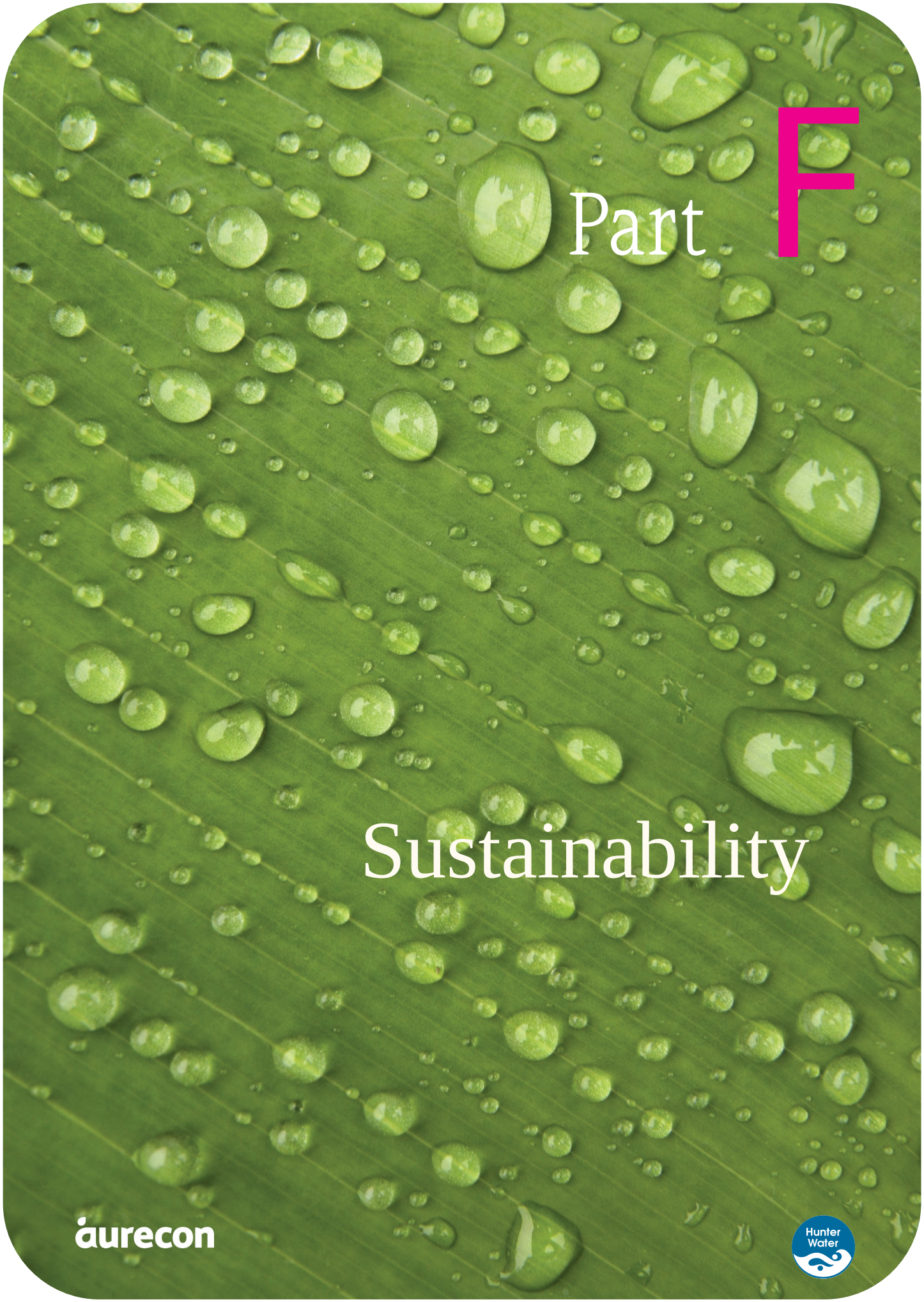
Part F
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19

Climate Change and Greenhouse Gas Emissions

This chapter discusses the relationship between the Tillegra Dam project and climate change issues. Climate change legislation, policy and case law relevant to the Project are summarised. The chapter discusses predicted impacts of climate change to Australia and the Hunter region, and evaluates potential climate change risks and opportunities to the Project. The potential contribution of the Project to climate change is assessed through estimation of its greenhouse gas emissions associated with its construction and operation. Possible mitigation and adaptation measures for the Project are also discussed.

