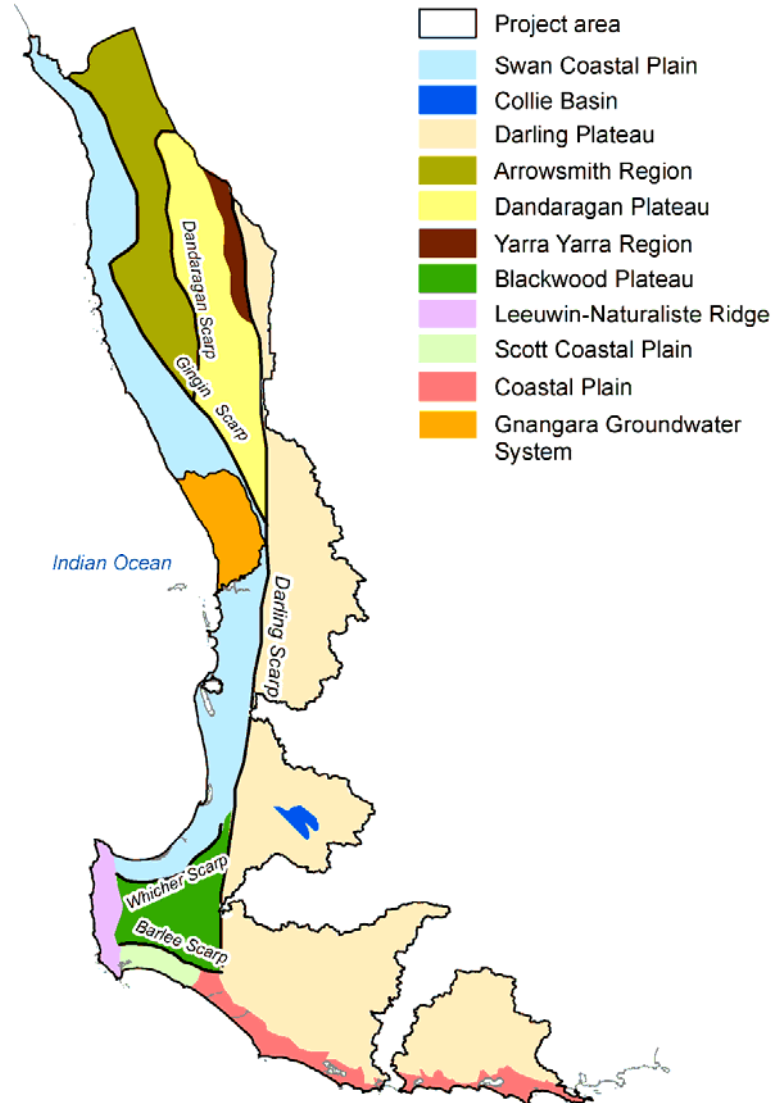
Groundwater areas

- All together 24 GWAs considered for groundwater modelling and/or assessment
- Recharge modelling in GWAs of the Northern Perth Basin and Albany area
- Recharge and groundwater modelling for all remaining GWAs



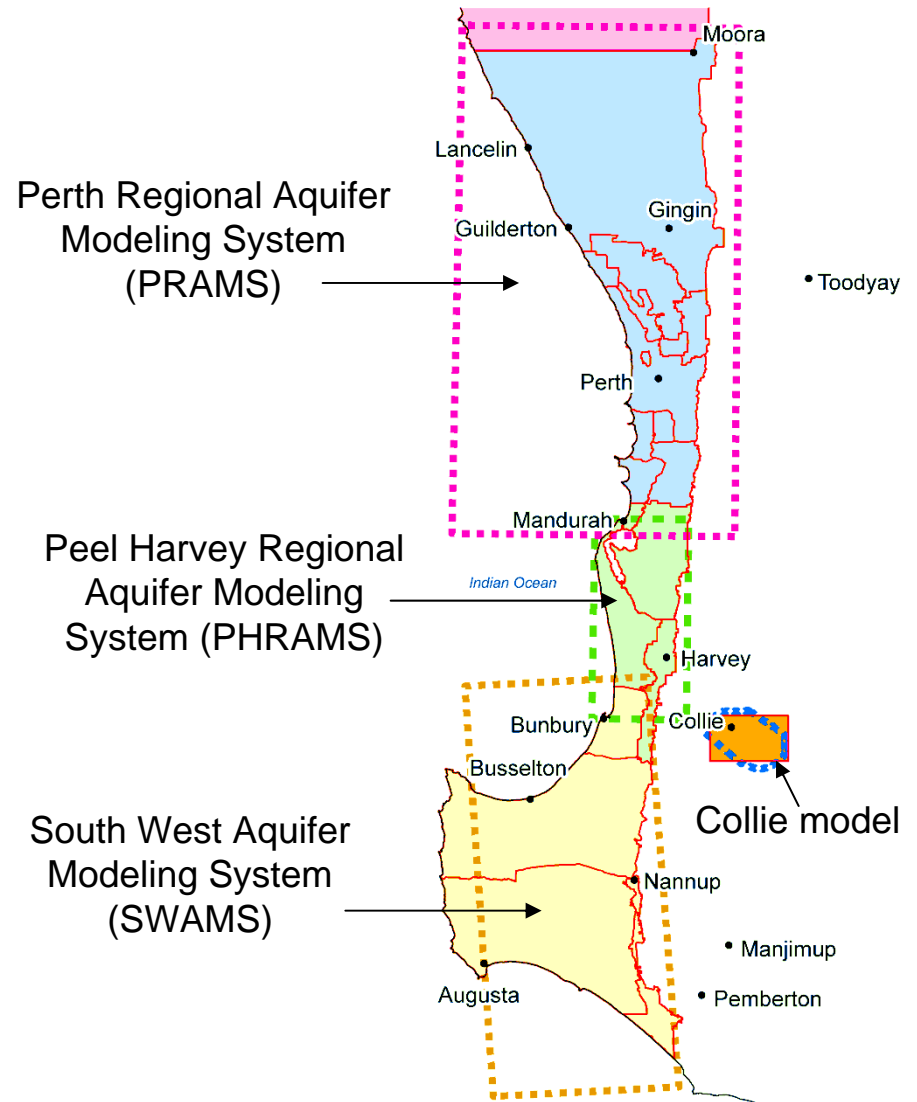
Landforms

Geomorphic landforms affect groundwater response to climate change



Groundwater models

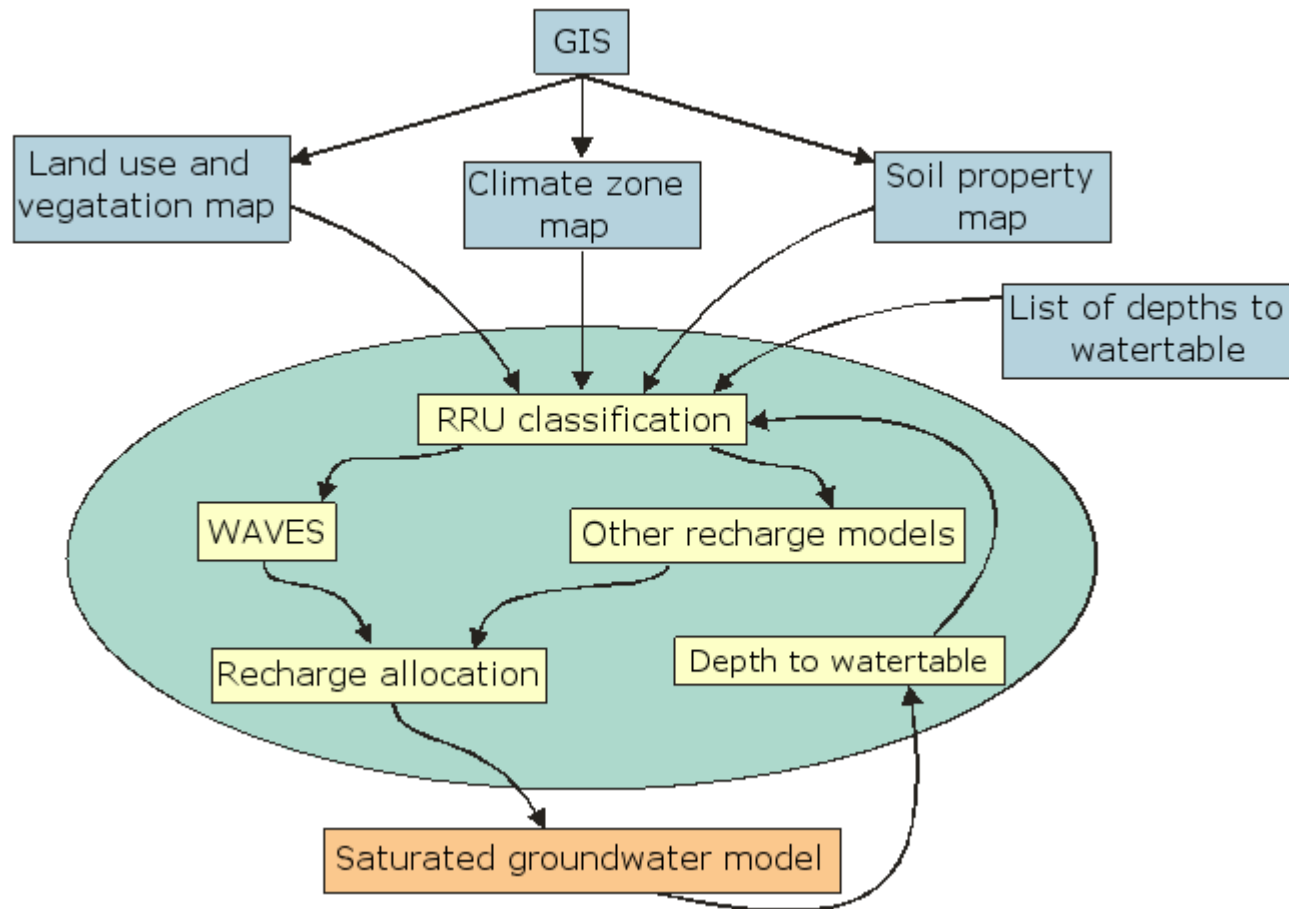
- The PRAMS model as used in the Gnamagara Sustainability Strategy was used
- A new model (PHRAMS) was developed for the Peel Harvey area
- The SWAMS model was linked to a recharge model and recalibrated
- The Collie model was linked to a recharge model and recalibrated



