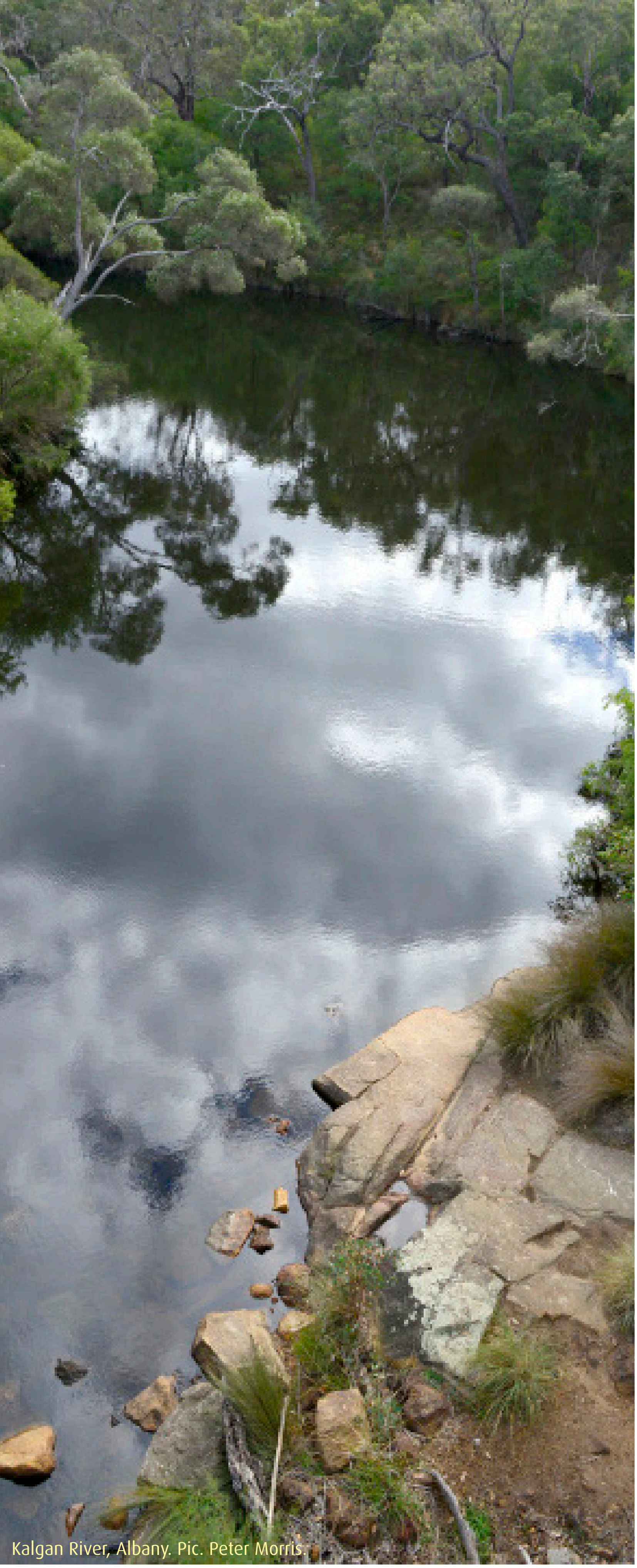
Kalgan River, Albany. Pic. Peter Morris.

Climate Change Adaptation & Water

South Coast Region of Western Australia

A background paper for the Climate Adaptation Addendum to Southern Prospects 2011-2016.
Prepared by Chris Gunby for South Coast NRM.

This project is supported through funding from the Australian Government's National Landcare Programme.

Gunby, C. 2014, Climate Change Adaptation and Water - South Coast Region of Western Australia. South Coast Region of Western Australia. South Coast NRM.

Acknowledgements
The author would like to thank those who provided comment or input on the report including Andrew Maughan (Department of Water), Barb Cook (Centre of Excellence in Natural Resource Management), Miriam Lang and John Simmons (Department of Agriculture and Food), Kaylene Parker and Dylan Gleave (South Coast NRM) and Mark Jendrzejczak (Department of Planning).

Australian Government The Regional NRM Planning for Climate Change project is funded by the Australian Government.

Contents

Foreword

The background papers to the *Climate Adaptation Addendum of Southern Prospects 2011-16* are a series of detailed technical documents on the potential impacts of the South Coast region's changing climate and how people are adapting to it.

The papers were commissioned by South Coast NRM in 2014 and were part of the Regional Natural Resource Management Planning for Climate Change - Stream 1 project of the Australian Government.

The background papers synthesise the current information on the effect of climate change on each natural resource theme, community capacity to adapt and how people are already adapting. They also document some of the gaps.

The papers provide useful background for community consultation through South Coast NRM reference groups. The reference groups have used the papers to develop climate adaptation goals and outcomes for *Southern Prospects 2011-2016.*

South Coast NRM recommends the papers are best read in conjunction with *Fry (2015) A Changing Climate- South Coast of Western Australia* and information on the CSIRO and Bureau of Meteorology Climate Change in Australia website *www.climatechangeinaustralia.gov.au/en/.*

Climate change planning at South Coast NRM will be flexible and adaptive and so information on climate and its impacts will be continually reviewed.

- Kaylene Parker, Climate Change Project Leader, 2015

3 - What we Know - Values & Threats

3.1 - Context & Discussion

The region's water resources and waterways are already highly modified from a natural state.

The most significant impact has been from the clearing of native vegetation for agricultural use and urban settlement.

This clearing has increased groundwater levels, raised water levels in wetlands, increased the rate and amount of streamflow, caused increased erosion and transportation of sediment and increased the frequency of estuary sandbar openings.

Since European settlement, the amount of water in the landscape has greatly increased and climate change impacts and management need to be assessed against this context.

