Climate Change Projections for South Australia

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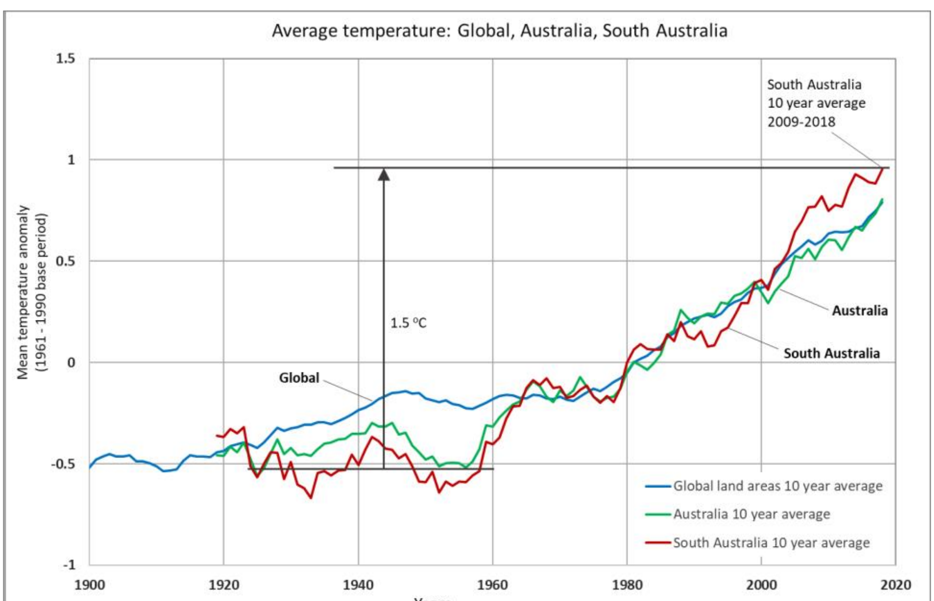
Department for Environment and Water



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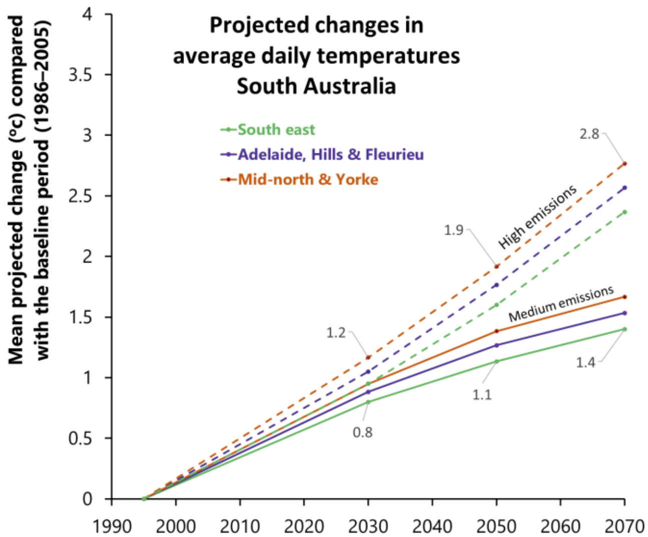
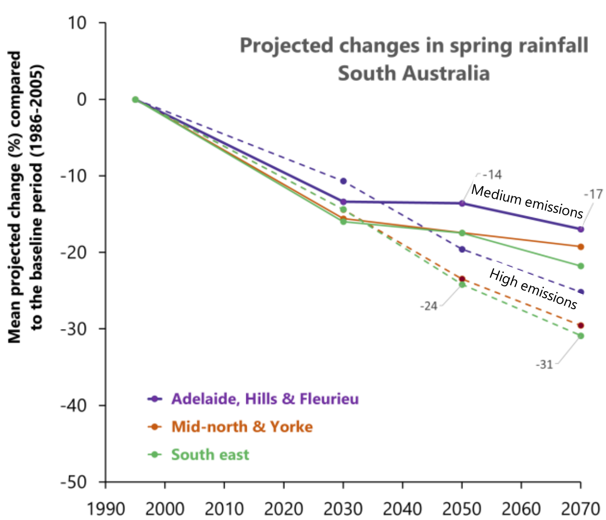
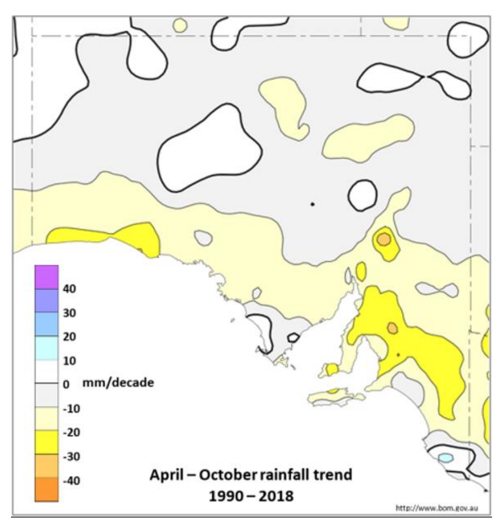
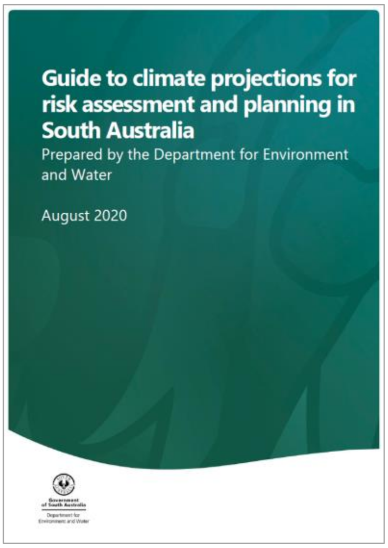


Observed changes in extreme daily temperatures Adelaide





Climate Projections for SA



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A1.1 Average annual maximum and minimum temperatures

Across all South Australian regions, annual average daily maximum and minimum temperatures are projected to increase at each of the future time horizons (2030, 2050 and 2090). The values shown in Table A1-1 and Table A1-2 are the average temperature change from the 1986–2005 baseline from six climate models (GCMs) selected for SA, and the range of average change amongst those GCMs (after Charles and Fu, 2015).