Recharge estimation

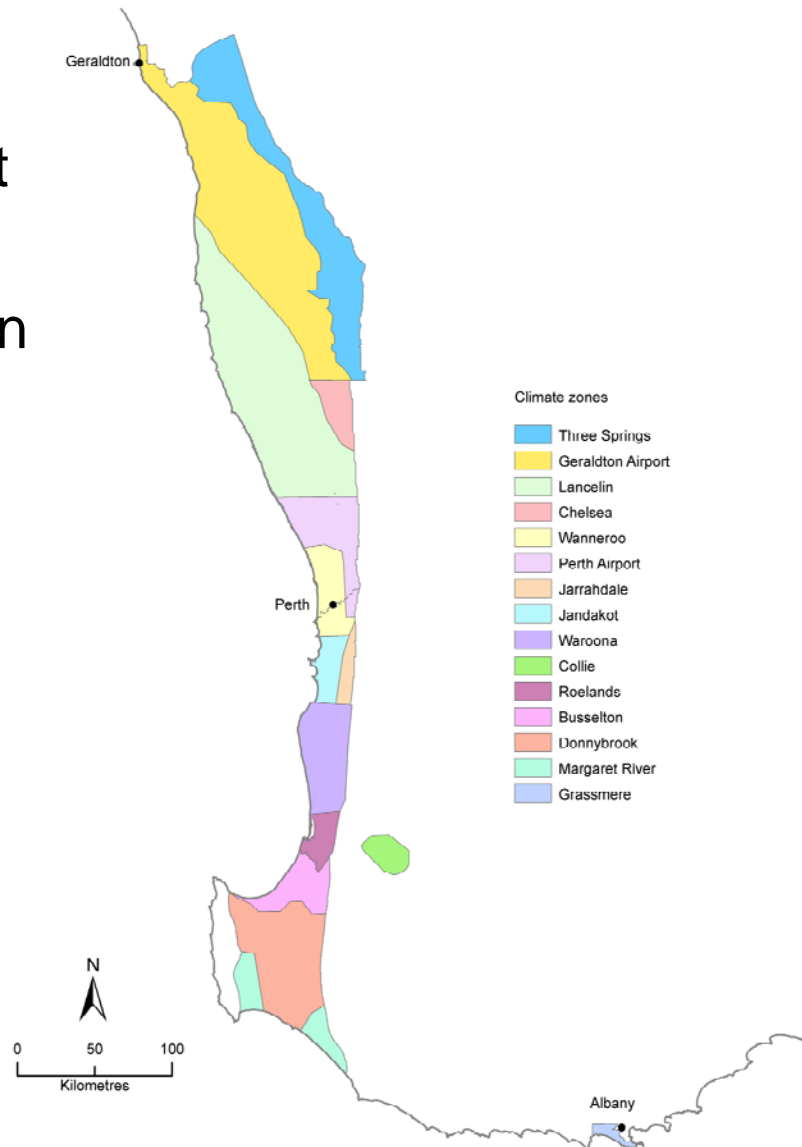
- Recharge estimation by using WAVES and VFM
- The project developed an estimate of net recharge discharge for combinations of:
 - Climate
 - Soil types
 - Land cover
 - Depth of the watertable
- These estimates were linked to the groundwater models

Vertical Flux Modelling



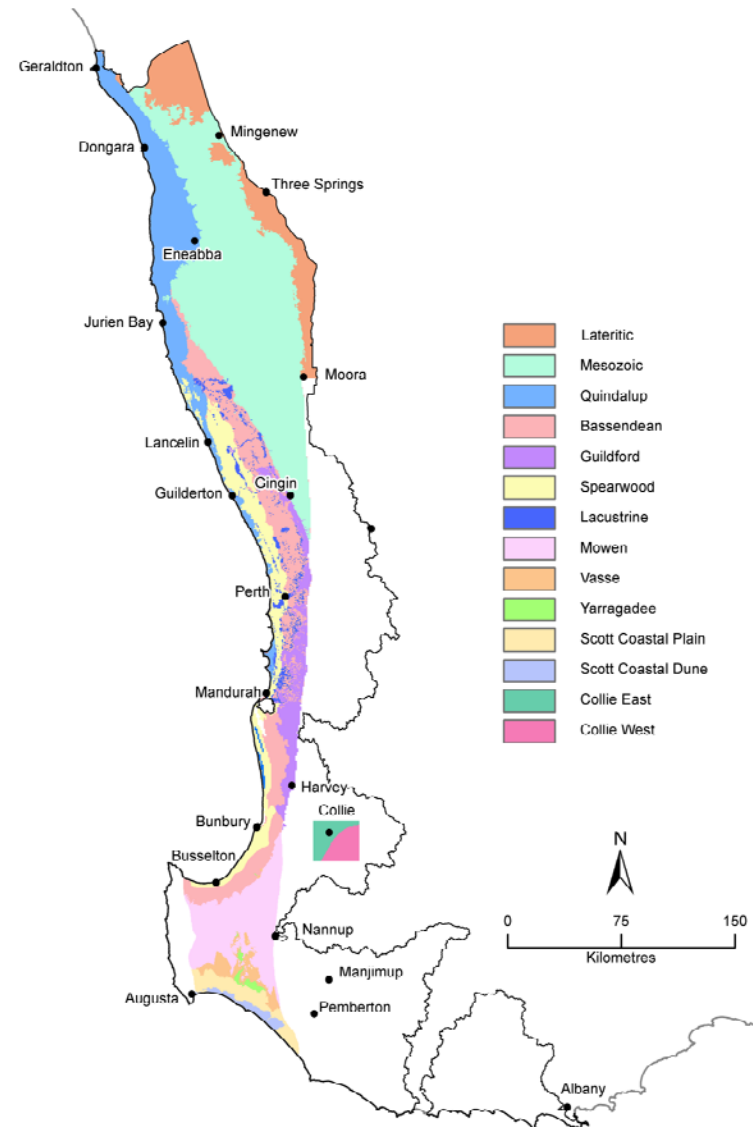
Climate zones

- 15 climate zones in the groundwater assessment area
- Representative stations in each zone were used



Soil types used in models likely to affect recharge

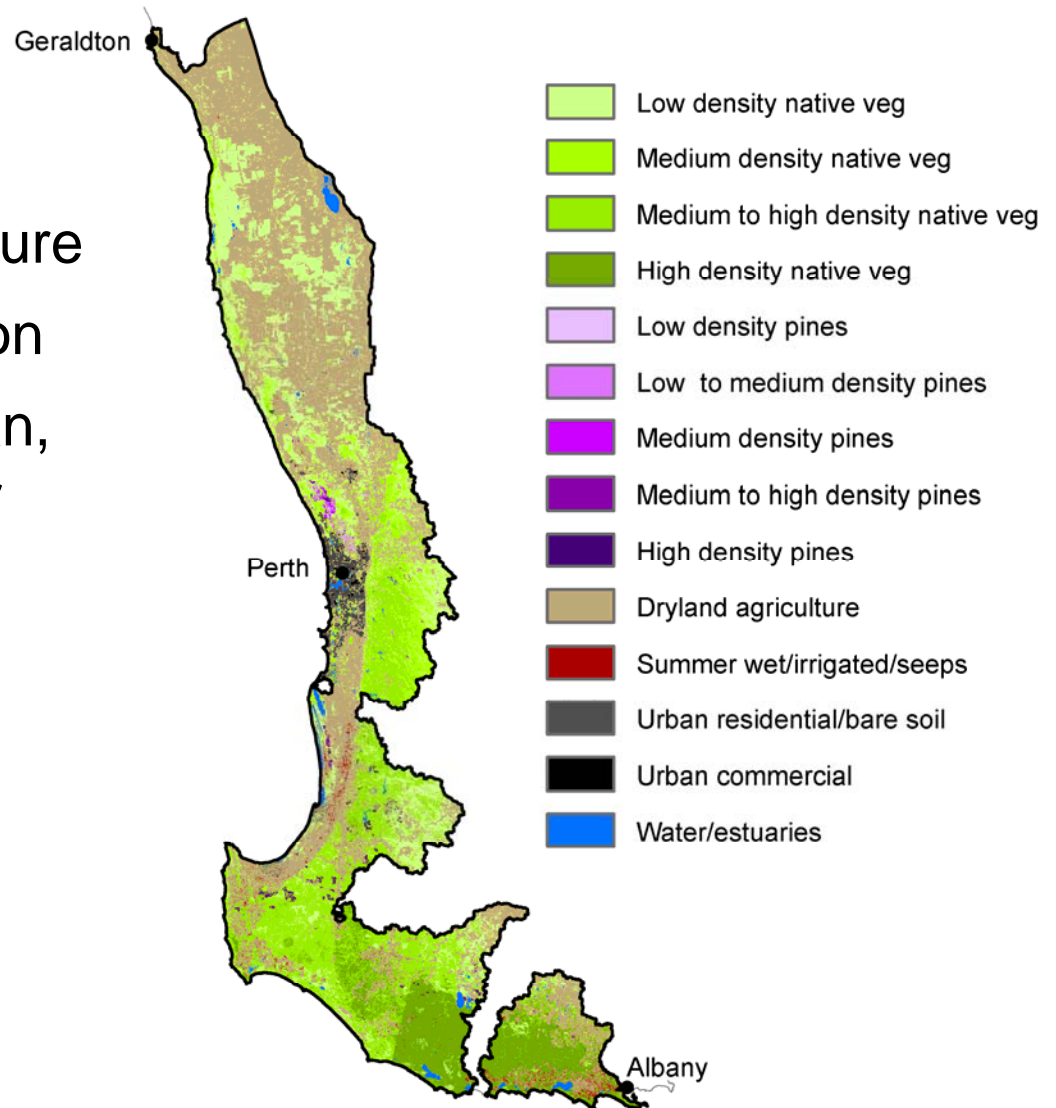
- Coastal plain soils are sandy except Guildford which is clayey
- Plateau soils are mainly gravelly (north) or clayey (Blackwood Plateau)