Climate change impacts will vary dependent on the condition of the waterway. In some circumstances climate change may provide beneficial impacts, e.g. on a heavily modified wetland suffering from increased water and salinity levels. A near pristine freshwater wetland dependent on rainfall is likely to be negatively impacted.

In addition to climate change there are other future pressures on water resources, such as population growth, land use changes (particularly agroforestry and urban development) and increased water abstraction.

Climate change needs to be managed in combination with these other factors, at a catchment scale, with a clear understanding of overall water resource objectives Rainfall has been declining in the western part of the region for nearly 100 years and eastern areas are experienced in dealing with low rainfall and drought. The areas of the region likely to be most impacted by reductions in rainfall can learn from these experiences.

Climate change impacts on water resources will be difficult to predict due to complex interconnected relationships.

Direct impacts from changing rainfall and streamflow will be combined with indirect impacts caused by, for example, changing land uses, population shifts, and carbon plantings.

Reduced rainfall could reduce coverage of plantations in some areas, increase coverage in others and encourage new types of plantings for carbon sequestration.

The change in land use and plantings could impact on streamflows in a short period of time. These inter-relationships are complex and variable and highlight the need for state, regional and local planning across all sectors as well as a flexible approach that can adjust to changing circumstances.

There is a need to make the impacts of climate change more 'real' by focusing at an asset level – by focusing on a river or estuary we can better determine and discuss the impacts of climate change.

Carbon sequestration offers an opportunity for the region as it provides a means of encouraging planting at a large enough scale to modify stream flows and groundwater to more 'natural' levels. The potential benefits would need assessment at an individual catchment level.

3.2 - Expected Climate Change

There is detailed information on projected climate change in the background paper– *Fry (2015)* *A Changing South Coast Climate.*Changes in rainfall in the western part of the region have had a large impact on streamflow.

3.2.1 - Rainfall

The region has rainfall data going back to the 1880s in some areas. Albany and Denmark's rainfall increased until the 1920s (using 10 year average trends), but has decreased since. Other locations have different patterns.

Figures from the upper reaches of the Deep River show rainfall declining since peaking in the 1940s and the 1950s. Measuring rainfall change is problematic as it is dependent on identifying different periods to compare.

The Department of Water (DoW) compared the period 2000-2006 with the long term records for Albany to show a recent 13.2 per cent decline in rainfall. A near identical result was provided for Denmark. A smaller reduction of 8.6 per cent was determined for the upper Deep River catchment.

Focusing on the past 40 years of data, there has been a 6-8 per cent reduction in rainfall for the Albany – Nornalup area, with Mt. Barker having a 15 per cent decrease *(DoW, WSCWRA in prep.).*
In comparison, annual rainfall in the middle and eastern parts of the region has shown little reduction in some areas, particularly in the centre of the region. Waychinicup, Bremer Bay and Jerramungup show little change in annual rainfall over the past 50 years.

DAFWA compared rainfall periods from 1910 - 1975 with 1976 - 2008 and most areas east of Albany showed only minor differences (within 5 per cent) between these periods for the period May - October, but there was increased rainfall of above 10 per cent for the period November - April *(Fry 2014).*

This increased summer rainfall is likely to have impacted on streamflows, but no investigation of this has occurred to date.

Projections of future rainfall have been modelled for only the western part of the region, and for Denmark show a 2-3 per cent reduction in annual rainfall by 2030, and a reduction of 8 per cent by 2085.

For more inland parts of the Great Southern the expected decline in rainfall is 15 per cent by 2030, relative to a 1990 baseline. *(DOW, GSRWP background paper, Climate Change).*

Information on rainfall projections for the middle and eastern portions of the region are limited to interpretation of coarse mapping from national projections, which would indicate limited reductions in rainfall when compared to the south west corner of the state.

Rainfall patterns are expected to change with more variability and intensity of rainfall events, and rainfall decreases mainly occurring due to less winter rainfall *(CSIRO and BOM 2014).*

3.2.2 - Streamflow

Streamflow monitoring has a shorter history than rainfall collection, starting from the 1960s to the 1990s. As such long periods of rainfall and stream flow cannot be compared.

DoW monitoring shows streamflow reduction has been greatest in the west of the region, with the Deep River having recent flows (2000 - 2006) some 33 per cent lower than the 40 years 'long' term average.

There has been a reduction of 25 per cent for the Denmark River and 16 per cent for Marbellup Brook. To the east stream flow changes have been minor *(DoW. WSCWRA. in prep).* Streamflow is influenced by many factors other than rainfall, most noticeably by vegetation coverage. The development of plantations will have influenced the Denmark River streamflow reduction (see later).

As the Deep River is within a relatively pristine catchment, climate variability is likely to be the reason for the recorded streamflow reduction.

Although the scale of stream flow reduction is markedly greater than rainfall reduction, this reduction could potentially be explained by changes in rainfall pattern, with less winter rain and less intense events, however this has not been examined. As a rule of thumb, streamflow can be expected to decrease three times the percentage change in rainfall.

Streamflow is expected to decrease by approximately 12.5 per cent in western coastal locations by 2030, and up to 50 per cent for inland areas in the Great Southern area *(DoW, GSRWP background paper climate change).*

The Department of Water has calculated there will be a 12 per cent reduction in the flow of the Denmark River (at Mt Lindesay) by 2030, and a 33 per cent reduction in flow by 2085 using a medium climate change scenario *(DoW. WSCWRA, in prep.).*

CSIRO predicts a 40-65 per cent reduction in flow for the Kent and Denmark rivers, with 20-30 per cent reduction for other nearby rivers *(CSIRO 2009).* In comparison and as a point of interest, the

Department of Water has predicted the growth of existing blue gum plantations will reduce the Denmark River's streamflow at Mt Lindesay by 28 per cent (by 2020). This demonstrates agroforestry can have a greater impact than climate change on streamflows in the shorter term. (DoW, WSCWRA. in prep.).

