The future for water availability in South-west Western Australia in a drying climate

Don McFarlane
Project Leader
Broad terms of reference

• Estimate the current and 2030 yield of water for catchments and aquifers in the south-west of WA considering climate change and development (plantations, farm dams, groundwater abstraction)

• Compare the estimated current and future water yields to those needed to meet the current levels of extractive use, future demands and environmental needs

This talk will cover the main findings but concentrate on water for irrigated agriculture especially
Sustainable Yields Projects – 2007 to 2009

Murray-Darling Basin
Northern Australia
South-West Western Australia
Tasmania
The ‘south-west’ as defined in this talk

- All fresh, marginal and brackish surface water catchments between Gingin Brook and the Hay River
- All aquifers within the Perth and Collie basins, plus the western Bremer Basin
- Combined area = 62,500 km²
Project area topography

- Short streams that arise in the Darling Ranges are fresh
- Darling Fault separates Perth Basin from Darling Plateau
- Coastal plains are flat and low lying – Swan Coastal Plain; Scott Coastal Plain; South Coast
- Perth Basin Plateaux are higher in elevation
Land cover

• Surface water catchments are mainly forested

• About 60% of the Perth Basin is cleared about 56% of this being under dryland agriculture

• The uncleared areas include coastal areas north of Perth, the Gnangara Mound and the Blackwood Plateau
Landforms

Geomorphic landforms affect groundwater response to climate change
Features of south-west WA

• We are relatively isolated from other irrigation areas
  • South Australia – lower Murray and Lower SE ca. 3000 road kms
  • Carnarvon mainly groundwater – sub-tropical crops – 900 km
  • Ord – sub-tropical crops – 3200 km

• Has experienced a drier, hotter climate in the last 35 years which has impacted on surface and groundwater yields

![Graph showing total rainfall (mm) from 1900 to 2010 with trends and percentage changes indicated.]
Features of south-west WA (cont.)

• Is experiencing some of the fastest growth in the economy and population in Australia, and in its own short history

• Aspects of water use and irrigation are different in south-west WA so we need to find our own solutions in some cases
Water use in the project area

• Total use is about 1200 GL/y of which 71% is self supplied (on-site bores and farm dams) and three quarters is groundwater

• About 35% is used for irrigated agriculture – elsewhere in Australia it is 66 to 75%

• Can be competition for water between water sectors – residential, industry, mining and agriculture

• Most irrigation water in south-west is used for high value products

• This, in addition to it being self supply and mostly groundwater, makes transfers and trading less feasible
Current agricultural irrigation water use
Surface water use is highest in central catchments and demand will grow in future

Current use = 299 GL/y

Growth in demand

Metro basins are fully used
Most groundwater abstraction currently occurs close to Perth because of high demand and water availability.
Scenarios

• The ‘historical climate’ assumed that the climate of the last 33 years (1975 to 2007) would continue until 2030. Used as a base case
• The ‘recent climate’ assumed that the climate of the last 11 years (1997 to 2007) would continue until 2030
• The ‘future climate’ used 15 GCMs with 3 greenhouse gas 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
• 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
Some terminology clarification

- **Runoff** = amount of surface water flow expressed as a depth (mm)

- **Streamflow** = amount of surface water flow expressed as a volume (runoff x area)

- **Surface water yield** = streamflow that can be diverted for use. Takes account of water for the environment and the location of nature reserves, national parks, irrigable land, etc.

- **Use** = water that is currently being used (metered, estimated)

- **Yield** = the amount of surface water and groundwater that is available for use – either under license and as unlicensed ‘stock and domestic’

- **Demand** – as estimate of the future requirement for water as a result of economic, demographic and industry growth. Unmet demand may result in higher water prices, reuse, water conservation, trading, desalination, etc. as well as the curtailment of growth
Rainfall, runoff and runoff coefficient under historical climate
14 of 15 GCMs predict 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%

Global climate models
- inmcm
- ncar_pcm
- cccma_t63
- ipsl
- iap
- miroc
- cccma_t47
- cnrm
- ncar_ccsm
- mpi
- mri
- gfdl
- miub
- giss_aom
- csiro

Change in annual rainfall (%)
-20 -15 -10 -5 0

Mid warming
High warming
Low warming
Averaged across the surface water basins
15 global climate models project less runoff

Runoff change across all basins
- Wet future climate: -10%
- Median future climate: -25%
- Dry future climate: -42%

Global climate models
- inmcm
- ncar_pcm
- iap
- cccma_t63
- ipsl
- miroc
- cnrm
- cccma_t47
- ncar_ccsm
- mri
- mpi
- gfdl
- csiro
- giss_aom
- miub

Change in runoff from historical (%)
Projected change in runoff relative to the historical climate

- Major decline in north and central region under recent climate
- Major impact in high rainfall areas under median and dry future climate
Current surface water yields

Total yield = 425 GL/y

- Public Water Supply 24%
- Irrigation schemes 27%
- Self supply 49%

- Harvey and Collie Basins contribute 43% of the total yield
Surface water yields are projected to change by -24% under a median future climate. Range of -4 to -49%.