Land cover likely to affect recharge / discharge

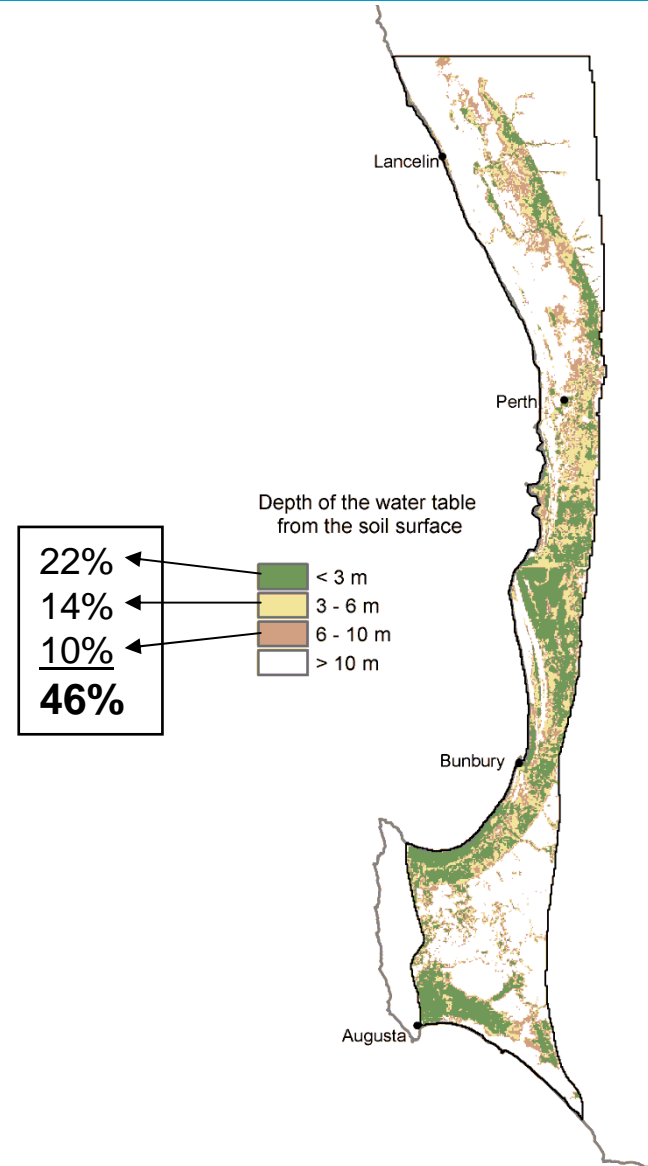
Groundwater assessment areas

- 56% dryland agriculture
- 38% native vegetation
- 6% plantations, urban, irrigated, open water



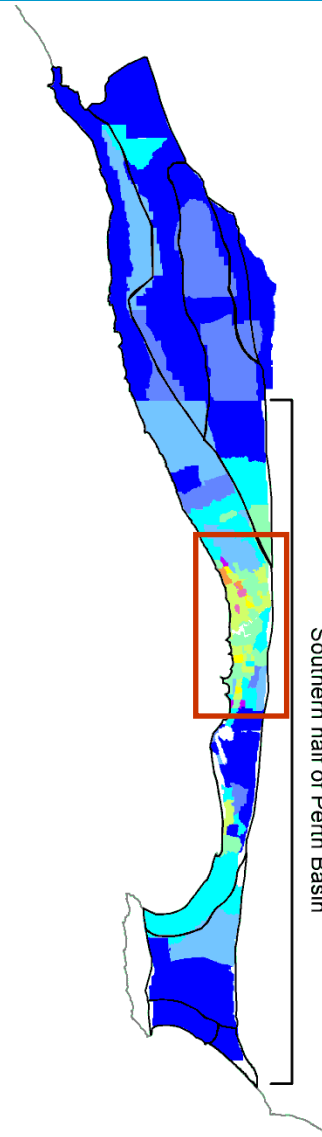
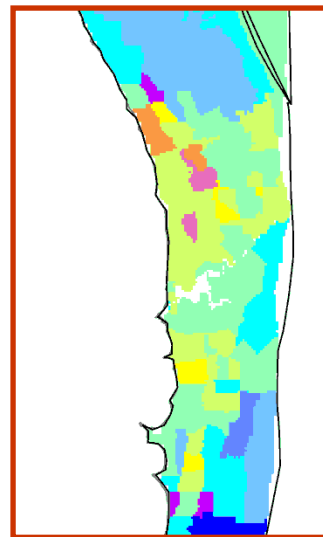
Maximum depth of the watertable in the southern half of the Perth Basin in 2007

- Coloured areas are potential GDEs if not cleared
- Coastal plain soils have very shallow watertables except Gnangara and Spearwood Dunes
- Plateaux areas mainly have deep watertables



Current abstraction by groundwater areas

Most groundwater abstraction currently occurs close to Perth because of high demand and water availability