To date there has been no predictions of impacts on water quality (salinity or nutrients) resulting from climate change.

3.2.3 - Groundwater Levels

The clearing of native vegetation for pasture and cropping that uses less water has increased recharge and increased groundwater levels. Rising groundwater levels are still occurring in the majority of bores located in agricultural areas in the region *(DoW, GSRWP background paper Climate Change and John Simmons pers. com.*).

Groundwater levels in the Albany groundwater area are showing a decreasing trend of 0.5m every 10 years, but it is not possible to determine the impacts of climate change from other factors (such as increased abstraction).

There is very limited knowledge of likely impacts of climate change on groundwater resources – levels or water quality. *CSIRO (2009a)* has undertaken modelling of groundwater levels to the west of the South Coast region and has concluded climate change impacts will vary dependant on the depth of groundwater, type of soil and present interaction with vegetation.

CSIRO predicts climate change will impact on groundwater levels most where there are clay soils and shallow groundwater levels presently accessed by vegetation.

Deeper groundwater overlain by sandy soils will be less impacted. In all cases rainfall recharge will be reduced, but in some inland areas the present rising groundwater levels will not be reversed by climate change.

Although CSIRO modelled groundwater in the Albany area, their conclusion that groundwater levels would reduce was accompanied by an acknowledgement the present model was inadequate for this aquifer and a new model needed to be used.

The lack of understanding of climate change impacts on groundwater levels and water quality is a major information gap at present, particularly given these are major influences on waterway condition in the region.

3.2.4 - Sea Levels & Estuaries

Over the past 7,000 years, sea levels have stayed within a 2 metre-wide band, a remarkably stable period given sea levels were 120-140m lower during the peak of the Ice Age some 20,000 years ago.

Sea-level at Fremantle Port has risen by 20cm from 1897 (1.5mm/year). Since the 1990s the southern coast of WA has experienced increases up to 4.6mm per year – less than the increase on the north and west coast of WA but much higher than on Australia's east coast *(Australian Department of Environment website).* With the sea warming and particularly the melting of the ice sheets, sea levels are forecast to increase well out of their stable recent historical record. The Australian Government has indicated sea level rise will be between 0.5m to 1.1m by around 2100 relative to 1990.

These projections are being constantly revised, with the increased rate of melting of the ice sheets making the upper forecast most likely. Along with sea level rise there are likely to be more frequent storm events and storm surges, as well as changes in currents and wind patterns. For more information please read the background paper on coastal and marine impacts.

3.3 - Likely Impact on Water Resources Value

3.3.1 - Potable Water Sources

Coffey (2009) undertook an assessment of likely climate change impacts and risks for the region. The highest ranked risks to water resources are shown in *Appendix 1* of this report. The most important source of present potable water supplies in the region is contained in the Quaternary dunes and Werrilup Formation along the coast. These loosely consolidated sedimentary rock formations provide a reservoir of groundwater reserves confined by suitable underlying impervious material.

This source provides the bulk of the region's present day reticulated water supplies, including the total supply for Esperance, Hopetoun, Bremer Bay and 80 per cent of the town water supply for Albany and Mt Barker. These groundwater resources will be impacted by projected reduced rainfall and projected increased sea-level rise and risk of saltwater intrusion.

These resources are already fully allocated or highly utilised and subject to increased pressure from population growth which is expected to double for these towns in the next 30 years. The Quickup and Denmark rivers provide Denmark's potable water supply, while Angove Creek is used to supplement Albany and Mt Barker groundwater supplies.

In the past Walpole has used its river for water supply, but more recently groundwater. All these rivers will be affected by predicted higher temperatures, lower rainfalls and reduced streamflows mentioned above. It is important to note only the Quickup dam is a storage dam as such, containing roughly at full capacity three times Denmark's annual water needs.

Supplies from each river are very susceptible to annual rainfall and therefore at high risk of climate variability and change. Even the Quickup dam is susceptible to climate variability and would only be able to meet Denmark's needs if there were no more than two consecutive dry years due to the impacts of evaporation. Several smaller towns are serviced by groundwater bores (e.g. Condingup and Gibson). Other towns are serviced by small roaded or bitumised artificial catchments feeding dams, such as Rocky Gully, Wellstead, Cranbrook and Frankland. Ravensthorpe has a combination of groundwater bore and roaded catchment *(Gunby 2004)*. These inland roaded catchment water supplies are at the greatest risk of climate change, as they are totally dependent on annual rainfall and the predictions for rainfall decline are greater for inland areas. Water loss due to evaporation from these dams is already 50 per cent and higher temperatures will increase this loss. Evaporation impacts on water quantity and quality.

The servicing of roaded and bitumen catchments is challenging due to high maintenance costs of such services and low population base. Costs per kilolitre are already some of the highest in the state (e.g. Borden $40/kilolitre, compared with approximately $2 for Albany *(DoW, GSRWP Background Paper Independent Towns in prep.)*.

Smaller settlements such as Peaceful Bay, Nornalup and individual rural properties are dependent on rainwater, sometimes supplemented by groundwater bores. These supplies are dependent on annual rainfall and at high risk from climate change. The western part of the region has several freshwater rivers that have been, or still are, considered potential new potable water sources.

The use of these rivers for potable supplies is already constrained by land tenure, distance from demand and ecological values. Reduced rainfall due to climate change will further reduce their value as potential potable water resources. Additionally to the direct impacts of reduced rainfall and streamflow, climate change could increase pressure on potable water resources though indirect impacts on land uses and population.