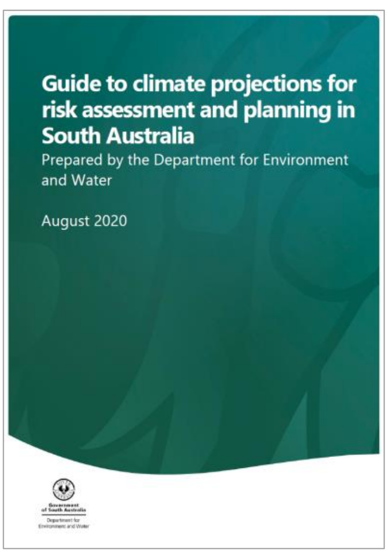
Table A1-1 Projected increase in annual daily maximum temperatures (°C) in the regions of South Australia by 2030, 2050 and 2090

NRM region	Increase in daily maximum temperatures (°C)					
	2030 (RCP4.5)	2030 (RCP8.5)	2050 (RCP4.5)	2050 (RCP8.5)	2090 (RCP4.5)	2090 (RCP8.5)
AMLR	0.9 (0.6 to 1.1)	1.1 (0.8 to 1.6)	1.3 (0.9 to1.6)	1.8 (1.5 to 2.6)	1.8 (1.5 to 2.4)	3.4 (2.7 to 4.8)
Eyre Peninsula	0.8 (0.6 to 1.0)	1 (0.8 to 1.4)	1.2 (0.9 to 1.5)	1.7 (1.4 to 2.3)	1.8 (1.4 to 2.3)	3.3 (2.6 to 4.3)
Kangaroo Island	0.7 (0.5 to 0.8)	0.8 (0.6 to 1.2)	1.0 (0.7 to 1.3)	1.4 (1.1 to 2.1)	1.5 (1.1 to 2.0)	2.8 (2.3 to 4.0)
Northern & Yorke	1.0 (0.7 to 1.1)	1.2 (0.9 to 1.7)	1.4 (1.0 to 1.7)	1.9 (1.6 to 2.8)	2 (1.7 to 2.6)	3.7 (2.9 to 5.1)
SA Arid Lands	1.0 (0.7 to 1.2)	1.3 (1.0 to 1.9)	1.4 (1.0 to 1.8)	2.1 (1.6 to 3.1)	2.1 (1.8 to 2.8)	4 (3.0 to 5.8)
SAMDB	0.9 (0.7 to 1.2)	1.1 (0.8 to 1.8)	1.3 (1.0 to 1.7)	1.9 (1.5 to 2.8)	1.9 (1.6 to 2.5)	3.6 (2.9 to 5.0)
South East	0.8 (0.6 to 1.0)	1 (0.7 to 1.5)	1.1 (0.9 to 1.5)	1.6 (1.3 to 2.5)	1.6 (1.3 to 2.2)	3.2 (2.7 to 4.5)

Table A3-1 Change in annual potential evapotranspiration

NRM Region	2030 (RCP4.5)	2030 (RCP8.5)	2050 (RCP4.5)	2050 (RCP8.5)	2090 (RCP4.5)	2090 (RCP8.5)
AMLR	+2.7	+3.1	+3.8	+5.2	+5.1	+9.9
Eyre Peninsula	+2.5	+2.7	+3.5	+4.6	+4.6	+9.0
Kangaroo Island	+2.2	+2.4	+3.1	+4.1	+4.2	+8.4
Northern & Yorke	+3.0	+3.4	+4.1	+5.5	+5.4	+10.5
SA Arid Lands	+2.7	+3.2	+3.8	+5.2	+5.2	+10.2
SAMDB	+2.8	+3.1	+3.9	+5.3	+5.2	+10.2
South East	+2.5	+2.9	+3.6	+4.8	+4.8	+9.7

Climate Projections for SA



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A2.1 Annual rainfall

Average annual rainfall across all South Australian regions is projected to decline to 2030, 2050 and 2090.

The values shown in Table A2-1 are the mean percentage change from the 1986–2005 baseline from six GCMs selected for SA, and include the range of mean change amongst those GCMs (after Charles and Fu, 2015).

Table A2-1 Projected change in **annual** rainfall (%) in the regions of South Australia by 2030, 2050 and 2090

Average change in annual rainfall from 1986–2005 baseline period (%)

Table A2-2 Projected change in **summer** rainfall (%) in the regions of South Australia by 2030, 2050 and 2090

Table A2-3 Projected change in **autumn** rainfall (mm) in the regions of South Australia by 2030, 2050 and 2090

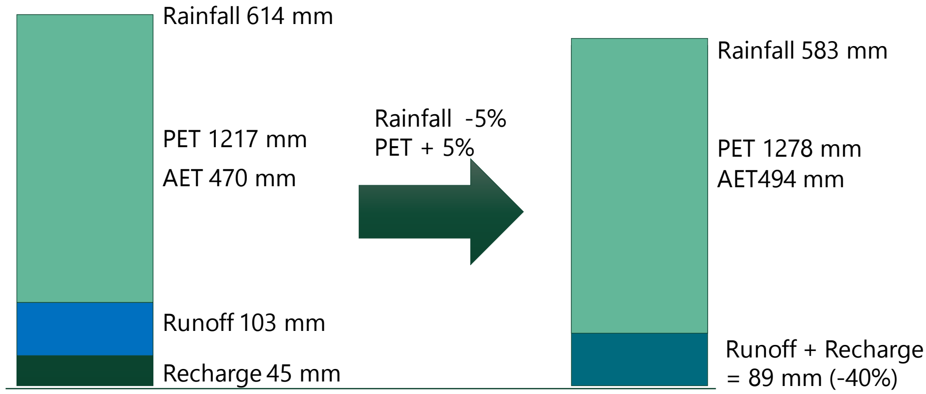
Table A2-4 Projected change in **winter** rainfall (mm) in the regions of South Australia by 2030, 2050 and 2090

*Table A2-5 Projected change in **spring** rainfall (mm) in the regions of South Australia by 2030, 2050 and 2090*

NRM region	Average change in spring rainfall from 1986–2005 baseline period (%)					
	2030 (RCP4.5)	2030 (RCP8.5)	2050 (RCP4.5)	2050 (RCP8.5)	2090 (RCP4.5)	2090 (RCP8.5)
AMLR	-13.4 (-9.2 to -20.2)	-10.7 (-4.1 to -19.9)	-13.6 (-8.4 to -23.1)	-19.6 (-8.5 to -30.4)	-17.6 (-11.6 to -31.2)	-31.9 (-22.8 to -49.0)
Eyre Peninsula	-18.8 (-4.3 to -33.7)	-16.3 (+5.6 to -33.4)	-20.9 (-10.0 to -33.6)	-27.9 (-10.0 to -45.3)	-24.8 (-11.4 to -41.0)	-43.2 (-30.0 to -62.4)
Kangaroo Island	-14.5 (-10.0 to -21.9)	-12.5 (-2.7 to -22.8)	-15.0 (-6.7 to -25.4)	-21.1 (-6.2 to -34.1)	-19.5 (-13.4 to -32.6)	-34.8 (-23.8 to -50.5)
Northern & Yorke	-15.6 (-4.2 to -28.5)	-14.4 (+2.0 to -29.0)	-17.4 (-8.7 to -27.2)	-23.5 (-6.9 to -39.4)	-21.9 (-11.8 to -35.2)	-38.5 (-26.9 to -56.9)
SA Arid Lands	-14.6 (+7.2 to -37.5)	-8 (+22.7 to -28.8)	-14.1 (+8.0 to -34.7)	-18.4 (-1.1 to -45.9)	-12.5 (+13.0 to -32.6)	-31.6 (-4.4 to -60.8)
SAMDB	-17.4 (-10.5 to -30.0)	-17.1 (-6.0 to -32.2)	-19.4 (-12.4 to -29.5)	-27.4 (-16.3 to -40.8)	-25.5 (-20.6 to -38.8)	-43.1 (-31.2 to -60.2)
South East	-16.0 (-11.7 to -	-14.4 (-3.2 to -27.1)	-17.5 (-9.8 to -25.6)	-24.2 (-9.0 to -37.0)	-22.8 (-16.1 to -	-40.3 (-31.5 to -55.8)