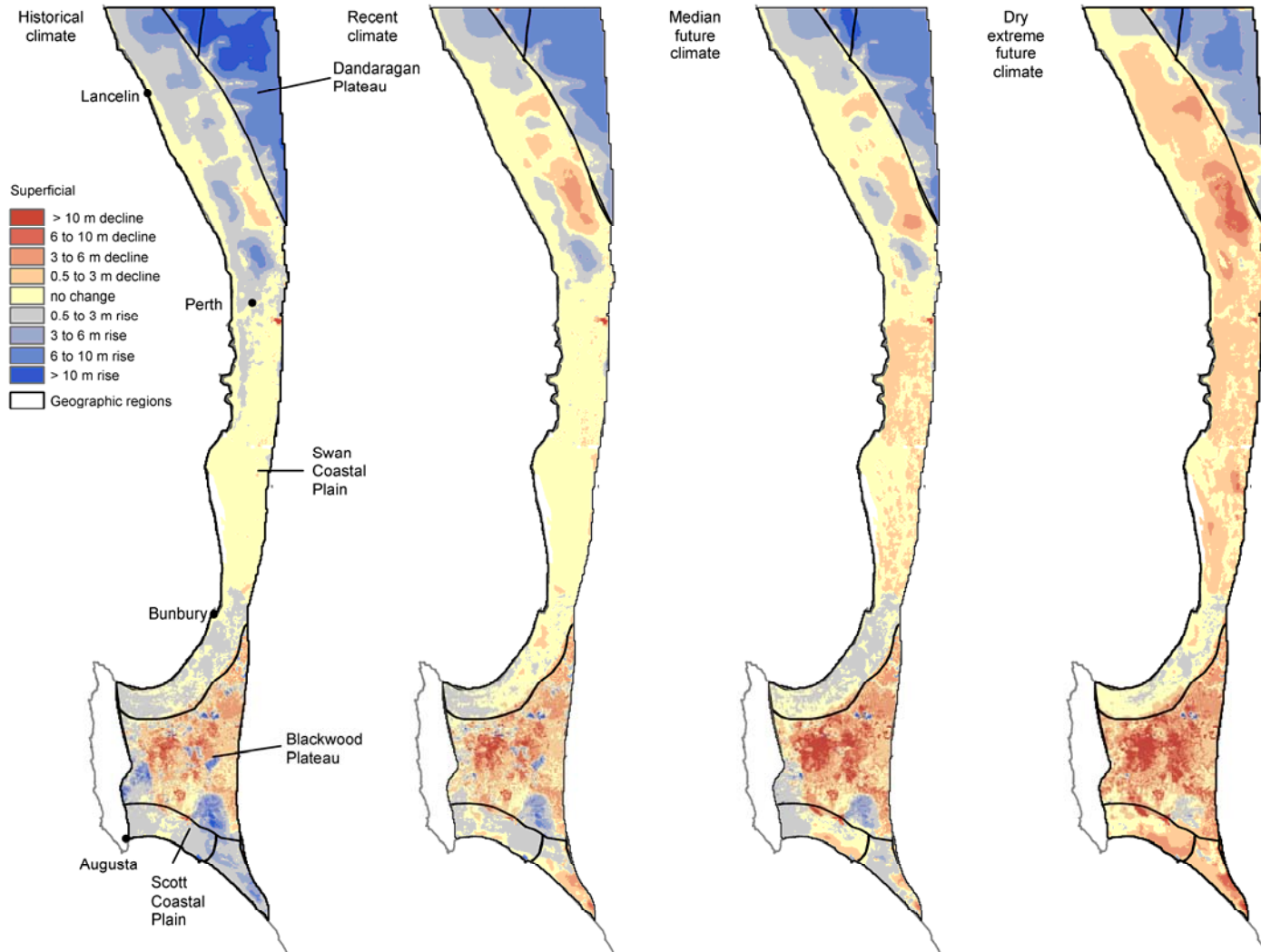
Current abstraction

ML/km²/year



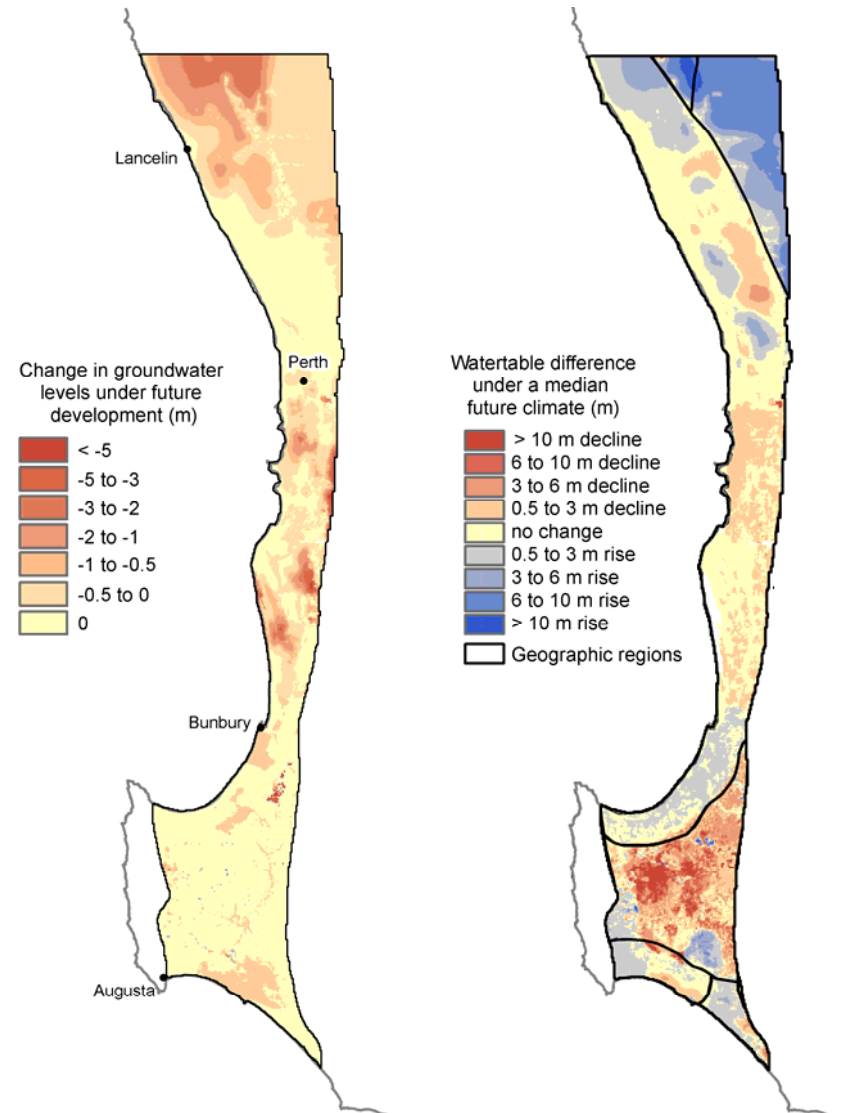
Results – Groundwater Levels

Change in groundwater levels between 2008 and 2030 under climate and development scenarios



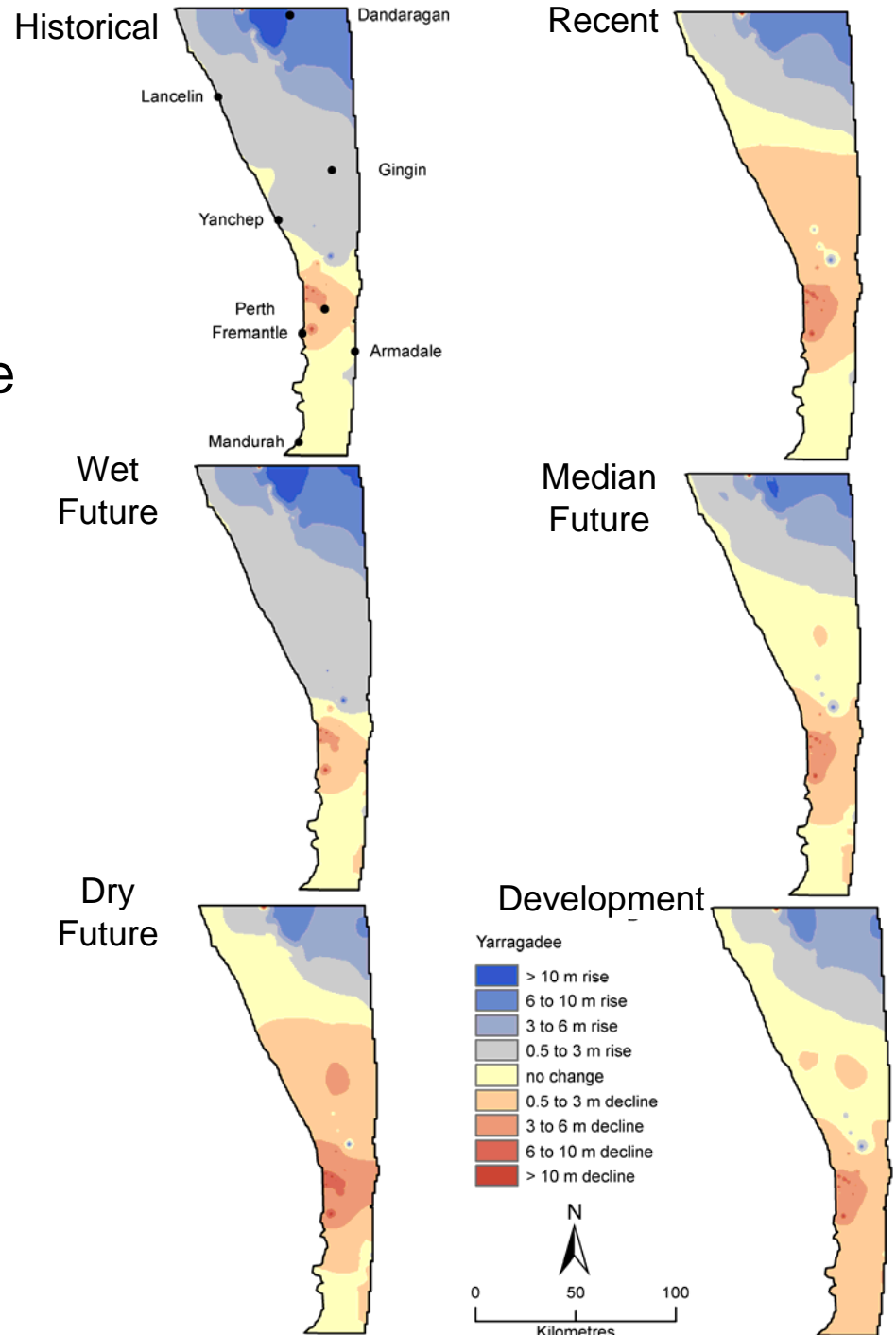
The additional impact on 2030 groundwater levels of allowing full abstraction under a median future climate

- There are a few areas where additional abstraction will cause a decline in levels
- This may not be a problem where groundwater levels are projected to rise
- There are many areas already fully allocated