19.1 Policy and legislative overview

19.1.1 Overview

A key factor contributing to climate change is the release of greenhouse gases into the atmosphere. Human activities have resulted in an increase in the concentrations of gases such as carbon dioxide (CO_2), methane, nitrous oxide, sulphur hexafluoride, perfluorocarbons and hydrofluorocarbons. Impacts resulting from the release of these gases include changing weather patterns and sea level rise (Commonwealth Scientific and Industrial Research Organisation 2004, Natural Resource Management Ministerial Council 2004). Although the release of greenhouse gases may be at a local scale (such as CO_2 released from electricity generation activities), climate change impacts are borderless and occur at a global scale. Importantly, there is a significant level of uncertainty associated with these impacts (Australian Greenhouse Office 2005a and 2006).

19.1.2 International

The global context of climate change requires international efforts, including the development of international policy and legal frameworks, to address the issue. The two main international instruments relating to climate change are the United Nations Framework Convention on Climate Change 1992 and the Kyoto Protocol 1997.

In 1992, a number of countries joined the *United Nations Framework Convention on Climate Change* (UNFCCC) which aims to facilitate global action on climate change and the associated impacts. A number of countries subsequently ratified the 1997 Kyoto Protocol including Australia on 3 December 2007. The Kyoto Protocol is an additional instrument to the UNFCCC that has had legally binding measures since 2005. There is a compliance mechanism associated with the Kyoto Protocol applicable to ratifying countries including Australia. The compliance mechanism allows for the suspension of eligibility should a signatory fail to meet protocol requirements.

For Australia, ratification means that emission reduction targets will need to be met and the fulfilment of those targets subject to the compliance mechanism. Recent developments in Federal policy to implement a Carbon Pollution Reduction Scheme and the establishment of the National Greenhouse and Energy Reporting System (NGERS) indicate a response to obligations under the Kyoto Protocol.

The *Asia Pacific Partnership on Clean Development and Climate 2006* (AP6) is an international non-binding agreement between Australia, India, China, South Korea, Japan and the United States. This agreement facilitates cooperation to address climate change through the transfer of clean technologies to promote energy security and to reduce national greenhouse gas (GHG) emissions while ensuring economic growth. Although AP6 does not provide binding targets, the agreement provides a platform for agreements and negotiations that could benefit a reduction in GHG emissions at a global scale (Committee for Economic Development of Australia 2007).

19.1.3 National

The current year has seen the commencement of the National Greenhouse and Energy Reporting (NGER) System through the enactment of the *National Greenhouse and Energy Reporting Act 2008*, the release of the Garnaut Climate Change Review Draft Report and the Green Paper on the Carbon Pollution Reduction Scheme. All these initiatives form part of the Australian Government's recent response to climate change that builds upon existing greenhouse initiatives.

National Greenhouse Strategy 1998

The National Greenhouse Strategy 1998 aims to make Australia effective in contributing to the stabilisation of greenhouse gas concentrations. The Strategy provides a number of goals to achieve this including to foster knowledge and understanding of greenhouse issues and to lay the foundations for adaptation to climate change.

National Greenhouse Gas Inventory

An obligation for signatories to the UNFCCC is to provide National Greenhouse Gas Inventories. Australia's National Greenhouse Gas Inventory (NGGI) produced by the Department of Climate Change (DECC) reports on the trends in Australia's GHG emissions for a given time period. The most recent inventory was published in 2005. This reported that Australia's emissions were 102.2 per cent of 1990 levels, largely consistent with Australia's 108 per cent emissions target as prescribed under the UNFCCC in 1992.