Why impacts of climate change on water resources may be greater than you expect:

Example catchment in Clare Valley, South Australia



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Potential impacts on water users…

- Reduction in rainfall – reduced water supply
  - Less surface water resources during irrigation season (less re-filling of dams)
  - Less natural replenishment of soil water
  - Less groundwater recharge to some aquifers
- Increased temperatures – increased water demand
  - Greater evapotranspiration
  - More very hot days & crop cooling required

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Climate change risk factors for water resources…

- Exposure – how much change in climate variables (RF, temp, ET)?
- Vulnerability – how will the resource respond to these changes?
- Significance – how much will the changes to the water resource affect things that matter – ecosystems, communities, industries?
- Mitigation options – can we adapt to less water; is there a substitute water source?

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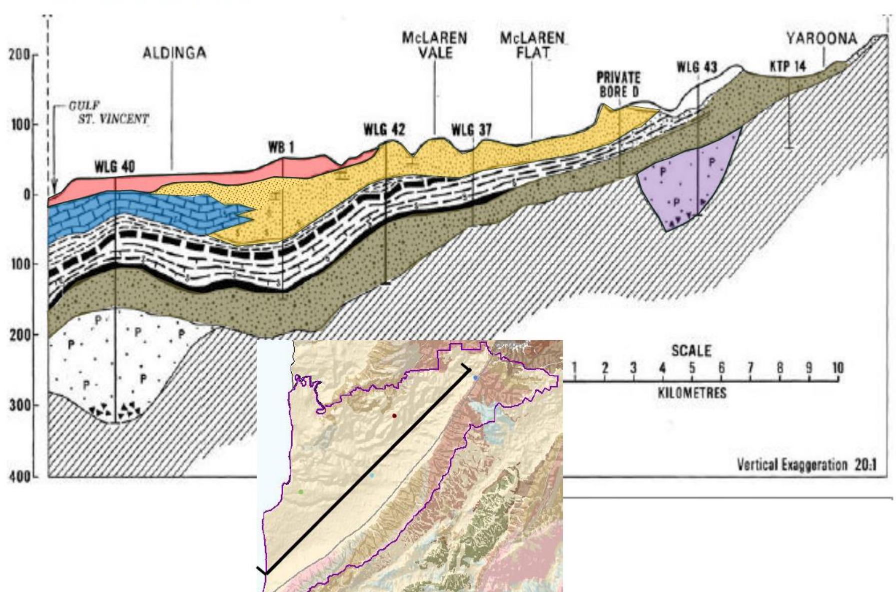
Groundwater System

Cross Section

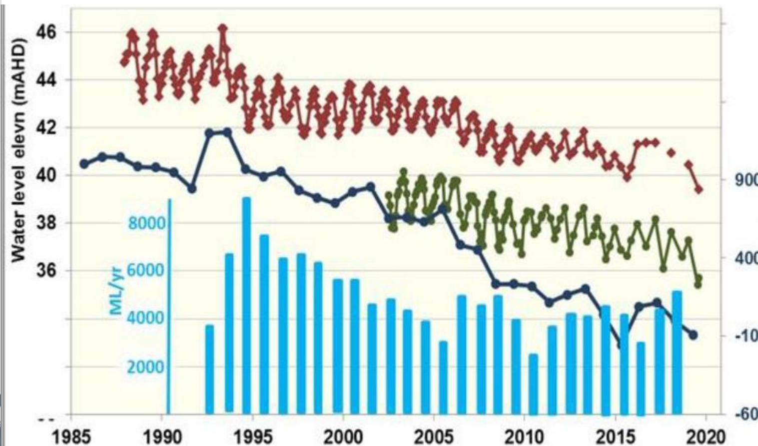


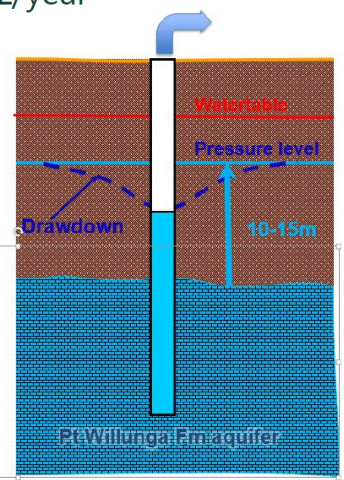
Port Willunga Formation

Water level trends

Gradual long term pressure decline in response to rainfall – not of concern at present

~350,000 ML in storage, currently using ~2,800 ML/year

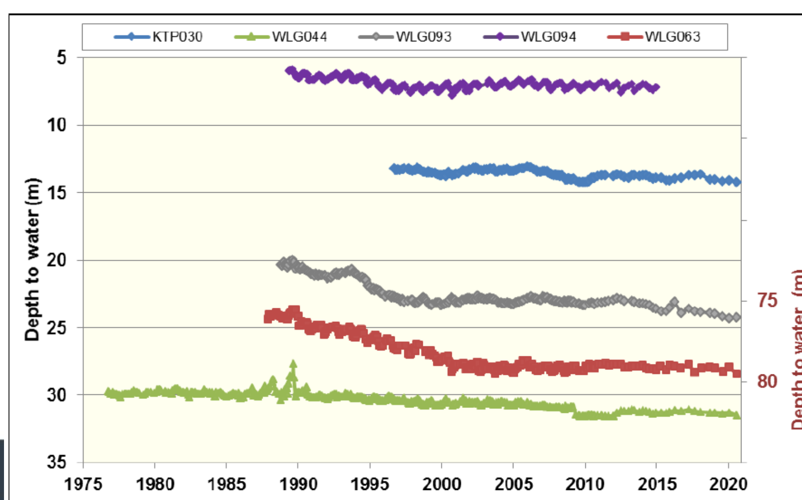




Maslin Sands

Water level trends

Gradual decline of 0.04 to 0.10 m/year in response to rainfall, but aquifer >50m thick