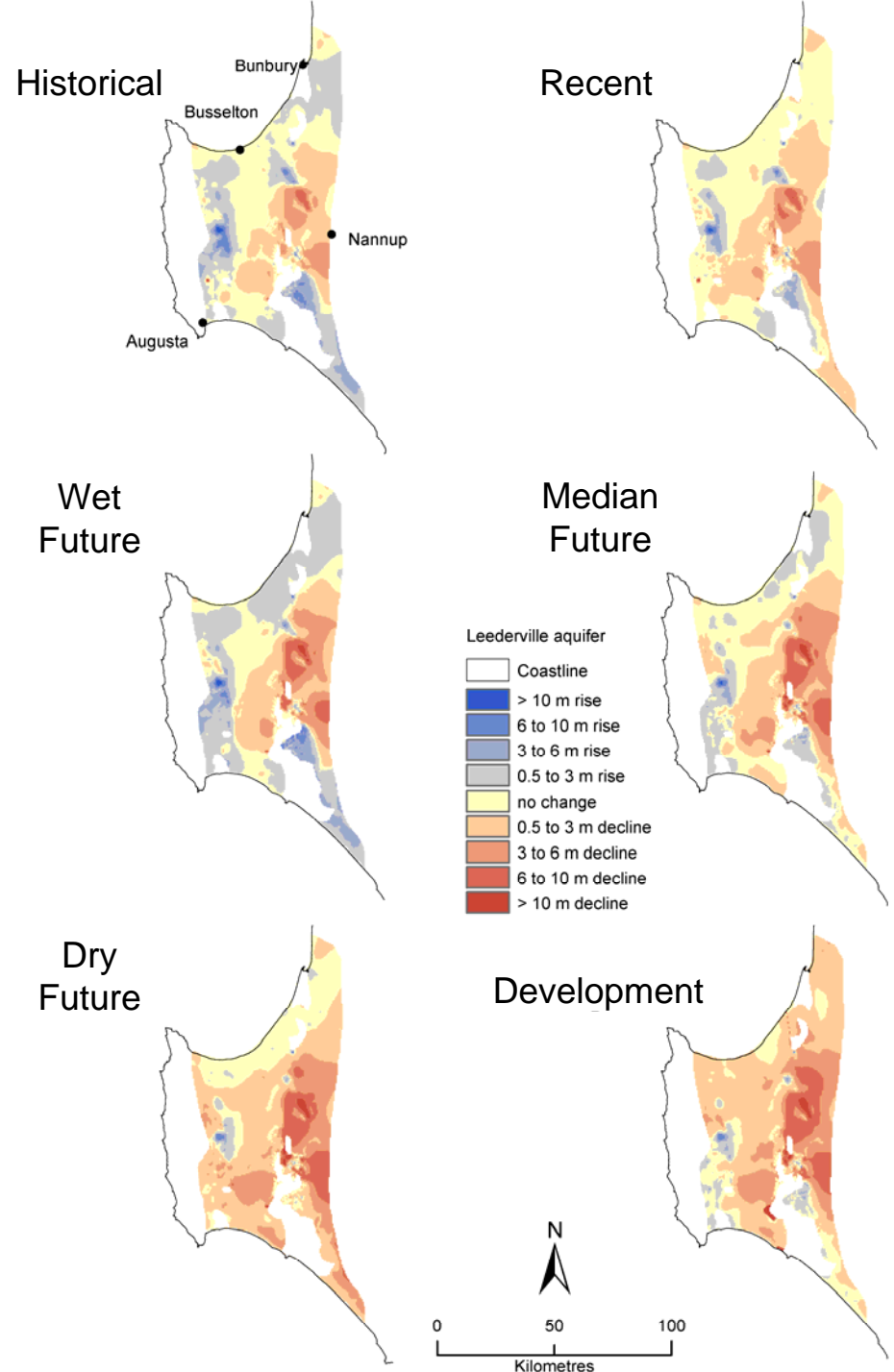
Central Perth Basin (PRAMS)

Change in groundwater levels in the Yarragagdee Aquifer 208 to 2030



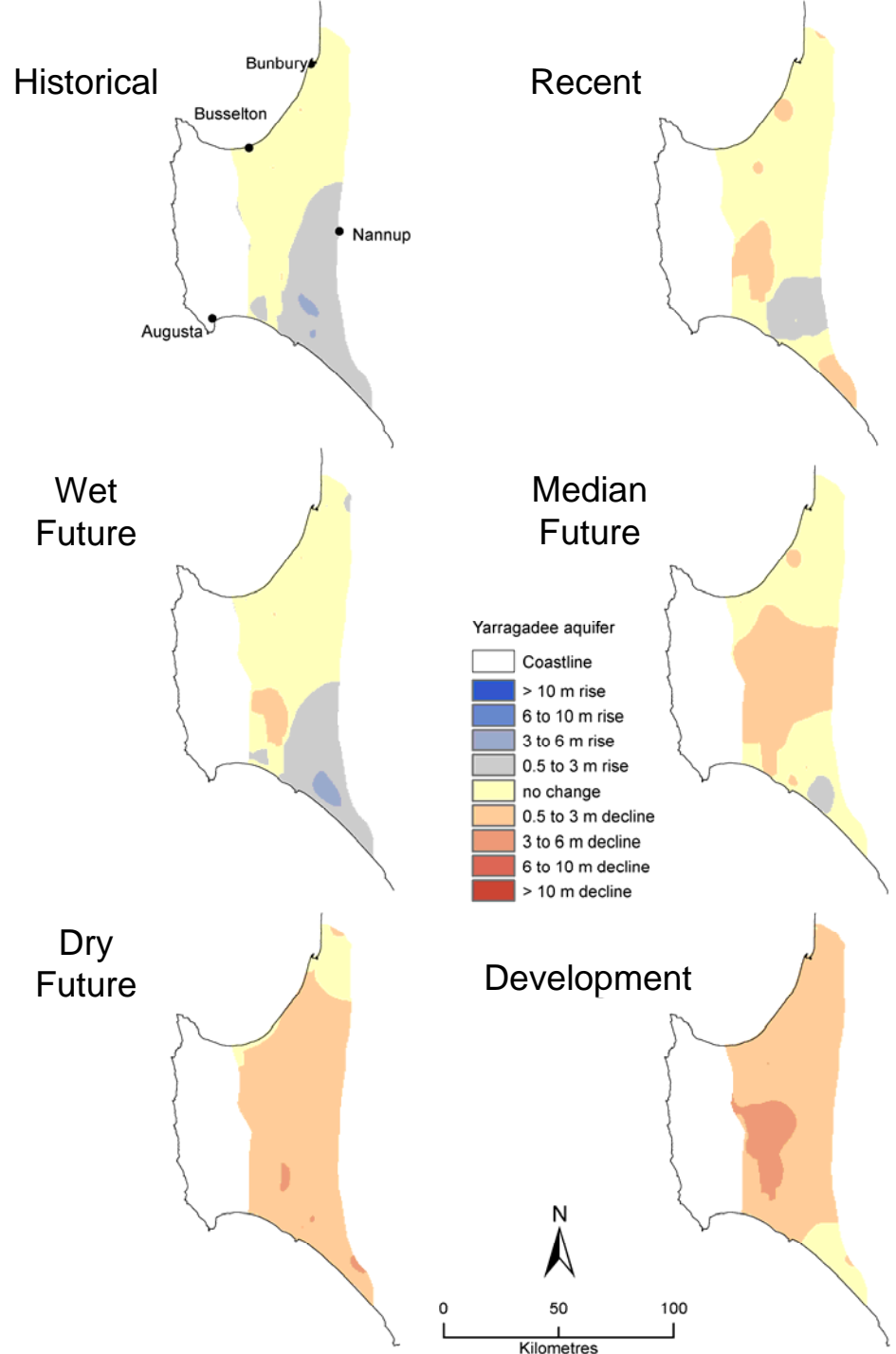
Southern Perth Basin (SWAMS)

Change in groundwater levels in the Leederville Aquifer 2008 to 2030

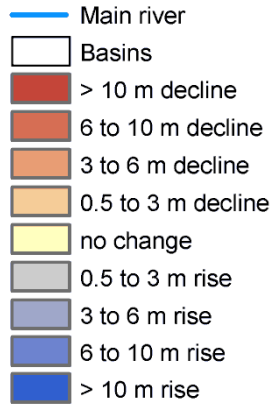


Southern Perth Basin (SWAMS)

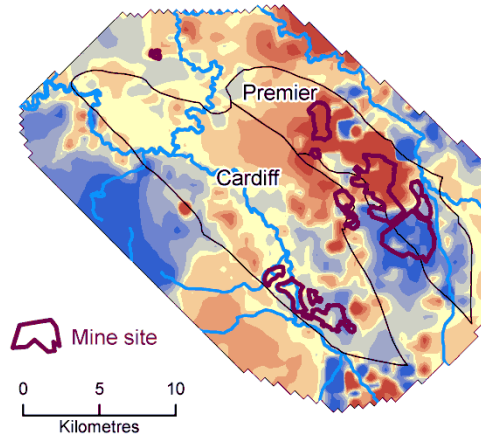
Change in groundwater levels in the Yarragadee Aquifer 2008 to 2030



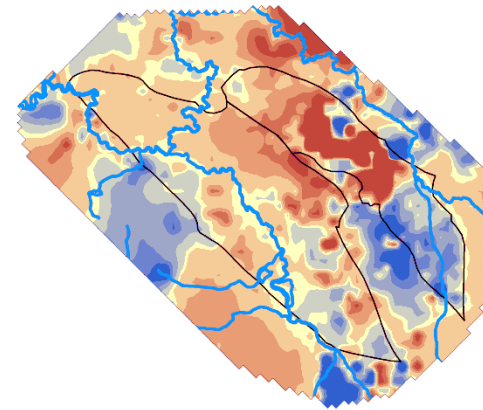
Collie groundwater basin level changes between 2008 and 2030



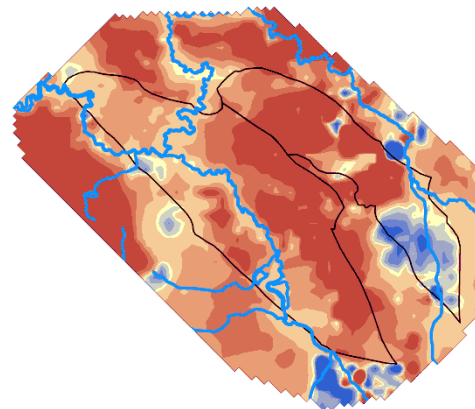
Historical climate



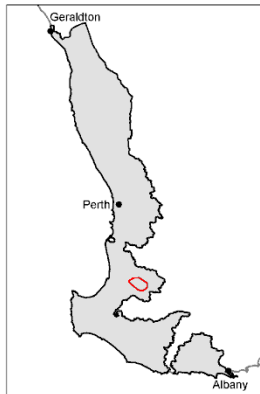
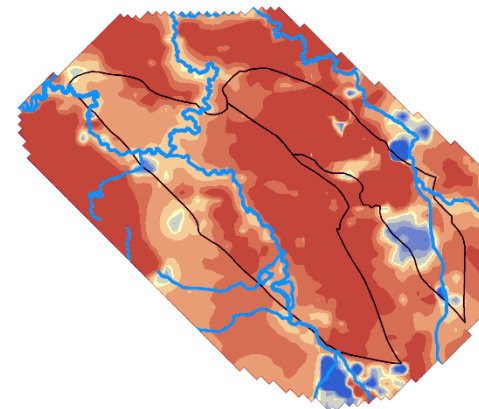
Recent climate