Garnaut Climate Change Review

The Garnaut Climate Change Review was commissioned to examine the impacts of climate change on the Australian economy and to recommend medium to long term policies and policy frameworks to improve the prospects of sustainable prosperity. The Review's draft report represents a detailed assessment of the implications of climate change for Australia. A key component of the draft report was a recommended framework to guide the design of the proposed emissions trading scheme. The Garnaut Review is one of a number of 'voices' helping shape the Government's Carbon Pollution Reduction Scheme.

National Greenhouse and Energy Reporting System

The National Greenhouse and Energy Reporting Act 2007 established a mandatory corporate NGER System for GHG emissions, energy consumption and production. From 1 July 2008, corporations are required to register and report for the 2008-09 financial year if:

- they control a facility that emits 25 kilotonnes or more of greenhouse gases (CO_2 equivalent), or produce or consume 100 terajoules or more of energy, or
- their corporate group emits 125 kilotonnes or more greenhouse gases (CO_2 equivalent), or produces or consume 500 terajoules or more of energy.

This legislation also establishes a system that will underpin the proposed Carbon Pollution Reduction Scheme.

Carbon Pollution Reduction Scheme

Fundamental to the Government's climate change response is the development of an emissions trading scheme, the Carbon Pollution Reduction Scheme. The Scheme will place a cap on the amount of carbon pollution industry can emit in Australia. It will require affected businesses and industry to buy a 'pollution permit' for each tonne of carbon they contribute to the atmosphere, giving them a strong incentive to reduce pollution. The ability to trade ensures carbon pollution is reduced at the lowest possible cost. The following is an overview of the mechanics of the Scheme as reported by the DECC (2008):

- the Government sets a cap on the total amount of carbon pollution allowed in the economy by covered sectors
- the Government will issue permits up to the annual cap each year
- industries that generate carbon pollution will need to acquire a 'permit' for every tonne of greenhouse gas that they emit
- the quantity of carbon pollution produced by each firm will be monitored and verified
- at the end of each year, each liable firm would need to surrender a permit for every tonne of carbon pollution the firm produced in that year
- firms compete in the market to purchase the number of permits that they require. Firms that value the permits most highly will be prepared to pay the most for them. For some it will be cheaper to reduce emissions than to buy permits.
- as a transitional assistance measure, certain categories of firms might receive some emissions permits for free. These firms could use these permits or sell them.

19.1.4 New South Wales

NSW Greenhouse Gas Plan 2005

The *NSW Greenhouse Gas Plan 2005* discusses the various frameworks in place within NSW that

address climate change including the *Greenhouse Gas Abatement Scheme* (GGAS). A more detailed description of the GGAS is provided in Working Paper F. The Plan highlights the need for cost effective reduction strategies and adaptation plans to provide solutions in a carbon constrained future. The Plan sets an 'aspirational' 60 per cent emissions reduction target for 2050 and aims to return to 2000 levels by 2025. Importantly, due to the ratification of the Kyoto Protocol, the Plan targets are likely to be revised to reflect a coordinated national approach.

Hunter Central Rivers Catchment Action Plan 2007

The *Hunter Central Rivers Catchment Action Plan 2007* discusses how climate change affects catchment management and provides a set of guiding principles. The Plan recognises that climate change would likely alter natural resources, requiring long-term planning. The guiding principles suggest that the Project should consider changes to natural resources from climate change in the planning, construction and operation of the dam.

A discussion of how climate change impacts could affect the Project, including impacts on water resources, and how the Project would address and/or mitigate these impacts is provided in Section 19.4.2. The Plan also encourages the use of revegetation and carbon credits to address climate change. Carbon offset initiatives proposed for the Project including implementation of the carbon neutral strategy address this recommendation. Details of the strategy are provided in Working Paper F *Sustainable Resource Use*.