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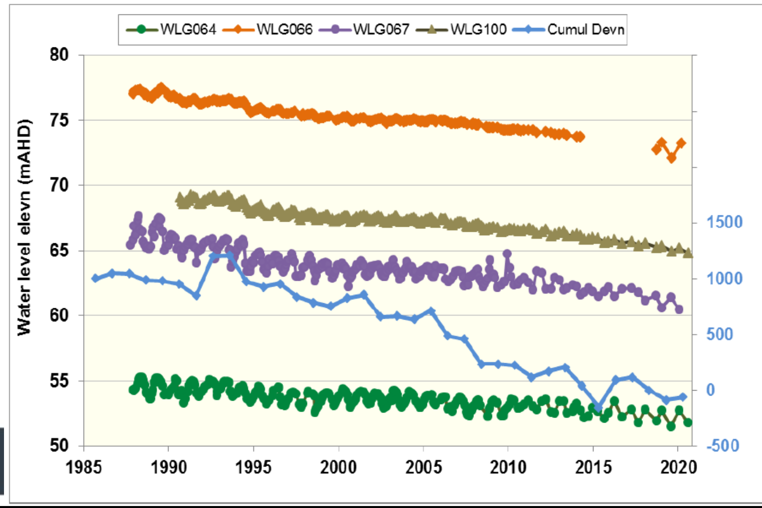
Pirramimma Sands

Water level trends

Gradual decline of 0.07 to 0.15 m/year since 1993 in response to below average rainfall – represents a loss of storage of 9%. Aquifer >50m thick



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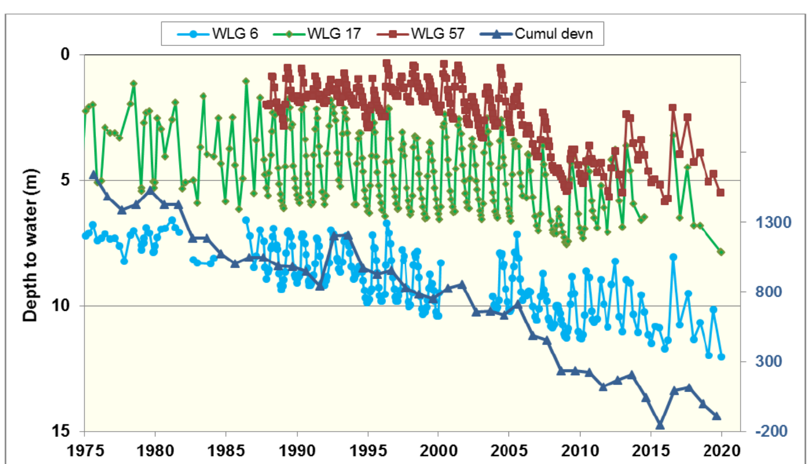
Quaternary aquifer

Water level trends

Gradual long term decline related to below average rainfall

May have impacts on GDEs in long term



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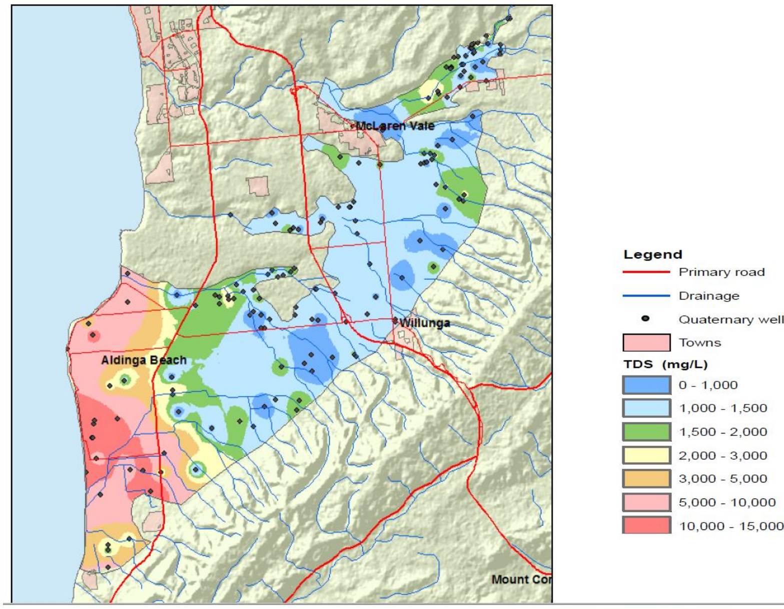
Quaternary aquifer



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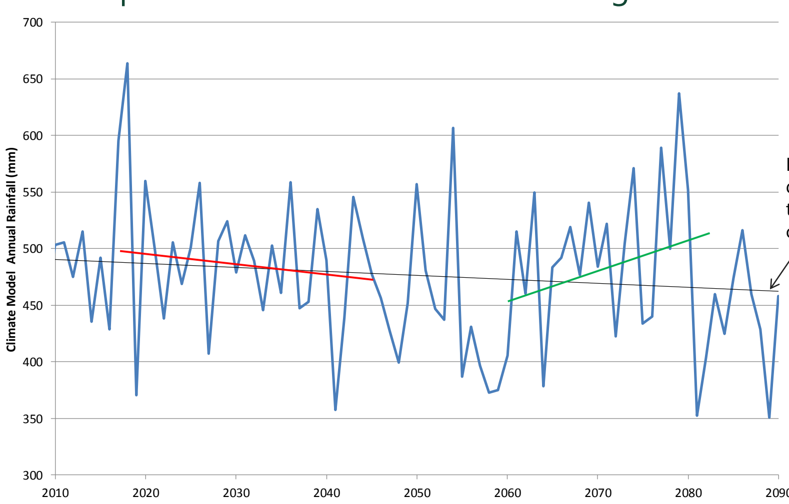
Annual variability + climate change

- a problem for water resource management



Long-term downward trend of 10% over 80 years

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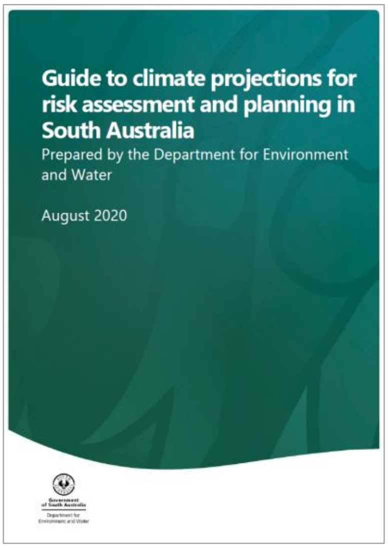
Climate Projections for SA