Median future climate



Dry extreme future climate

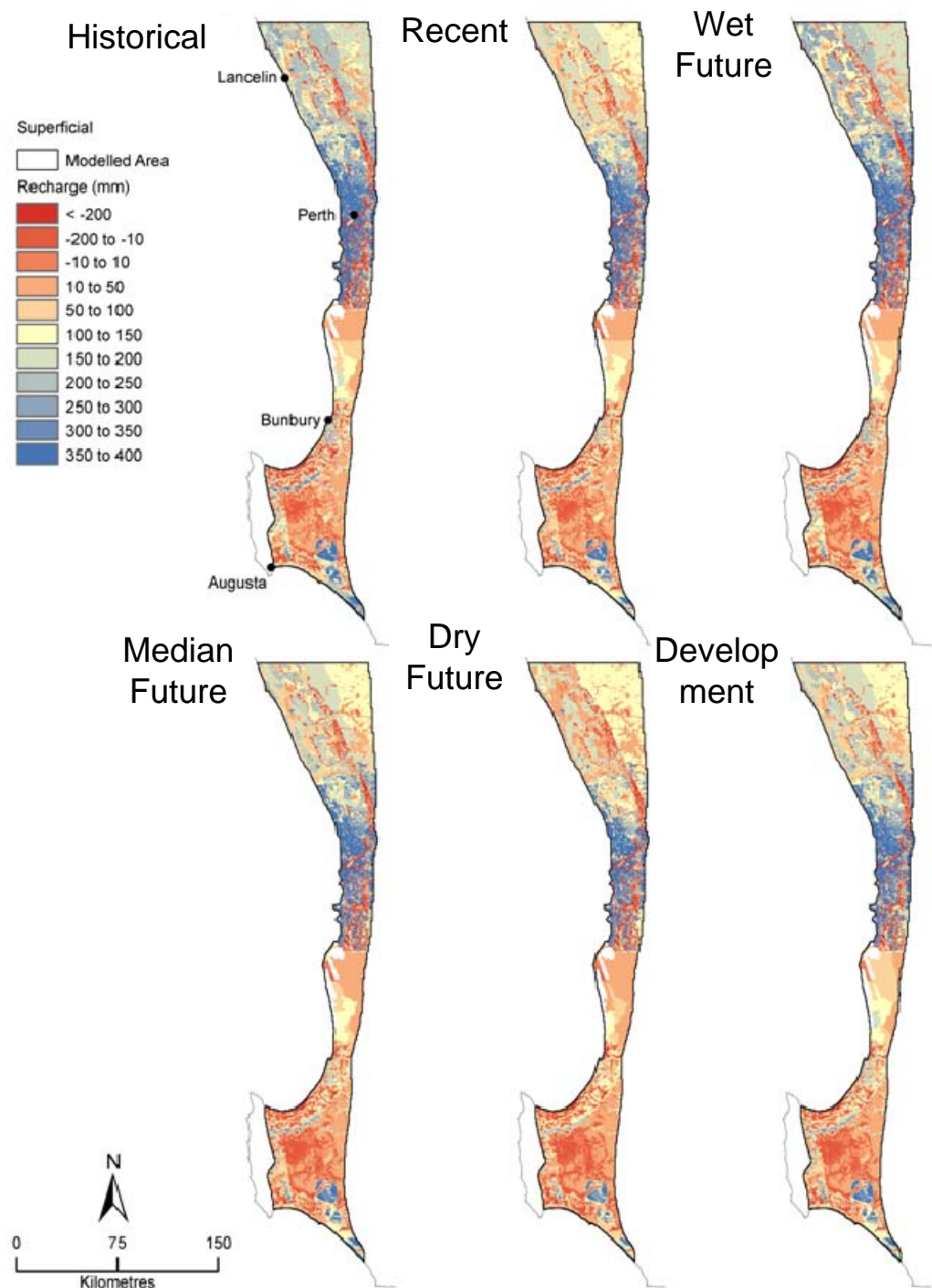


Groundwater levels are less affected near rivers

Recharge

Recharge

Depth of net recharge (mm)



Recharge in Albany Area (Grassmere) under A and C scenarios

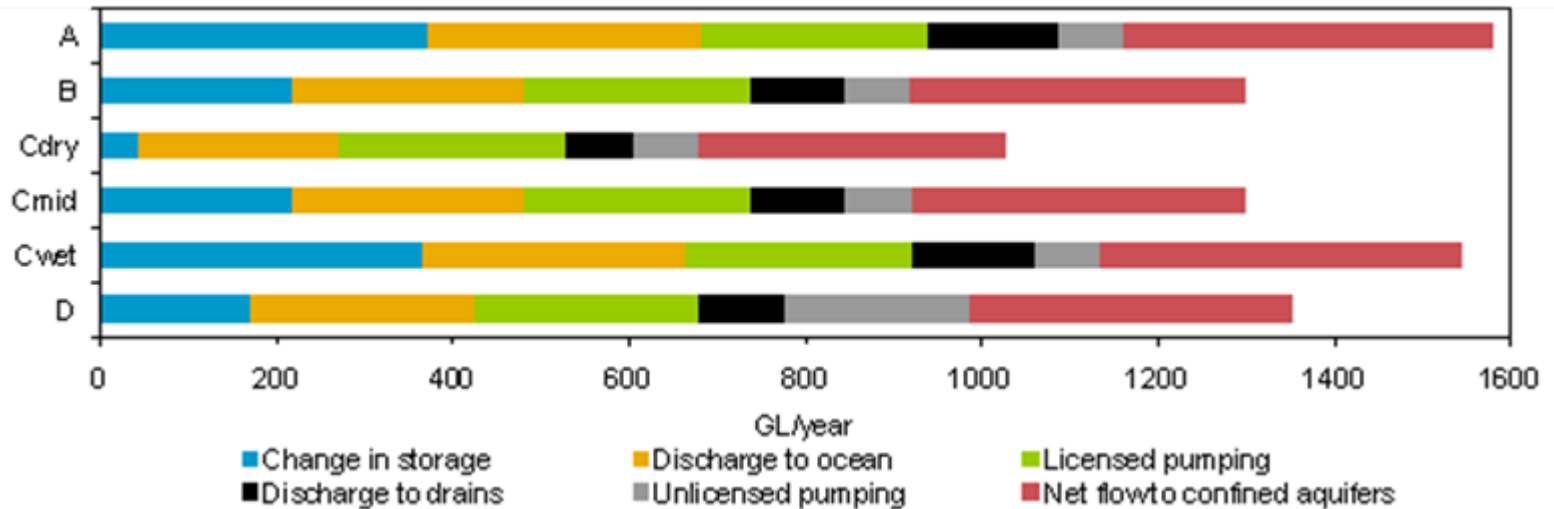
Cover	Leaf area index	Roots	Ground-water	Recharge			
				Historical	Wet future	Median future	Dry future
		m	m	mm/y			
Bare	0.0	0.0	10	593	550	505	469
Grass	1.0	0.5	10	377	335	303	272
Grass	2.0	1.0	10	254	226	201	177
Trees	1.5	5.0	10	265	225	192	159
Trees	1.5	10.0	20	215	174	140	109

Recharge in North Perth Basin under A and C scenarios

Cover	Leaf area index	Rooting depth	Water-table level	Historical climate	Wet future climate	Median future climate	Dry future climate
		m	m	mm	Percent of Historical climate		
Geraldton Airport							
Bare	0.0	0.0	10	225.7	112%	91%	74%
Grass	0.5	0.5	10	139.4	113%	85%	60%
Grass	1.0	1.0	10	45.6	139%	80%	39%
Trees	0.5	5.0	10	-4.4	211%	0%	0%
Trees	0.5	10.0	20	0.3	0%	0%	0%
Three Springs							
Bare	0.00	0.0	10	82.0	114%	84%	52%
Grass	0.50	0.5	10	31.3	115%	75%	33%
Grass	1.00	1.0	10	8.6	122%	56%	1%
Trees	0.33	5.0	10	-7.8	0%	0%	0%
Trees	0.33	10.0	20	-1.4	0%	0%	0%