Corporate Environmental Management Plan 2008-2013

Goal 6 of HWC's Corporate *Environmental Management Plan 2008-2013*. includes the objective of minimising the environmental impact of HWC's use of energy and GHG emissions. An action identified for this objective is the development of a Greenhouse Gas Emission Strategy for the whole of HWC's operations by the end of 2008. This strategy is still under development.

19.2 Climate change and recent case law

There have been a number of recent court cases relating to climate change in Australia. A discussion of the relevance of these court cases is important in providing the context for the Project's compliance with relevant policy and legislation. In addition, the issues raised in these court cases provide guidance for assessing the potential impacts of climate change on the Tillegra Dam project.

19.2.1 New South Wales

Gray v the Minister for Planning and Ors [2006] NSWLEC 720 (27 November 2006)

One of the recent landmark cases with regard to climate change litigation involved a proposal by Centennial Coal to construct and operate an open cut coal mine at Anvil Hill in the Hunter Valley. The project was assessed under Part 3A of the EP&A Act. The requirements for the environmental assessment included 'a detailed greenhouse gas assessment'. The assessment was based on the Greenhouse Protocol 2004 and listed the assessment of three types of emissions: Scope 1 – *Direct GHG emissions*, Scope 2 – *Electricity indirect GHG emissions* and Scope 3 – *Other indirect GHG emissions*.

The EA Report for the project was approved by the Director-General for exhibition and addressed Scope 1 and 2, but not Scope 3. The Land and Environment Court upheld that the assessment needed to consider impacts which have a '*real and sufficient*' link to the proposed project, and that the mining of coal for predominantly power use was a '*sufficiently proximate link*'. The EA Report was later amended to include Scope 3 assessment.

It was also argued and upheld that the assessment failed to adequately address issues of ESD, in particular inter-generational equity and the precautionary principle with regard to the cumulative impacts associated with coal burning. Consequently, the Minister for Planning's decision to release the EA Report for exhibition was declared to be void and without effect.

This decision focused on the EA process and not on the merits of the project, and approval for the mine was later granted. However, the result of the case did stress the importance of considering principles of ESD (and greenhouse gas emissions) in an EA.

Walker v Minister for Planning [2007] NSWLEC 741 (29 November 2007)

The project in question was for a housing development in Sandon Point, located 14 kilometres north of Wollongong. The proposed concept plan for 285 houses and an aged care facility was assessed under Part 3A of the EP&A Act. A local resident lodged a case against the Minister for Planning for failing to conduct a thorough flood risk mapping of the area. Justice Biscoe ruled that the Minister had failed to consider the possible effects of climate change with regard to flood risks for the proposed coastal development.

Taralga Landscape Guardians Inc v Minister for Planning and RES Southern Cross Pty Ltd [2007] NSWLEC 59 (12 February 2007)

The Land and Environment Court assessed the development application of a wind farm at Taralga, 140 kilometres southwest of Sydney. There were issues surrounding visual and noise impacts as well as threats to wildlife. The Minister for Planning approved the development for 69 wind turbines and related infrastructure but under the condition that two rows of turbines were removed for aesthetic reasons. The proposal was later challenged in court but the development was approved and the condition of removing two rows of turbines was also deleted.

The court considered inter-generational equity and noted the role of energy systems in contributing to greenhouse gas emissions; and that renewable energy systems are an important method of reducing emissions. The court maintained that the overall public benefits outweighed any private disadvantages.

19.2.2 Other States

There have been a number of other legal cases in other jurisdictions regarding consideration of GHG emissions and climate change including:

- *Xstrata Coal Queensland Pty Ltd & Ors*, Re [2007] QLRT 33 (15 February 2007)
- *Wildlife Preservation Society of Queensland Proserpine/ Whitsunday branch Inc v Minister for the Environment and Heritage & Ors* [2006] FCA 736 (15 June 2006)
- *Australian Conservation Foundation v Minister for Planning* [2004] VCAT 2029 (29 October 2004).