Annual and seasonal temperatures and rainfall		*1981–2010 Baseline (for location)*	*Mean estimate of change 2030*	*Mean estimate of change 2050*
Annual mean temperature (°C)		Mean daily max: 22.3	+1.1	+1.8
		Mean daily min: 12.2	+0.8	+1.4
Seasonal temperature (°C)	Summer	Mean daily max: 28.5	+1.0	+1.7
		Mean daily min: 16.6	+0.8	+1.4
	Autumn	Mean daily max: 22.7	+1.0	+1.7
		Mean daily min: 12.7	+0.9	+1.6
	Winter	Mean daily max: 16.0	+0.9	+1.6
		Mean daily min: 7.9	+0.7	+1.2
	Spring	Mean daily max: 22.0	+1.3	+2.2
		Mean daily min: 11.7	+0.8	+1.4
Mean annual rainfall		546 mm	-5.4%	-8.4%
Seasonal rainfall	Summer	63 mm	2.7%	-6.5%
	Autumn	127 mm	-4.3%	-3.9%
	Winter	226 mm	-5.0%	-5.0%
	Spring	131 mm	-10.7%	-19.6%
Extreme temperature and rainfall events		**1981–2010 Baseline frequency**	**Mean projected frequency 2030**	**Mean projected frequency 2050**
Mean number of very hot days (over 40°C) per year		2.4	4.3	6.2
Mean number of very cold nights (minimum less than 2°C) per year		1.1	0	0
Heavy rainfall (mean days per year above 99.9th percentile		0.38	0.6	0.6

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- Quaternary aquifer
  - Water levels - declining
  - Salinity – mostly still low (<1500 mg/l)
- Port Willunga Formation aquifer
  - Water levels - declining
  - Salinity – approximately stable
- Pirramimma Sands aquifer
  - Water levels - declining
  - Salinity – increasing in some areas
- Maslin Sands aquifer
  - Water levels – approximately stable
  - Salinity – increasing in some areas
- Fractured rock aquifers
  - Water levels – stable for last 10-15 years
  - Salinity – approximately stable

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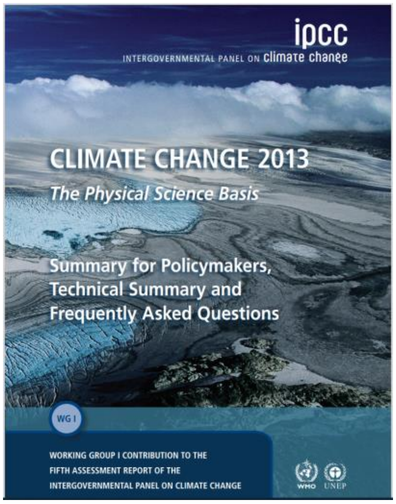
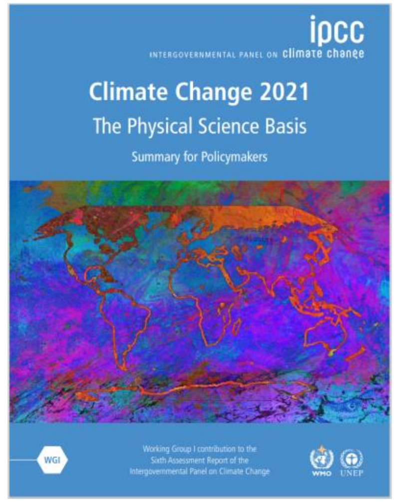
IPCC Sixth Assessment Report





•First assessment report (1990): "By increasing their concentrations, and by adding new greenhouse gases like chlorofluorocarbons (CFCs), humankind is capable of raising the global-average annual-mean surface-air temperature."

•Second assessment report (1995): "The balance of evidence suggests a discernible human influence on global climate."

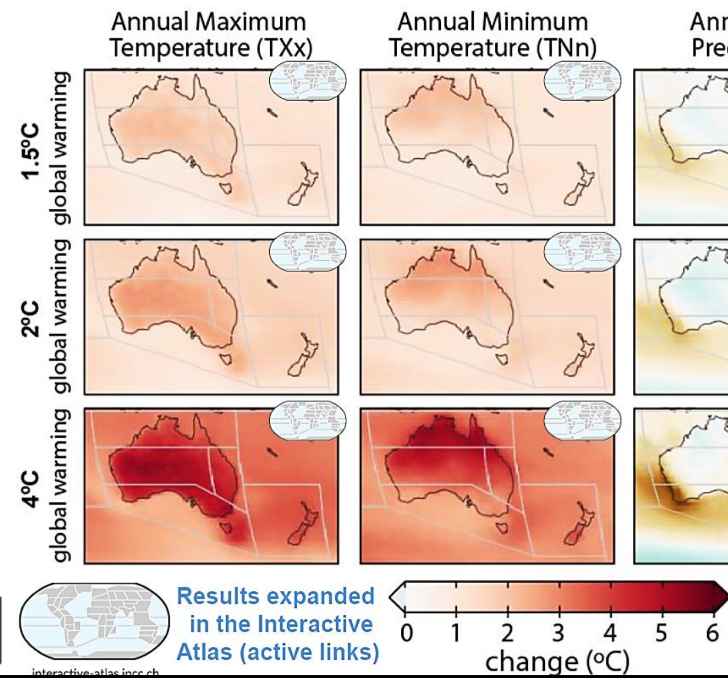
•Third assessment report (2001): "Most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations."

•Fourth assessment report (2007): "Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."

•Fifth assessment report (2013): "It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century."

•Sixth assessment report (2021): "It is unequivocal that human influence has warmed the atmosphere, ocean and land."

Projections at 1.5°C, 2°C, and 4°C global warming



IPCC AR6 – projected global average temperature changes

	Near term, 2021–2040		Mid-term, 2041–2060		Long term, 2081–2100		
Scenario	Best estimate (°C)	*Very likely* range (°C)	Best estimate (°C)	*Very likely* range (°C)	Best estimate (°C)	*Very likely* range (°C)	
SSP1-1.9	1.5	1.2 to 1.7	1.6	1.2 to 2.0	1.4	1.0 to 1.8	(implausibly) low emissions
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 2.4	low emissions
SSP2-4.5	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5	medium emissions
SSP3-7.0	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	2.8 to 4.6	high emissions
SSP5-8.5	1.6	1.3 to 1.9	2.4	1.9 to 3.0	4.4	3.3 to 5.7	very high emissions (unlikely)

IPCC AR6 WG I SPM, Table SPM.1: Temperature differences relative to the average global surface temperature of the period 1850–1900, reported in °C.

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IPCC AR5 (2013)

	2081 - 2100	
Scenario	Mean	Likely range (5 – 95%)
RCP2.6	1.6	0.9 – 2.3
RCP4.5	2.4	1.7 – 3.2
RCP8.5	4.3	3.2 – 5.5

IPCC AR6 (2021)

	Long term, 2081–2100	
Scenario	Best estimate (°C)	*Very likely* range (°C)
SSP1-1.9	1.4	1.0 to 1.8
SSP1-2.6	1.8	1.3 to 2.4
SSP2-4.5	2.7	2.1 to 3.5
SSP3-7.0	3.6	2.8 to 4.6
SSP5-8.5	4.4	3.3 to 5.7

IPCC AR6 WG I SPM, Table SPM.1: Temperature differences relative to the average global surface temperature of the period 1850–1900, reported in °C.