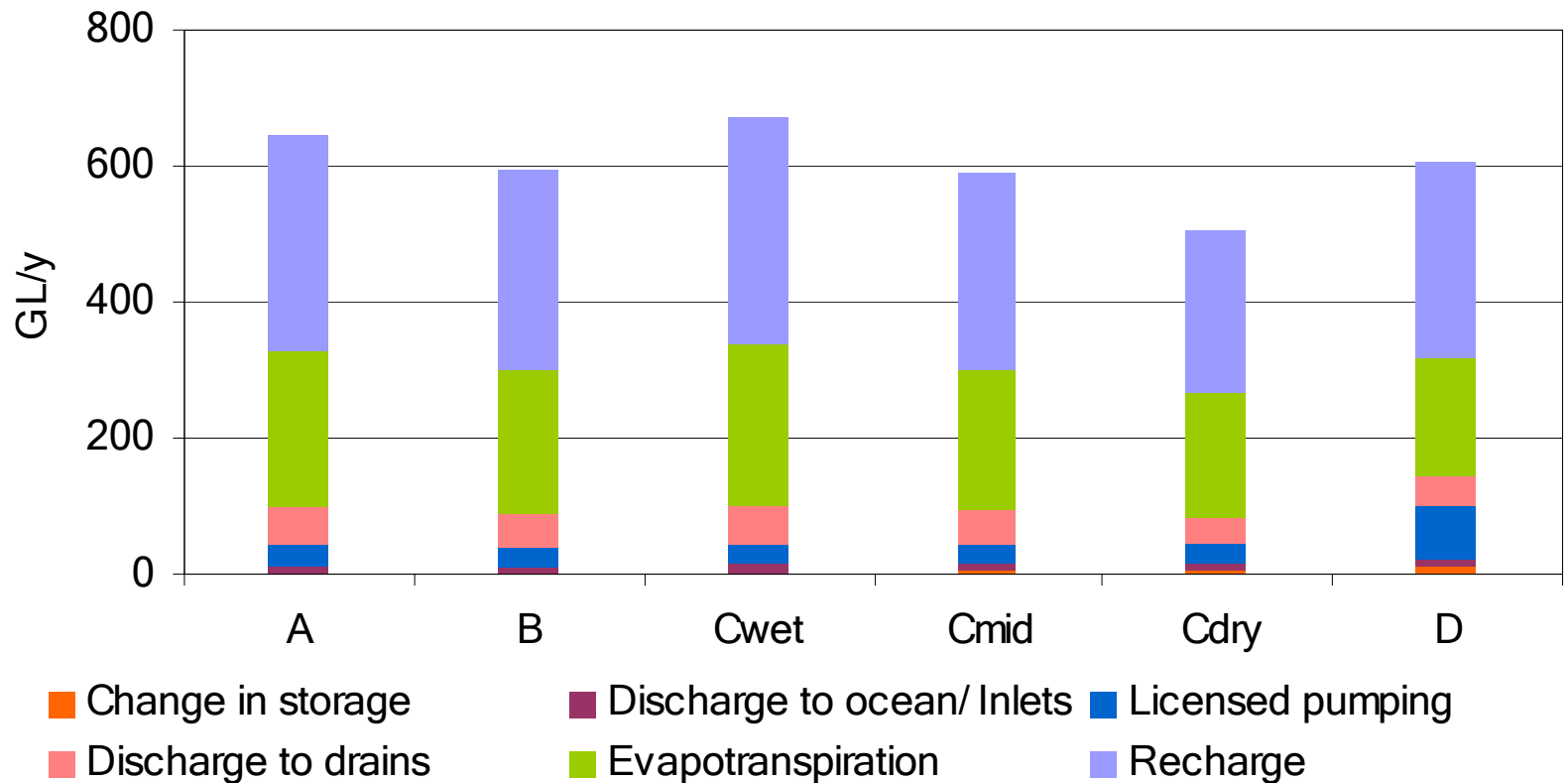
Water Balance

Superficial aquifer water balance – Central Perth Basin



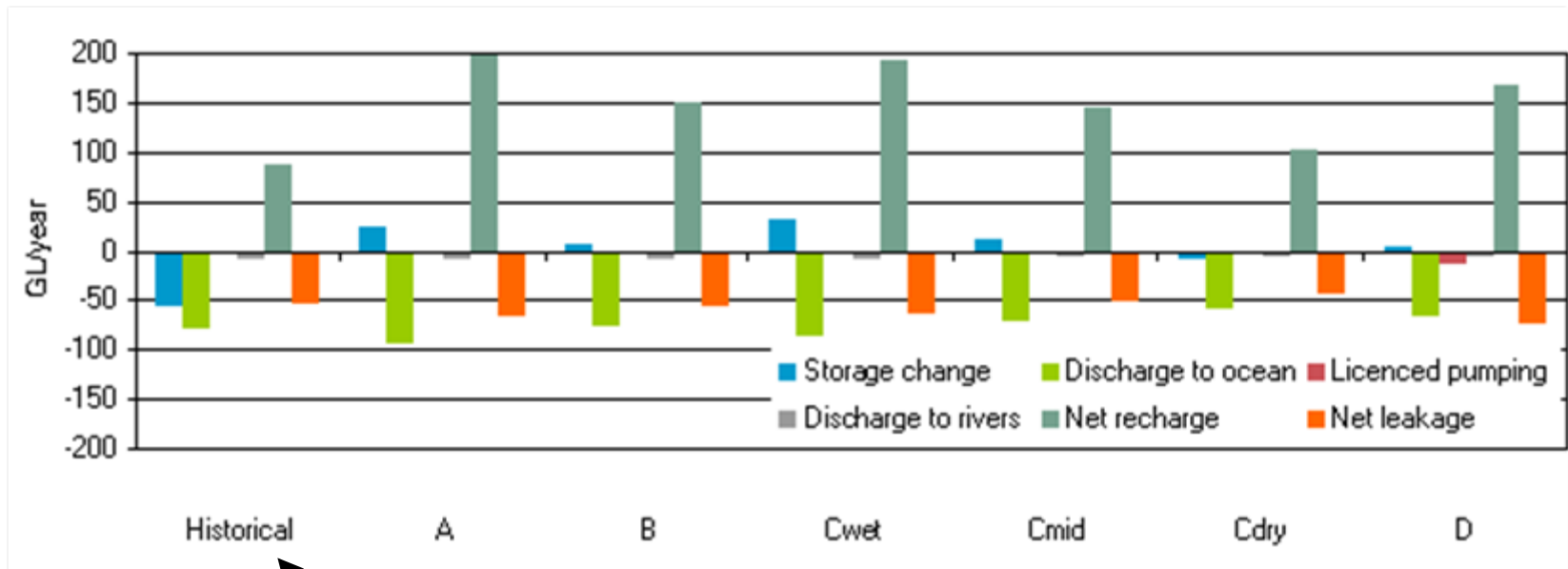
Scenario	Change in aquifer storage	Recharge	Discharge to ocean	Discharge to drains	Licensed pumping	Unlicensed pumping	Net flow to confined aquifers	Balance error
	GL per annum							
A	372	1579	-311	-147	-257	-75	-417	-0.1
B	218	1299	-263	-105	-257	-75	-380	-0.2
Cwet	364	1544	-299	-140	-257	-75	-409	-0.1
Cmid	217	1299	-263	-107	-257	-75	-379	-0.2
Cdry	43	1028	-227	-77	-257	-76	-349	-0.2
D	170	1351	-253	-97	-257	-209	-366	-0.2

Superficial Aquifer water balance – Peel-Harvey Area



Superficial Aquifer water balance – Southern Perth Basin

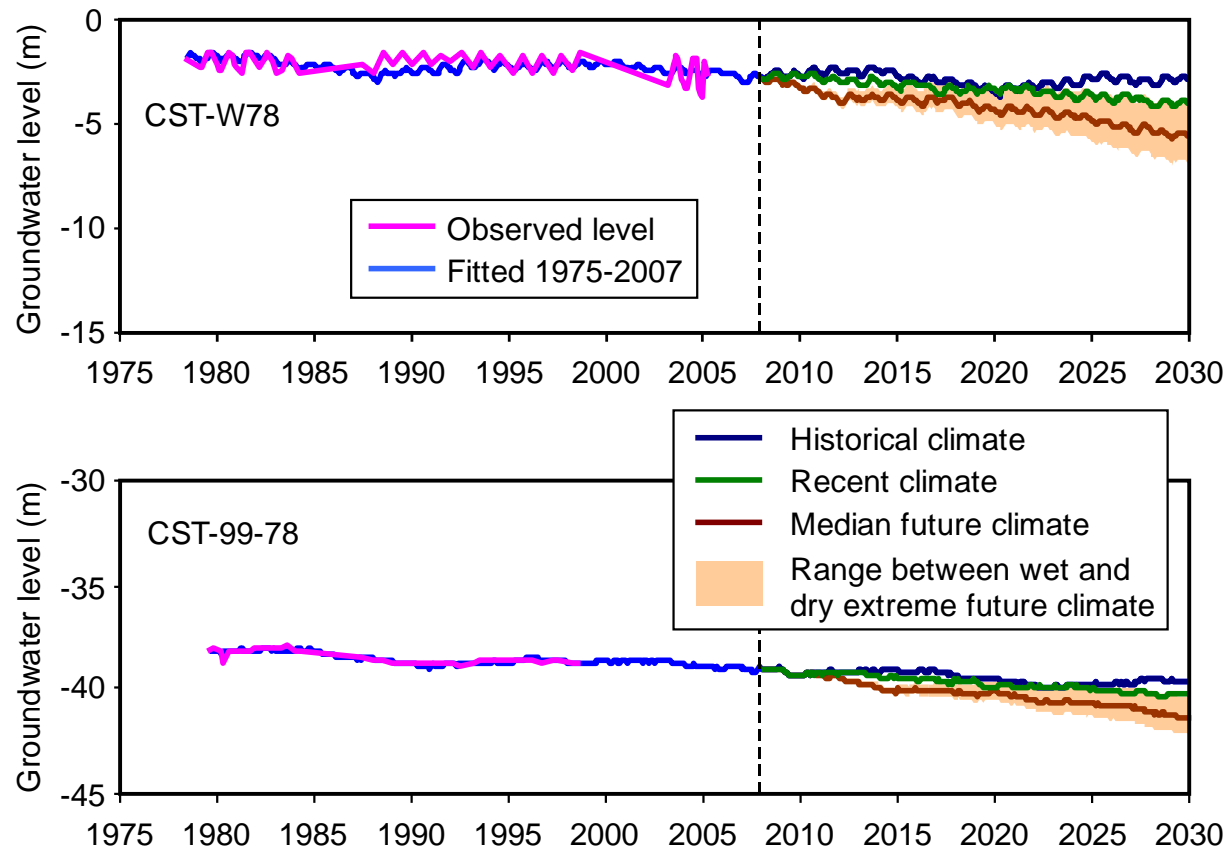
23-year (2008-2030) mean annual values in GL