A statewide southwards population shift will place more pressure on existing potable sources. Agro-forestry and irrigated agriculture could seek to relocate to higher rainfall areas. By doing so it will in conflict with existing or potential potable water source catchment area objectives. In short, climate change will have a negative impact existing on potential potable water resources.

Existing and potential freshwater resources will become scarcer, demands will increase, competition for the limited sources will increase from other sectors creating a need to maintain ecological values of that resource by reducing water use.

3.3.2 - Water Supplies for Agriculture & Industry

Agriculture is the dominant land use and water user in the South Coast and as the majority of this is sourced from rainfall, will be the land use most affected by climate change.

Crops, mainly cereal and livestock production comprise the region's main land use and are dependent on seasonal rainfall. Forestry and irrigated agriculture cover only a small percentage land area but are important regional industries.

The biggest change in land use in the past 10 years has been the expansion of the plantation industry. This has significantly impacted on streamflows, with some catchments likely to have experienced a 20 per cent reduction in streamflow during this time *(DoW, WSCWRA in prep.)*.

Climate change will impact on future plantation coverage. With reducing rainfall some previously planted areas may not be viable for agroforestry and plantations may not be replanted causing increased streamflows. New plantations could be located in higher rainfall areas, or carbon plantings could occur and both would decrease streamflows. This highlights the complexity of assessing and managing climate change and the need for local catchment scale planning and assessment.

Above the 600mm rainfall isohyet agriculture land uses are varied, and include irrigated agriculture, forestry and mixed cropping. Below 600mm dry land broadacre cropping and livestock dominate. A change in rainfall will see a change in land use patterns, with a likely westwards expansion of broad acre cropping and a westerly and southwards shift in forestry and irrigated agriculture. Water supplies for cropping and livestock will be impacted by the projected decrease in rainfall levels and seasonal changes. This will place more pressure on emergency water supplies, town standpipes and reticulated water supplies that supplement the normal on-farm water supplies.

Water capture, storage and use will need to be more efficient, so too will irrigated agriculture which mainly depends on local roaded or bitumised catchments.

With the projected changes in inland rainfall, viticulture and olive production around Mt Barker will be affected and a southerly or westerly shift in this land use could occur, dependent on suitable land and growing conditions *(DoW, GSRWPP Background Paper Agriculture)*. Shires in the Great Southern and South Coast NRM region have experienced several drought declarations in recent years with the carting of water.

The South Coast has several major industries also dependent on water supplies. Agricultural value adding industries such as grape processing, timber processing and meat works presently use local surface and groundwater sources, with a high dependence in some cases on high quality water for processing *(DoW, GSRWP Background Paper, Industry)*.

Again, there is a reliance on the capture and storage of rainwater, so climate change and reduction in rainfall could impact on these industries.

Mining, although a potential big water user, is not dependent on rainfall for processing and can utilise lower quality water or undertake desalinisation.

3.3.3 - River & Wetland Ecological Values

Rivers and wetlands have been greatly modified in the region, particularly through changes in hydrology caused by the clearance of native vegetation.

Increased groundwater levels due to increase recharge have brought salts to the surface and increased salinity levels in many rivers and wetlands, particularly in inland and eastern areas. Wetlands have been affected by higher water levels and increased river flows have caused greater erosion and transportation of sediment into downstream estuaries or wetlands, promoting algal growth and impacts on native species such as seagrass. The region still contains some wetlands and rivers in a 'natural' state, within catchments unmodified by vegetation clearing. Some river and wetland ecosystems are also naturally more saline and have intrinsic values. *CENRM (2008)* undertook an assessment of the ecological values of rivers based on their naturalness, diversity and rarity and found two 'eco-regions', one in the east of the region with greater salinity and nitrogen levels, the other in the west based on fresher water quality with a higher species richness.

As these eco-regions are influenced by rainfall, their boundaries are likely to be influenced by climate change. There is no single recognised means of determining the ecological value of rivers and the assessment of climate change impacts needs to recognise the above complexity in present ecological values and distribution.

To simplify is dangerous, but the likely impacts of climate change on ecological values for both rivers and wetlands are probably greater and more negative on presently largely natural and unmodified ecosystems than on highly modified ecosystems.

Wetlands having a high dependence on direct rainfall, such as the palusmont and palusplain wetlands near Walpole (which occur in high rainfall areas on the top and side of hills) will be at risk. These wetland types could be extinguished by reduced rainfall. Freshwater wetlands adjacent to the coast and subject to sea water intrusion could also be greatly affected. Naturally saline wetlands would also be subject to increased salinity levels caused by less inflows and increased evaporation.

Highly modified wetlands would also be impacted by reduced inflows, groundwater inputs, increased evaporation and temperatures. The changes will vary, and in some cases the changes may be positive, particularly if changes in rainfall and temperature cause reductions in artificially high groundwater levels, which reduce inundation and salinity risks. Rivers could be affected by less streamflow, altered seasonal flows, reduced connectivity between pools, less sediment transportation, less flooding of floodplains, decreased water quality due to higher temperatures and stagnation of pools, warmer water and increased evaporation. Flora and fauna could become distressed and certain species, such as fish found only in a few coastal streams, could become extinct if they are unable to adjust to new conditions and move to new locations.

Connectivity, the ease by which species can move between or along waterways, will be a major influence on the impact of climate change on biodiversity values. The more fragmented river stretches, isolated river pools and riparian vegetation all have species less able to move and adjust to climate change. Again, these impacts are likely to have the greatest ecological impacts in rivers in a relatively pristine condition, with species of flora and fauna dependent on natural flows. Small freshwater systems will be highly vulnerable. With some species of fish so localised, the impacts on small coastal streams like Angove Creek will be a concern.

Actual assessments of ecological impacts of climate change are being presently undertaken, at a broad national and more specific regional level. *NCCARF (2013)* identify freshwater fish populations at particular risk in the south west, due to the high (80 per cent) degree of endemism and restricted range.