McLaren Vale Water Allocation Plan Advisory Committee

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Risk Identification – The Bow-tie and Risk Statements

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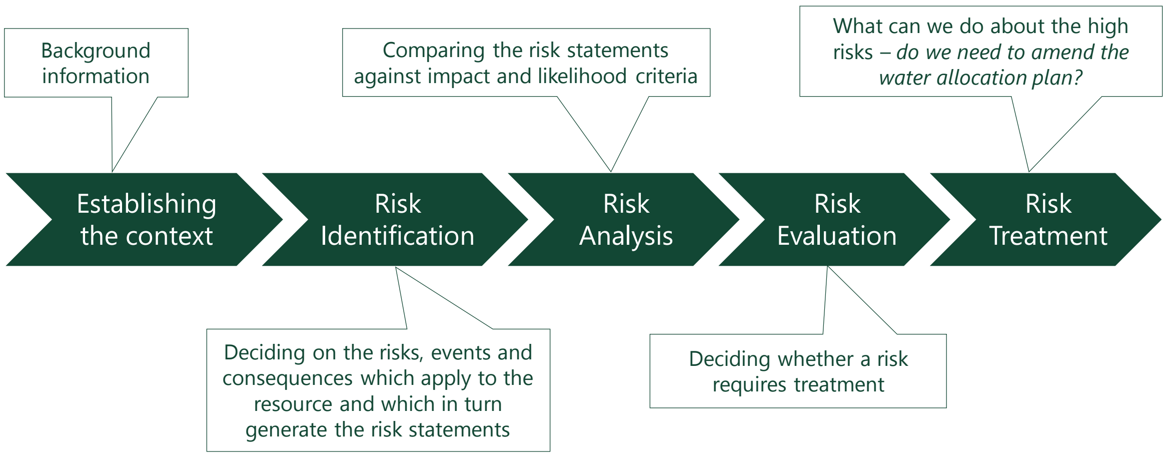
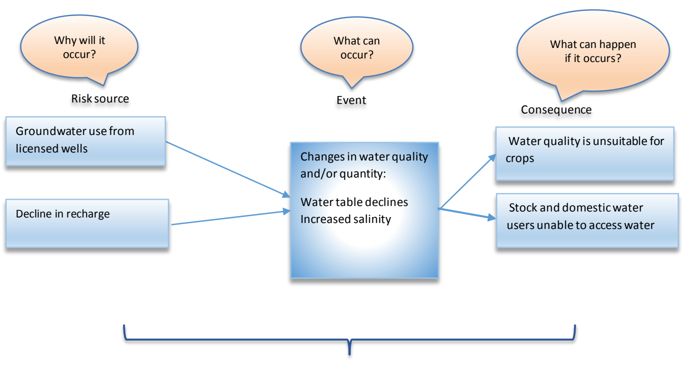
What is risk assessment?



Risk Identification: example of a simple bow tie diagram



Risk statements

- There is the potential that **groundwater use from licensed wells** leads to **changes in water quality and/or quantity** which results in **water quality being unsuitable for crops**
- There is the potential that **groundwater use from licensed wells** leads to **changes in water quality and/or quantity** which results in **stock and domestic water users unable to access water**
- There is the potential that **a decline in recharge** leads to **changes in water quality and/or quantity** which results in **water quality being unsuitable for crops**.
- There is the potential that **a decline in recharge** leads to **changes in water quality and/or quantity** which results in **stock and domestic water users unable to access water**

Risk Analysis:
Comparing the risk statements against impact and likelihood criteria

There is the potential that **groundwater use from licensed wells** leads to **changes in water quality and/or quantity** which results in **impacts on economic use**

Consequence category	Descriptor
Catastrophic	Water not available for economic consumptive use purposes. Water allocation <30% for a single year or <50% for two or more consecutive years, or Economic losses from impacts to ecosystem service provision including reduced productivity of non-consumptive economic use and damage to assets and infrastructure with a total value of >$x
Major	Water not available for economic consumptive use purposes having market value $x. Water allocation <50% for a single year or 50–75% for two or more consecutive years, or Economic losses from impacts to ecosystem service provision including reduced productivity of non-consumptive economic use and damage to assets and infrastructure with a total value of $x
Moderate	Water not available for economic consumptive use purposes having market value $x. Water allocation 75–90%, or Economic losses from impacts to ecosystem service provision including reduced productivity of non-consumptive economic use and damage to assets and infrastructure with a total value of $x
Minor	Water Allocation >90 %, or Losses or damage <$x
Insignificant	No losses or damage

Example, actual descriptors will be decided by WAPAC

Likelihood category	Descriptor	Probability
Almost certain	Expected to occur in all circumstances	91% -100%
Likely	Greater than even chance of occurring	51% - 90%
Possible	Less than even chance of occurring	26 % - 50%
Unlikely	Unusual but not exceptional	11% -25%
Rare	Only occurs in exceptional circumstances	0% -10%

		Consequence				
		Insignificant	Low	Moderate	Major	Catastrophic
Likelihood	Very Likely >90%	Low	Medium	High	High	High
	Likely 60% - 90%	Low	Medium	Medium	High	High
	Possible 31% - 59%	Low	Low	Medium	Medium	High
	Unlikely 10% - 30%	Low	Low	Low	Medium	Medium
	Very Unlikely <10%	Low	Low	Low	Low	Low

Risk Identification

Risk identification is the process of finding, recognising and describing risks including deciding on the important values and risks to those values.

- Risk source
  - e.g. seasonal variability
- Event
  - e.g. water table decline
- Consequence
  - e.g. economic impacts

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Risk Identification cont.

- Relevant to the resource and the water allocation plan
- Meaningful to the WAPAC undertaking the risk assessment
- Collectively cover the issues – but can use broad statements if needed
- Multiplier effect – adding extra sources, events of consequences multiplies the number of risk statements to assess
- One resource or multiple aquifers?