These cases and the associated legal reviews demonstrate that the assessment of GHG emissions, climate change impacts and adequate application of ESD principles should be incorporated into the environmental assessment of a project. For the Tillegra Dam project, potential climate change impacts are discussed in Sections 19.3 and 19.4 while the use of the principles and instruments of ESD, including the precautionary principle and inter-generational equity, are addressed through the preliminary sustainability assessment framework developed for the Project (refer Chapter 2).

19.3 Predicted climate change impacts

19.3.1 Overview

The Intergovernmental Panel on Climate Change (IPCC) is considered to be the leading and authoritative voice on climate change science. The IPCC comprises a panel of scientists and researchers who provide advice to governments and industry on climate change. The IPCC has produced a number of reports that have underpinned the development of international and domestic response to climate change. The most recent IPPC *Fourth Assessment Report 2007* asserts that the evidence for climate change is unequivocal, including evidence of increases in global temperatures and the melting of snow and ice.

It is noted, however, that there are inherent limitations to existing knowledge about the climate system and system responses to climate change impacts (eg Australian Greenhouse Office 2006, Preston and Jones 2006, Committee for Economic Development of Australia 2007). Variability and uncertainties in climate systems make outcomes difficult to predict. There are also limitations in knowledge of detailed interactions and interdependencies of climate-affected systems (Australian Greenhouse Office 2005a). However, climate change impact assessment and mitigation actions should not await developments in climate science. The use of the precautionary principle in decision-making processes associated with climate change risk is important as lack of scientific evidence should not be reason to delay activity or response to potential climate change impacts. The precautionary principle has been integrated into the EA for the Tillegra Dam project through the sustainability assessment framework.

19.3.2 Regional

Historic climate change

Australia has a recorded history of climate change and further change is predicted. According to the CSIRO, since 1910 Australia has experienced large variations in rainfall. The east coast of Australia has experienced a decrease in rainfall of 50 millimetres per decade since 1910. A decline in rainfall has also been recorded in eastern Queensland and southwest Western Australia (Commonwealth Scientific and Industrial Research Organisation and Bureau of Meteorology 2007, Natural Resource Management Ministerial Council 2004). The variation in rainfall can partly be attributed to the El Niño Southern Oscillation (Bureau of Meteorology 2008a).

Australia has also experienced temperature variations with an increase in both minimum and maximum temperatures since 1910. Annual mean surface temperature has increased over the last century by approximately 0.9°C. The year 2005 was the warmest year since 1910 with a national average temperature of 22.9°C, 1.1°C above the 1961-90 averages. Higher temperatures and an increase in evaporative potential has produced drought conditions accompanied by heatwaves. Rainfall decline has caused decreases in streamflow across eastern and southern Australia (Commonwealth Scientific and Industrial Research Organisation 2007).

On the east coast of Australia, there have been numerous low pressure systems known as 'east coast lows' that usually bring strong winds and high rainfall such as those affecting the Hunter Valley in June 2007 (Bureau of Meteorology 2008b). East coast lows usually follow El Niño years, particularly when an El Niño is followed by a La Niña. Hail storms have increased in severity, with the April 1999 Sydney hail storm incurring $1.7 billion worth of damage, the most costly hailstorm in Australian insurance history (Steingold and Walker 1999). Over the period 1920 to 2000 the estimated average relative sea level rise around Australia was 1.2 millimetres per year (Commonwealth Scientific and Industrial Research Organisation and Bureau of Meteorology 2007).

CSIRO climate change predictions

The CSIRO has used climate modelling to produce climate change projections for Australia, largely based on IPCC greenhouse gas emissions, concentrations and radiative forcing scenarios. The CSIRO acknowledges the difficulties in making accurate climate change predictions due to unforseen variations in emissions scenarios and the advancement of technology such as carbon capture and storage.