The Centre of Excellence in Natural Resource Management (CENRM) is presently undertaking research into the vulnerability of aquatic species as a consequence of climate change. Initial work suggests a likely contraction of species distribution, typically to the south and west, with both rainfall and temperature important influences *(CENRM 2013)*.

3.3.4 - Water Supplies for Recreational Use

Climate change can impact on recreational use by affecting the abundance and quality of river flow and quality, by impacting on coastal foreshore reserves and by altering water levels in wetlands.

Climate change will also put additional pressure on reticulated public water supplies and priority will be to maintain potable water demands. Other uses, such as the watering of public open space, football ovals, golf courses and playing fields may no longer be able to utilise these supplies.

This is already the case with many inland and eastern towns. The loss of water supplies for public open spaces and recreational grounds has been identified as a major risk by local governments in other regions. For example the South Metropolitan Council's assessment of climate change risks identified the loss of watering public open space the highest risk within their area *(GHD 2009)*.

Maintaining recreational facilities in most South Coast towns is a high priority for communities who see their local oval, cricket pitch or public open space as a fundamental part of the town's character. Many towns with stable or declining populations see the retention of these facilities as essential in order to save the town's identity and existence *(DoW, GSRWP Background Paper Recreation in prep.)*.

3.3.5 - Coastal Foreshores & Estuaries

Note: This paper includes consideration of climate change on estuaries and coastal foreshores, but not on coastal marine waters.

Coastal Foreshores

Sea-level rises and increased storm events are most likely to cause erosion and flooding where there are beaches, estuaries and adjacent low lying areas, such as wetlands.

With coastal scenery dominated by beaches and estuaries and the largest towns located near such features, the South Coast region is vulnerable to sea-level rise.

Most reports focus on impacts on development, with the Australian Government website predicting 20-30,000 buildings at risk in WA. The main risk areas being Mandurah, Rockingham and Bunbury.

The Australian Government advises only 200 buildings are located within 110m of the coast in Albany *(Australian Government 2009)*. No detailed surveys have been undertaken for the region and detailed mapping of predicted sea level rises has not occurred across the region's coast.

This focus on property protection and development setbacks is to be expected, but from an NRM perspective of equal concern is the loss of coastal foreshore reserves. As vulnerable coasts erode, important vegetated corridors can be lost through either erosion or works to prevent this erosion.

The coastal foreshore reserves provide an important biodiversity corridor and visual backdrop, as well as important recreational areas. Loss of these areas from sea level rise will be greatest where the existing foreshore areas are adjacent to beaches. Opportunities to expand these reserves and biodiversity corridors will be most limited where the existing reserves are narrowly constrained by agricultural land or urban development.

Examples would include Esperance beach front and Albany's Middleton Beach and Two Peoples Bay. The environmental values of these areas is at most risk from climate change as adaption options are more restricted, and particularly within urban areas protection works are likely to be favoured that can compromise these values (such as at Emu Point in Albany).

Estuaries

Rainfall and streamflow have a major bearing on estuary character in the South Coast region. The only 'permanently' open estuary (Nornalup Inlet) is kept open by the high rainfall and stream flow found in the west of the region.

As rainfall levels and streamflows decline to the east, the frequency of sandbar openings decline from seasonal (such as Wilson Inlet and Torbay Inlet) to infrequently (Wellstead and Stokes) to permanently closed systems. With climate change reducing rainfall and streamflow, this pattern is likely to change.

In time, Nornalup Inlet will likely become a seasonally opened estuary and present annually opened estuaries will open infrequently, and some systems may close completely. Saltwater intrusion into the estuaries will be less frequent and salinity levels in estuaries will be more variable, as rainfall events and evaporation combine to create more extreme conditions.

Sea-level rise is predicted to also increase water levels in estuaries, either caused by seawater intrusion (when a sandbar is breached) or due to flood waters building up behind the higher sandbars. These impacts are complex and will need to be assessed on each estuary, based on predicted sea level rise and rainfall/streamflow changes.

However, to generalise, changes to estuaries can be predicted by looking to the east – estuaries will have more infrequent openings, will have wider ranges in salinity ranges due to increased impacts of evaporation and will have a wider range of water levels. This will impact on visual values, commercial and recreational fishing, recreation and biodiversity values (with less marine dependent species).

It is important to note that present estuary openings are highly modified. The frequency of openings has increased as a consequence of catchment vegetation clearing, increased streamflows and drainage. The present opening frequency has already been greatly influenced, as has water quality and for 11 of the region's estuaries artificial breaches of the sandbars already occurs *(Gunby 2004)*. *Coffey (2009)* listed decreased inflows into estuaries as the second highest risk to water resources in the region.

4 - Managing the Impacts - Achievements

4.1 - Water Supplies for Potable Use

Responding to the pressures on potable water resources is already well advanced, given these scarce resources are already under pressure from population and economic growth.

In 2007 the State Water Plan set a target of 100 kilolitres/person/year for potable water use. At the time, residents in Perth were using 106 kilolitres, 44 per cent of which was used outside the home. The Water Corporation has advised water use in Walpole is 109 kilolitres, Denmark 111 and Albany 143 kilolitres. *(Water Corporation 2010).*

Statewide initiatives to reduce potable water use have included garden sprinkler restrictions since 2007, a leak detection program and water efficiency plans for larger businesses, all managed by the Water Corporation. Building codes require the use of water conservation measures such as dual use toilets. The DoW is responsible for the preparation of water conservation plans with local government authorities.

The Australian Government has also previously managed a rebate scheme for various water saving devices. *(DoW, GSRWP – Background Paper Water Conservation).* The government is also considering a new suite of water resource management legislation that better considers climate change, by enabling statutory water allocation plans that can base water entitlements on a share of a resource, allowing for reductions in entitlements as climate changes.