(1975-2007)

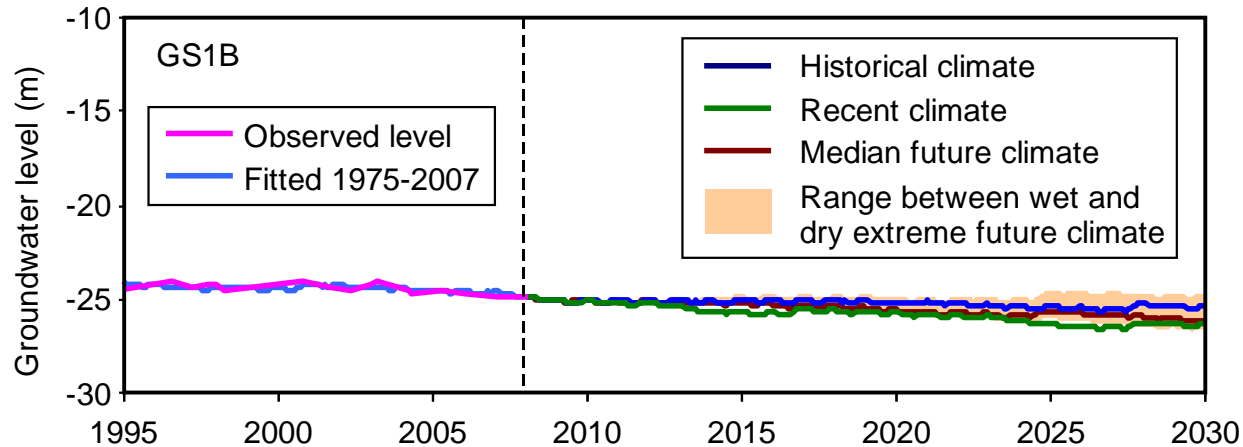
HARTT Projected Hydrographs

Albany Area bore hydrographs

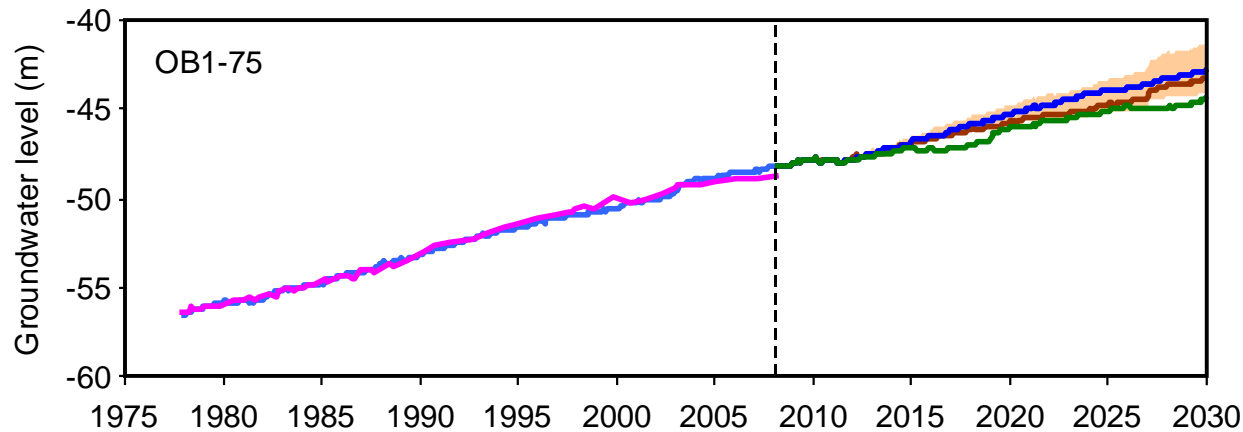


Groundwater levels are projected to decline under all future climates

Northern Perth Basin bore hydrographs



Slight fall in groundwater levels under native vegetation



Rising levels under dryland agriculture since 1978

Surface-Groundwater Interactions

Groundwater discharge to creeks and rivers in Southern and Central Perth Basin

Scenario	Southern Perth Basin				Central Perth Basin	
	Blackwood River		Capel River		Gingin Brook	
	Ground-water discharge (2008–2030)	Percent change from the historical climate	Ground-water discharge (2008–2030)	Percent change from the historical climate	Ground-water discharge (2008–2030)	Percent change from the historical climate
	GL/y	percent	GL/y	percent	GL/y	percent
Historical climate	33		11		58	
Recent climate	32	3%	11	0%	39	33%
Wet future climate	29	12%	11	0%	56	3%
Median future climate	26	21%	10	9%	42	28%
Dry future climate	24	27%	9.5	14%	30	48%
Future development	25	24%	8.9	19%	40	31%

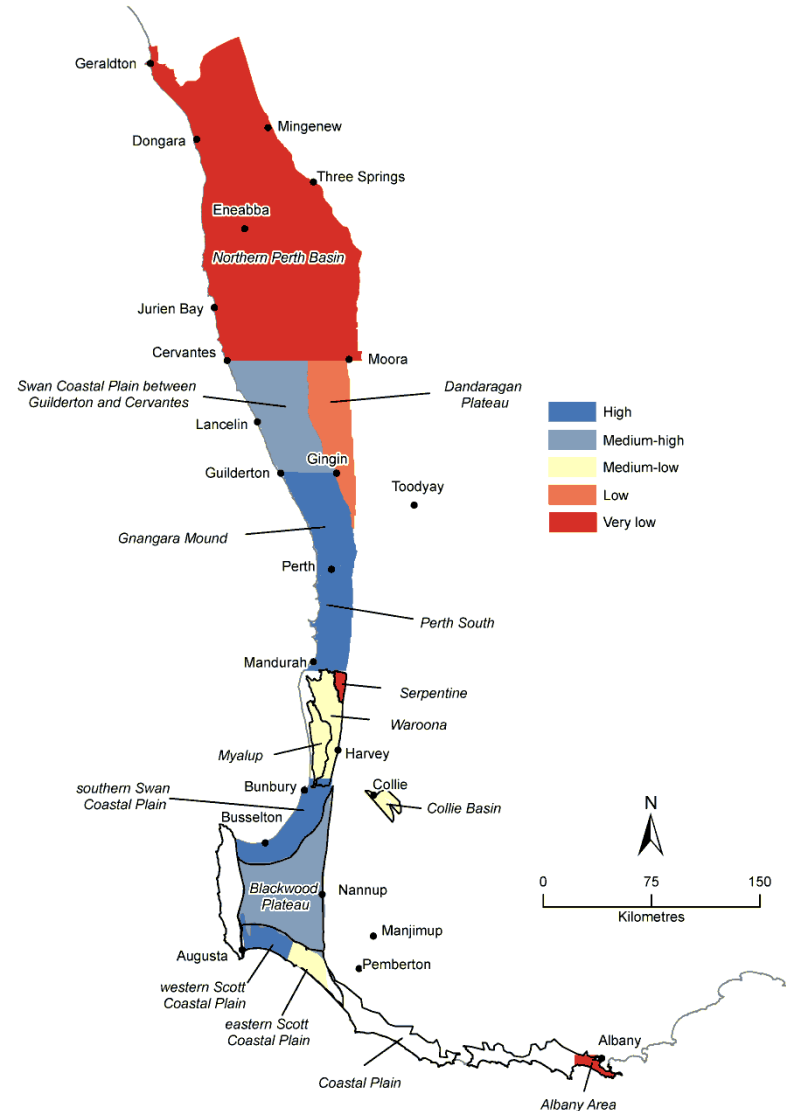
Mean annual groundwater discharge to the Collie River

Scenario	River head reduction	Collie River leakage within:	
		Premier sub-basin	Cardiff sub-basin
		GL/y	
2000–2007	0%	0	-1.4
Historical climate	0%	0	-1.4
Recent climate	10%	0	-1.3
Wet future climate	0%	0.1	0.2
Median future climate	20%	0.1	0.4
Dry future climate	40%	0.1	0.7
Future development	20%	0.1	0.3

Confidence in Model Predictions

Level of confidence in the 2030 projections of groundwater levels

- Central and Southern Perth Basin groundwater models are generally better than others
- Northern Perth Basin and Albany Area require models



Key Findings

Key findings – Groundwater

- A future drier and hotter climate is likely to lower groundwater levels, especially where there is perennial vegetation
- Groundwater levels under cleared, sandy coastal plains are expected to be less sensitive to climate change except under the dry future climate and high abstraction
 - As groundwater levels fall in these areas, evapotranspiration and drainage losses decrease and there is room in the aquifer to accept recharge

Key findings – Groundwater (*cont.*)

- Interactions between surface water and groundwater may change in both volume and direction as a result of lower water levels in rivers and surrounding aquifers
- Groundwater models are needed to estimate the impact of climate change and development for the Northern Perth Basin and Albany Area to extend the results of this project
- Confidence in model predictions varies depending on calibration error, hydrogeology, data quality, model maturity and other factors

Questions?