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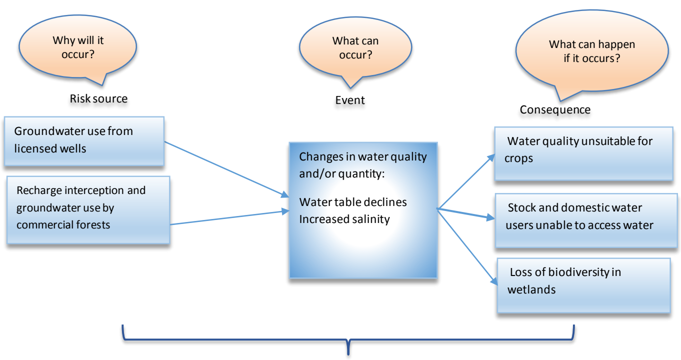
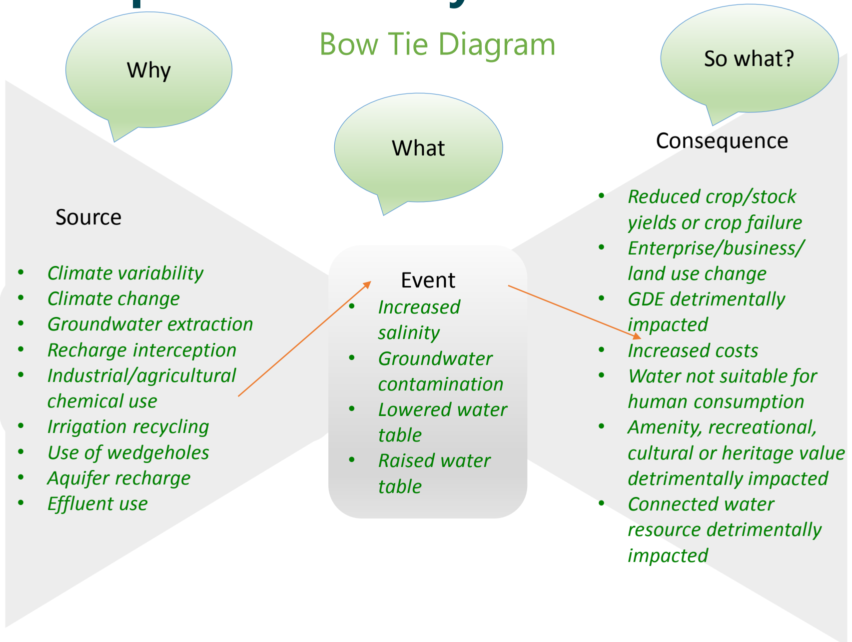
Some examples: DEW draft guidelines



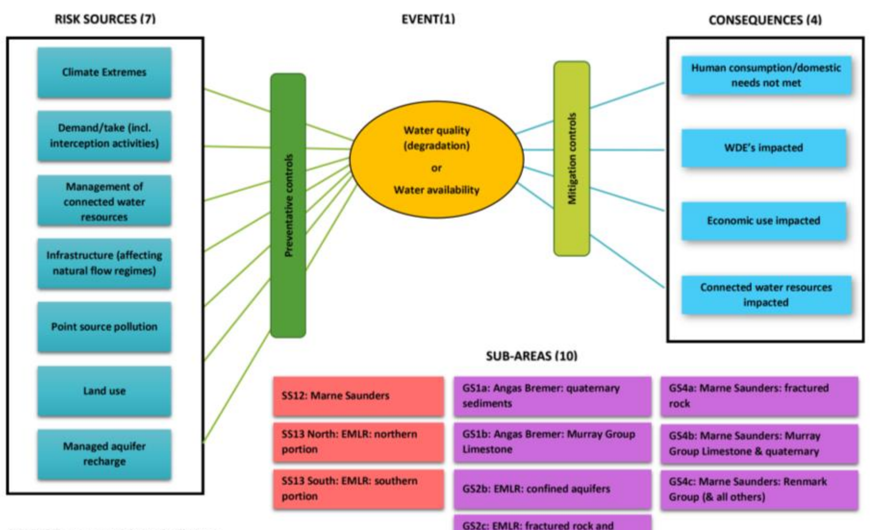
Risk statements

- There is the potential that **groundwater use from licensed wells** leads to **changes in water quality and/or quantity** which results in **water quality unsuitable for crops**
- Etc.…

Some examples: Padthaway WAP Review



Some examples: Eastern Mount Lofty Ranges



EMLR risk assessment bow-tie diagram

What does a bow tie diagram look like for McLaren Vale?

Risk sources | Events | Consequences

Area:

-Whole McLaren Vale Prescribed Wells Area, OR
-Assess each aquifer (4)

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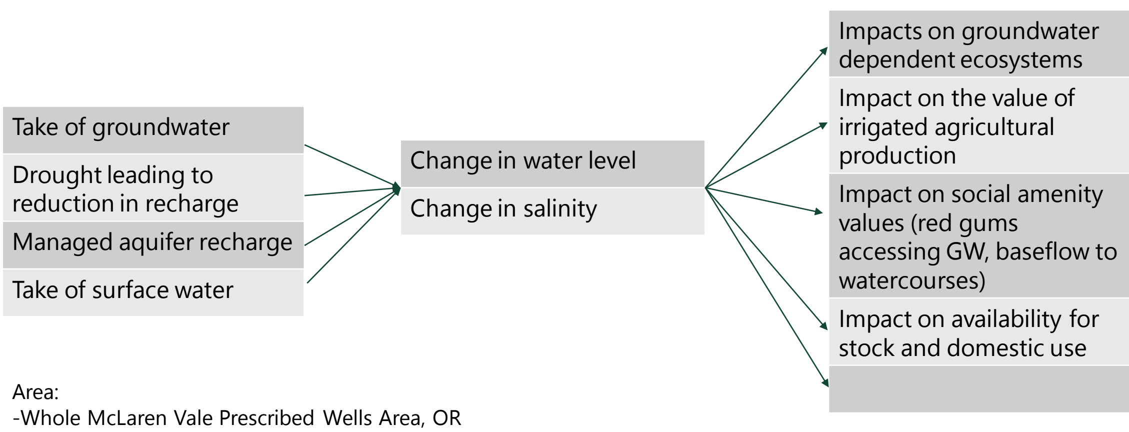
Risk sources | **Events** | **Consequences**



Area:
-Whole McLaren Vale Prescribed Wells Area, OR
-Assess each aquifer (or group them):
- Quaternary
- Port Willunga Formation
- Pirramimma Sands
- Maslin Sands
- Fractured Rock

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Risk Identification – Consequence & Likelihood Tables

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Consequence tables

- Before we start on the risk analysis we need to agree on a consequence table for each consequence in the bow-tie diagram
- Fortunately I have borrowed a few examples

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Consequence tables

Groundwater dependent ecosystems

Consequence category	Descriptor
Catastrophic	Water dependent ecosystem values destroyed or unrecoverable. Up to 80% of species lost.
Major	Significant loss of water-dependent ecosystem values. Up to 60% of species lost. Recovery of ecosystem values not feasible over medium term (less than a decade).
Moderate	Some loss of water-dependent ecosystems values. Up to 40% of species lost. Recovery of ecosystem values is feasible over medium term.
Minor	Some loss of water-dependent ecosystem values up to 10% of species lost. Recovery of ecosystem values is feasible over short term.
Insignificant	Any loss of water-dependent ecosystem values is minimal. Less than 10% of species lost.