At a policy level, the preparation of water allocation plans are required to consider the impacts of climate change on a resource and ensure consumptive water use is managed to maintain environmental values. At a sub-regional level, the government has undertook investigations, public consultation and developing strategies to ensure public water supplies are securely provided, particularly in the lower Great Southern.

An assessment of all potential water source options has been undertaken in the sub-region and the likely impacts of population growth, land use change and climate change undertaken *(DoW, WSCWRA in prep).* The Water Corporation has undertaken consultation on possible means of meeting future public water supplies for Walpole, Albany, Mt Barker and Denmark *(Water Corporation 2010)* and the DoW has provided policy and strategic advice on how these public water supplies will be met *(see DoW, LGSWRDS 2010 and DoW, GSRWSS in prep.).* Although investment and infrastructure decisions are yet to be made for some of these new sources, it is clear the preferred options are more climate resilient.

The proposed use of coastal desalinisation to supplement groundwater resources in Albany and the use of a number of different sources as proposed for Albany, Denmark and Walpole are in part based on the need to provide security in times of reduced rainfall. Single surface water sources are not favoured, given the increased likelihood of reduced rainfall, streamflow and limited storage. The Water Corporation's *Water Forever – Lower Great Southern* initiative demonstrated there is strong public support for reduced per capital water use.

Reduced water use has been promoted by the corporation using statewide water efficiency programs and in addition behavioural change programs, residential and business retrofit and leak detection initiatives have been undertaken in selected areas. The corporation also introduced a rainwater tank incentive program for non-potable use.

The potential impact of these water reduction measures on water use is considerable, with rainwater tanks alone able to save 20 per cent of the average household's water consumption. The success of these schemes has not been formally assessed but the water demand for Albany has not grown noticeably in recent years despite population growth. This would suggest water use per person has fallen and the corporation's initiatives are successful.

Public water supply planning for inland towns has focussed more on infrastructure (rather than source) planning, but still with regard for climate change amongst other criteria. The extension of regional integrated supply schemes, for example the extension of the lower Great Southern Towns Scheme to Cranbrook, provides one means of ensuring reliable water supplies.

Other options include the provision of shade cloth or other coverings for towns relying on bitumen or roaded catchments (which can reduce evaporation by 75-95 per cent), or resurfacing of the catchments with new impervious surfaces such as plastic liners. However, the cost is potentially $1M for each covering.

Water supply costs for each town are already very high relative to other towns, so there has been a strong need to prioritise works. Cartage of water is preferred for many towns rather than refurbishment of existing dams. The cost of infrastructure upgrades planned for the Great Southern region amount to $580M over the next 10 years and there will be pressures to reduce this expenditure given the global economic situation (*DoW, GSRWP, Background Paper, Independent Towns).*

As a consequence of costs, there has been limited infrastructure improvement to many inland town water supplies. Water cartage has been preferred in some cases.

There are many outstanding examples of water re-use, conservation and use of alternative water sources at a local level that reduce reliance on reticulated water supplies. The usual challenges of a variable and dry climate in inland and eastern areas have promoted normal practices that minimise water use and wastage.

Many inland towns use captured stormwater to use on public open spaces or football ovals (e.g. Gnowangerup). Domestic treated wastewater is re-used on a vineyard in Mt Barker and Jerramungup uses a combination of native plants and artificial surfaces to avoid having to water its public open space.

The shires of Gnowangerup, Jerramungup and Plantagenet have local planning policies promoting the use of rainwater tanks to reduce demands on potable water. Tanks are also used on all new council buildings.

The Shire of Cranbrook has undertaken investigations into the use of inland desalinisation as a means of providing water for industry, and the southern link of four local governments in the mid-Great Southern have joined together to investigate better options for stormwater re-use.

Across the region there is considerable work at a policy and operational level aimed at reducing use of reticulated water supplies, by using alternative water resources, improving water conservation and water reuse. This all has NRM benefits by reducing pressures on our natural water resources, both those presently used and potential new sources for potable water sources.

4.2 - Water Supplies for Agriculture & Industry

Managing water supplies for agriculture in a drying climate faces the same challenges as potable supplies to inland towns; the challenge of effective collection, storage and minimising wastage.

The difference is it is mainly undertaken by individual landowners, making investment decisions even harder. Government assistance is provided in a number of ways.

The DoW administers a *Farm Water Supply Scheme* in areas of less than 600mm rainfall and a *Farm Water Rebate Scheme* with a contribution of up to $15,000 and 50 per cent of the cost of capital on farm projects aimed at drought proofing farms. A *Community Water Scheme* provides higher levels of support for community off-farm supplies.

Drought emergency water response plans are prepared at shire level and emergency measures (such as the carting of water) can be provided when there are declarations of deficiency.

Plans exist for all shires in the eastern half of the region *(DoW, LGSRWP background paper Agriculture in prep).* Presently the *Farm Water Rebate Scheme* does not extend to farms on reticulated water supplies. This, along with access to town standpipe supplies, puts pressure on public water supplies in drought. Additional emergency water supplies have been provided through the use of ex-Water Corporation dams.

The Department of Agriculture has prepared water management plans for certain inland towns as part of the Rural Towns *Liquid Assets Scheme.* These plans have been valuable in providing integration of different water resource issues, such as linking emergency water supply options with rural towns' stormwater management, the management of rising groundwater levels and shire water supplies for public open space.

Using groundwater as an alternative source is generally not possible in inland areas due to pumping and desalinisation costs.

A study by URS in 2011 commissioned by the DoW, estimated water costs of between $2-50/kilolitre, with the cheaper costs based on larger scales of production and fresher water sources.