IWSS yields reduced by 18% to 77 GL/y under a median future climate.
Gaps in surface water yields and demands in areas where irrigation is important

Recent climate-2030 gap

Median future climate-2030 gap

Dry extreme future climate-2030 gap

ML/km²/y

>20 10 2 -2 -10 -20 <-20

Harvey

Warren
Yield and demand gap in the Harvey, Collie and Preston surface water basins
Groundwater models

• The PRAMS model as used in the Gnangara 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
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
Change in groundwater levels between 2008 and 2030 under climate and development scenarios
Current groundwater yields as estimated by adding the 2009 Allocation Limits

Total yield = 1556 GL/y

Main aquifers:
- Superficial 58%
- Leederville 12%
- Yarragadee 26%
Groundwater use and future demand is highest near Perth and Bunbury

Current use = 808 GL/y
(2.2 x surface water)

Growth in demand

Perth – Peel area
Bunbury
Groundwater yields are projected to change by -2% under a median future climate. Range = +2 to -7%

Yield reductions are low because
1. Drain and ET losses reduce as watertables fall
2. Areas under dryland agriculture (56% of Perth Basin) have rising levels
3. Allocation Limits account for a future drier climate
Groundwater deficits may develop near Perth, Collie and Albany.
Combined yield and demand for the Perth Demand Region

Potential gap under median future climate and medium demand within 15 years
Current agricultural irrigation water use
The project area can meet all except high demands until 2030 under a median future climate. A 250 GL/y deficit may develop under a dry future climate and high demand.
Key findings

1. South-west Western Australia has experienced a significant climate shift since 1975 which is thought to include a component of climate change. Climate models project that rainfall could decline further by about 7% by 2030 (up to 14%)

2. Surface water yields are projected to decrease by about 24% (up to 49%)
   - The yields have already decreased in northern catchments and may decrease further by 2030
   - Central catchments are higher yielding and the decrease could be less
   - Streamflows are projected to decrease the most in the Southern catchments
Key findings (cont.)

3. Groundwater levels are projected to fall most under areas of perennial vegetation, e.g. Gnangara, Blackwood Plateau, Collie and Albany.

Levels are least affected in areas with high watertables such as coastal areas under dryland agriculture, e.g. Swan and Scott Coastal Plains; Dandaragan Plateau.

As watertables fall, drainage and evaporation from GDEs decrease and this slows the rate of fall.

4. Water dependent ecosystems have already been impacted and these impacts are projected to worsen, especially for high streamflows and GDEs with a watertable depth of 6 to 10 m.
5. Water deficits between yields and demands are likely in:
   - Surface water irrigation catchments
   - Aquifers near Perth, Collie and Albany

6. Overall there is enough water to meet all except high demands under a median future climate. However if there is a dry extreme climate and a high demand the deficit may be as much as 250 GL/y
Key findings – agriculture focus

7. Competition for available water for irrigating agricultural crops and pasture is likely to become more intense as Perth, Bunbury and Busselton expand and require more residential water. This includes water for outdoor use.

8. There appears to be available groundwater with increasing distance from Perth for irrigation, especially where dryland agriculture is currently raising groundwater levels. Lower value irrigation uses may also be replaced by crops that can be transported to urban centers.

9. Water, not land, seems to be the main constraint to irrigation, although the fertile and well-drained Spearwood Dune system is a premium landform for many uses.
Acknowledgements

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  • Resource Economics Unit – demand estimation
  • Geographic Information Analysis – model data preparation
  • Jim Davies and Associates – yield and demand analyses
• 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)
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Questions?
Game: more than just meat

Professor Louw Hoffman
University of Stellenbosch, RSA

Time: 16 March 2010 from 5-6pm
Place: Agriculture Lecture Theatre (G013), UWA
      (Hackett Drive, Entrance No 3, Car Park 8)