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Consequence tables

Economic impact

Consequence category	Descriptor
Catastrophic	Water not available for economic consumptive use purposes. Water allocation <30% for a single year or <50% for two or more consecutive years, or Economic losses from impacts to ecosystem service provision including reduced productivity of non-consumptive economic use and damage to assets and infrastructure with a total value of >$x
Major	Water not available for economic consumptive use purposes having market value $x. Water allocation <50% for a single year or 50–75% for two or more consecutive years, or Economic losses from impacts to ecosystem service provision including reduced productivity of non-consumptive economic use and damage to assets and infrastructure with a total value of $x
Moderate	Water not available for economic consumptive use purposes having market value $x. Water allocation 75–90%, or Economic losses from impacts to ecosystem service provision including reduced productivity of non-consumptive economic use and damage to assets and infrastructure with a total value of $x
Minor	Water Allocation >90 %, or Losses or damage <$x
Insignificant	No losses or damage

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Consequence tables

Community or amenity values

Consequence level	Descriptor
Catastrophic	Complete destruction of amenity value of the resource. Community no longer able to use resource.
Major	Significant destruction of the amenity value of the resource. Most (80)% community uses no longer possible.
Moderate	Amenity value of the resource impacted. Community uses possible but impaired.
Minor	Amenity value of the resource impacted. Community uses possible but slightly impaired.
Insignificant	Amenity value maintained or improved.

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Consequence tables

Availability for stock and domestic use (example from River Murray)

Consequence category	Description
Catastrophic	Interruption of primary supply of water to >100,000 customers for > 48 hours Interruption of primary supply of water to 10,000 – 100,000 customers for an extended period of time (> 1 week)
Major	Interruption to primary supply of water to 10,000 – 100,000 customers for > 48 hours Interruption to primary supply of water to 1000 – 10,000 customers for an extended period of time (> 1 week)
Moderate	Interruption to primary supply of water to 1,000 – 10,000 customers for >48 hours Interruption to primary supply of water to 100 – 1,000 customers for an extended period of time (> 1 week)
Minor	Interruption to primary supply of water to 100 – 1000 customers for > 48 hours Interruption to supplementary non-potable town water supply
Insignificant	Interruptions of primary supply to < 100 customers or for periods of < 48 hours

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Likelihood Table

Rating	Description	Probability
Very likely	Almost certain, expected in all circumstances during the life of the plan	90% to 100%
Likely	Greater than even chance but not certain during the life of the plan	50% to 90%
Possible	Less than even chance but not unusual during the life of the plan	25% to 50%
Unlikely	Unusual but not exceptional during the life of the plan	5% to 25%
Rarely	May occur in exceptional circumstances during the life of the plan	0% to 5%

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Risk Analysis

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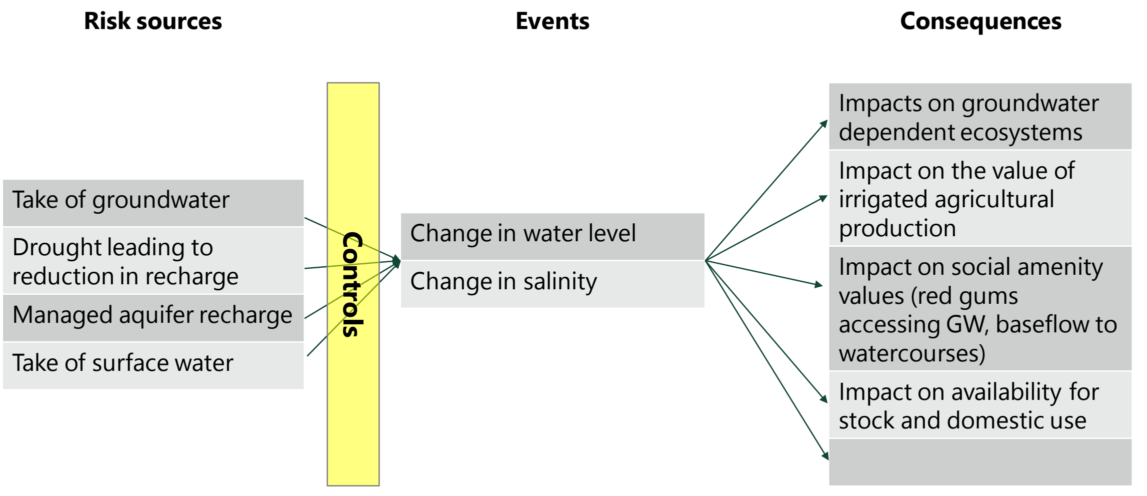

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Risk Analysis

Consequence Level	Percent chance of consequence in 10 years										
Very high	0	10	20	30	40	50	60	70	80	90	100
High	0	10	20	30	40	50	60	70	80	90	100
Medium	0	10	20	30	40	50	60	70	80	90	100
Minor	0	10	20	30	40	50	60	70	80	90	100
Insignificant	0	10	20	30	40	50	60	70	80	90	100

Most likely (60% chance) that the **minor** consequence level will occur over the next ten years, but a 20% chance that the **insignificant** level will occur, and a 20% chance that a **medium** level consequence will occur.

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Risk Analysis

Consequence Level	Percent chance of consequence in 10 years										
Very high	0	10	20	30	40	50	60	70	80	90	100
High	0	10	20	30	40	50	60	70	80	90	100
Medium	0	10	20	30	40	50	60	70	80	90	100
Minor	0	10	20	30	40	50	60	70	80	90	100
Insignificant	0	10	20	30	40	50	60	70	80	90	100

Most likely (70% chance) that the **high** consequence level will occur over the next ten years, but a 20% chance that the **very high** level will occur, and a 10% chance that a **medium** level consequence will occur.

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Risk Analysis

Consequence Level	Percent chance of consequence in 10 years										
Very high	0	10	20	30	40	50	60	70	80	90	100
High	0	10	20	30	40	50	60	70	80	90	100
Medium	0	10	20	30	40	50	60	70	80	90	100
Minor	0	10	20	30	40	50	60	70	80	90	100
Insignificant	0	10	20	30	40	50	60	70	80	90	100

Most likely (70% chance) that the **insignificant** consequence level will occur over the next ten years, and a 30% chance that the **minor** consequence level will occur.

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Risk Analysis

Consequence Level	Percent chance of consequence in 10 years										
Very high	0	10	20	30	40	50	60	70	80	90	100
High	0	10	20	30	40	50	60	70	80	90	100
Medium	0	10	20	30	40	50	60	70	80	90	100
Minor	0	10	20	30	40	50	60	70	80	90	100
Insignificant	0	10	20	30	40	50	60	70	80	90	100

Completely uncertain

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