Presently only mining has the appropriate scale and resources to utilise desalinisation, but with technology changes smaller organisations could use this in the future to provide water supplies. Desalinisation of groundwater has been investigated by the Shire of Cranbrook as a source for industry.

Viticulture operations have also investigated it, but to date groundwater use is still mainly limited to freshwater aquifers nearer the coast. A way of coping with climate change has been to move to higher rainfall areas - the plantation industry being an example, with marginal rainfall areas being not replanted.

4.3 - River & Wetland Ecological Values

There is a long history of waterways management in the region, The eutrophication of estuaries has been a driving force for much of this work in the west of with the inundation and loss of riparian vegetation of the wetlands near Esperance another focus.

River restoration activity has focused on maintaining the values of downstream estuaries, or in improving the values of rivers as biodiversity corridors.

This work has been valuable. By revegetating streamlines, planting and rehabilitation will also assist in shading of minor streams, lowering water temperatures and easing one of the impacts of climate change. This is particularly important on west-east stretches of river, particularly on the northern bank, as this would maximise temperature reductions *(Davies 2010).*

Most catchment rehabilitation works to date have not been aimed at restoring or achieving target streamflows, groundwater levels or salinity levels, or undertaken at a scale where such impacts could be achieved.

The main exceptions have been within the salinity recovery catchments of the Kent and particularly Denmark River, although the focus of this work is to restore public water sources to potable water quality.

Catchment vegetation controls introduced since the 1970s have been used to maintain vegetation cover to address rising groundwater and salinity levels. For the Denmark River, the development of bluegum plantations on more than 5,000 ha of the upper catchment has led to river flows falling from 23GL to 17GL and salinity from 735 mg/L to 410 mg/L.

Drainage and revegetation is also being undertaken to better achieve a more 'natural' water balance for the Esperance lakes, with lowering of the wetlands to counter the impacts of increased inundation caused by rising groundwater levels. The Denmark and Lake Warden catchments are unusual in that they have specific hydrological objectives, with regards to flows, salinity or water levels. Most catchments do not have such objectives and this makes the assessment and management of climate change challenging. An example of protection work undertaken has been the assessment of ecological values and environmental flows for Marbellup Brook and the Denmark River.

These assessments were undertaken to ensure adequate flows are maintained to retain ecological values, should the water source be developed for public water supplies and has included modelled projections of climate change.

The removal of obstacles within rivers of high ecological value has also been undertaken and will be important with climate change.

The movement of aquatic flora and fauna will be important to allow such species to move and cope with variable rainfall, so the removal of obstacles such as dams or spillways, or the introduction of fish passageways (as provided for the Goodga River), will be beneficial.

The provision of 'green corridors' is very important for biodiversity, allowing movement of flora and fauna. The macro-corridor concept and implementation (such as Gondwana Link) have often been based on rivers given they often have reserves and are linear in nature. These corridors will provide a level of resilience against climate change impacts.

The National Climate Change Adaptation Research Facility (NCCARF) is guiding research on the likely impacts of climate change and has undertaken broad assessments of impacts across the country.

This has included broad assessments of the changing nature of Ramsar wetlands and on the perennial nature of rivers (the south-west shows most changes). This work has predicted species richness decline in the south-west. NCCARF has provided guidance on the value of climate change 'refuges' and on their identification (NCCARF 2013) and CENRM is furthering this work in assessing the vulnerability of species to climate change in the region and identifying 'refugia' where species are most likely to be able to survive the impacts of climate change. The identification of the species and the areas most likely to offer longer term viable protection for threatened species will allow targeted management responses to the impacts of climate change on aquatic biodiversity *(Barb Cook per. comm).*

4.4 - Water Supplies for Recreational Use

Existing management responses to ensure supplies for recreational water are met in a drying climate have been covered in the section on potable water supplies.

A major theme of reducing impacts on potable supplies has been to reduce demand on public water supplies for non-potable needs, such as for the watering of public open spaces and recreational grounds. Inland towns such as Gnowangerup have used stormwater collection from the townsite and airport runway to meet the needs of recreational facilities. Again, with reduced rainfall these supplies may be at risk.

The Shire of Jerramungup has used artificial grass within its public open space and many inland areas use non-grassed golf courses and other public areas.

Existing low rainfall area towns have a very different attitude to watering of public facilities than the higher rainfall areas in the west and coastal areas. There is less expectation of watering of public open space and gardens and road verges are often not watered, with water having a higher perceived value. Public attitude and expectation is framed based on a knowledge of water scarcity and highlights the importance of community education and engagement.

4.5 - Coastal Foreshores & Estuaries

The Australian Government has provided information on expected sea level rise and has also mapped sea level rise projections for some major cities, including Perth.

The Australian Greenhouse Office in 2006 provided guidance on how coastal risk assessments should be undertaken and through the local Adoption Pathways Program funding has provided grants for councils to undertake such assessments.

The Australian Government recognises there will be challenges in mapping and undertaking risk assessments in regional areas due to capacity issues.

At a state level, the State Government updated the *Coastal Planning Policy* (SPP 2.6) in 2013 and increased the sea level component to a 0.9m sea level rise by 2110, with a horizontal allowance of 90m (in addition to normal development set-backs).

The policy provides a hierarchy of management options for development, including avoidance, planned or managed retreat and protect. The Department of Planning is updating the guidelines to this policy to provide more detailed guidance on how to undertake coastal vulnerability assessments *(Mark Jendrzejczak per com).*

At local government level Mandurah and Cottesloe have undertaken first stage coastal risk assessments and drafted adaption measures.

Within the South Coast region, *Coffey et al. (2009)* provided a landscape scale assessment of climate change, including a coastal vulnerability assessment.

The mapping of sea-level rise was undertaken, but due to deficiencies in data only a 2m increase was shown on a large scale map. This revealed considerable impacts on Esperance in particular and to a lesser extent Albany.

The mapping showed areas at risk were in low lying areas close to the coast, such as around lakes and wetlands.

Coffey et al. (2009) recommended coastal vulnerability mapping and risk assessment be undertaken for existing development areas and the identification of facilities at risk (including reserve loses) and recommended estuary management to consider climate change.

No detailed coastal vulnerability assessments have been undertaken for the South Coast, although these have been identified as a priority in the Great Southern and Esperance and Goldfields Planning and Infrastructure Frameworks.

The Department of Planning has indicated funding for this work is not presently considered a priority *(Mark Jendrzejczak per com)*. As stated previously, much of the coastal policy and vulnerability mapping has focused on development and infrastructure and not on natural values such as biodiversity, vegetation corridors or recreational values. Given that in most cases foreshore reserve width is determined by the need to protect these values (rather than protect development), there needs to be more consideration of the ecological and amenity impacts of sea level rise and coastal erosion.

Estuary management activities specific to climate change has been very limited. Some shires (e.g. Denmark, Albany) have planning policies catering in part for sea level rise (for new developments).

The impact of climate change on South Coast estuaries and how this needs to be managed has received little attention to date, although estuaries are likely to be most at risk of change as a consequence of sea-level rise and reduced rainfall and stream inputs.

5 - Gaps

There has been considerable work with regards to managing water resources, particularly with planning of potable water resources and water conservation levels, but there remain other priorities.

5.1 - Measures & Monitoring

The existing monitoring of water resources will need reviewing and revising to ensure it's possible to detect the impact of climate change.

Monitoring will be needed in catchments not affected by other factors and include detecting change to priority assets at risk such as shallow freshwater wetlands.

The impacts of climate change on rainfall, streamflow and salinity levels needs to be mapped at catchment level. Present modelling is coarse and broad-scale and needs to be viewed from a local scale to assist with management. The impacts on salinity need to be determined and considered in existing management.

The impacts of climate change on estuaries is particularly complex, given the interaction of sea level rises, sandbar management and reduced streamflows.

These impacts need examination at an asset level, with the Nornalup, Walpole and Wilson inlets suggested as priorities. Impact on biodiversity - species richness and individual species needs to be identified and mapped and climate refugia need to be identified.

5.2 - Planning

Existing water resource plans need to be reviewed to ensure they incorporate climate change considerations.

Waterways at most risk of climate change need to be identified and management plans prepared to identify the likely impacts.

Potential benefits of carbon plantings need to be maximised through identification of priority catchments that can benefit from planting in order to restore more natural hydrological regimes, whilst not impacting on their values (eg as potential sources of potable water). Drought response plans and emergency water sources need to be prepared for all local government areas subject to rainfall below 600mm.

The impact of sea-level rise has only been assessed broadly and more detailed mapping of predicted sea-level rises is needed at Esperance and Albany townsites.

5.3 - On-ground Management

The use of water conservation, reuse and use efficiency needs to be maintained for all water supplies – much is already happening but this needs to be maintained.

Potential use of carbon planting as a means of restoring hydrological balance for modified catchments and increasing connectivity needs to be maximised. Climate changes needs to be recognised when undertaking river rehabilitation works. Some waterways will be lost as a consequence of climate change.

Shading of watercourses is important to reduce temperatures. River pools will be important refuges.

Once identified, climate refugia will need management actions for enhancement and protection, this may include fencing, planting and land tenure matters.

5.4 - Capacity

The community's knowledge of climate change and its management including the need to conserve water, varies.

There needs to be an increased education program about the impacts of climate change. Best practice management, for example on water conservation, is being undertaken but there is limited sharing of this information, partly as there are limited forums to use. The spreading of best management practices needs to occur and mechanisms set-up to facilitate this for industry, government and community.

6 - Measures & Indicators

Southern Prospects 2001-2016 provides details of measures and indicators for water and *Table 10* a comprehensive list of recommended indicators. Of key relevance for assessing climate change impacts will be monitoring for streamflow and groundwater levels in areas unaffected by other processes.

Priorities are likely to include freshwater systems in the west of the region, particularly wetlands and rivers dependent on local rainfall (rather than larger recharge areas and aquifers). This monitoring would need to tie in with biodiversity indicators of species health and diversity. A monitoring program would need to be developed to ensure climate changes are determined

Other monitoring would be required at a specific asset or management level (for example, sea-levels in Albany and Esperance and groundwater and streamflow in areas of extensive vegetation plantings to assess impacts on the hydrological processes.

7 - Further Reading

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APPENDIX

Coffey et al. (2009) results of South Coast Climate Change Risk workshop - Surface and Groundwater.
Risk ratings based on assessment of potential consequence and likelihood.

Assessment of the risks and how they are to be managed is required. This needs to include the impact on NRM assets and values. Note: only risks of 7+ are shown here.

RISK	RATING
Loss of coastal water bodies and resources due to seawater intrusion	9
Reductions to estuarine (wetland water inflows)	8/9
Drying of wetlands	8.5
Loss of rivers due to drying climate	8
Increased cost/feasibility of water infrastructure (bores/storage)	8
Loss of aquatic flora and fauna due to drying climate	8
Water supply shortages due to ecological requirements	7/8
Water supply shortages due to reduced run-off and flows	7/8
Reduced water quality/quantity due to algal blooms, nutrients	7
Water supply shortages due to lower groundwater levels	7
Water supply shortages due to saline intrusion into aquifers	7
Loss of aquatic flora and fauna due to rising salinity	7

water

land

coastal
and
marine

cultural
heritage

biodiversity

Layout & design by Peter Morris/Morris Design & Communications 02/16 - 0466 647 410