The 2007 CSIRO and Bureau of Meteorology *Climate Change in Australia–Technical Report* projects an annual temperature increase over Australia by 2030 of 1.0°C, with a 0.7-0.9°C increase in the coastal areas and 1-1.2°C inland. The report states that by 2050, annual warming across Australia is predicted to range from 0.8-1.8°C. Precipitation is expected to increase in daily intensity with heavy precipitation events in summer and autumn, and longer dry spells. Changes in solar radiation which can impact on human health, agriculture and infrastructure, are predicted with a range of -1 to +2 per cent variation by 2030. The magnitude of change is expected to be larger by 2050 and 2070. Small changes in relative humidity are predicted as well as an increase in evapotranspiration by up to six per cent by 2030. Drought is predicted to increase, particularly in southwestern Australia. Simulations show up to 20 per cent more drought months over most of Australia by 2030 with up to 40 per cent more droughts by 2070 in eastern Australia and up to 80 per cent more in southwestern Australia (Commonwealth Scientific and Industrial Research Organisation and Bureau of Meteorology 2007).

19.3.3 Hunter Region and Hunter-Central Rivers Catchment

The following discussion of the predicted impacts of climate change in the Hunter region and the Hunter-Central Rivers Catchment utilises the most recent published climate change information provided by the CSIRO in 2007. The report on climate change in the Hunter Central Rivers Catchment indicates that rainfall events are likely to be more extreme, including an increase in the frequency of floods and severe storm events. An extreme rain event is defined as an event where the total rain recorded within a period of consecutive days exceeds a nominated threshold value (Commonwealth Scientific and Industrial Research Organisation and Bureau of Meteorology 2007). A summary of the findings of the report are summarised in Table 19.1.

TABLE 19.1 CURRENT AND PROJECTED CLIMATE CHANGE IN THE HUNTER-CENTRAL RIVERS CATCHMENT

	PRESENT (1990)	PROJECTED CHANGE	
		2030	**2070**
Temperature			
Average	Paterson: 17-32°C	+0.2 - +1.6°C	+0.7 - +4.8°C
	Scone: 17-29°C		
	Williamtown: 18-29°C		
No. days above 35°C annually	Scone: 17	Scone: 19-32	Scone: 24-78
No. days above 40°C annually	Scone: 1	Scone: 1-4	Scone: 2-23
Rainfall			
Annual Average	Paterson: 928 mm Scone: 647 mm Williamtown: 1,120 mm	-7 - + 7%	-20 - +20%
Extreme rainfall		-10 - +12%	-7 - +10%
Evaporation		+1 - +13%	+2 - +40%
No. droughts per decade	3	1-5	1-9
Extreme winds		-5 - +8%	-16 - +24%
No. fire days annually	Williamtown: 16	Williamtown: 17-19	Williamtown: 18-24

Source: Adapted from the CSIRO 2007 report Climate Change in the Hunter-Central Rivers Catchment. Paterson, Scone and Williamtown are located within 32, 85 and 56 kilometres of Tillegra respectively.

The DECC report *Summary of Climate Change Impacts – Hunter Region* released in 2008 after CSIRO's report, notes that for the Hunter Region temperatures may raise in the future by 1-3 ºC. Rainfall will change with wetter summers and drier winters expected. Annual runoff may change by about –5 to +12 percent. The DECC report also notes that while rainfall may increase substantially during summer, at the drier end of the scale predicted, water storages in the Hunter Region risk annual inflow reductions of between 5-10 per cent.

The DECC 2008 report is based on the results of four climate models. A complementary study by DWE considered climate change predictions from 15 different models and noted that runoff estimates could change by ±20 per cent in the eastern parts of New South Wales. Ultimately it is possible to conclude that whilst climate change modelling has improved greatly in the past few years and provides the best available guide for future climate, there is still an element of uncertainty in predicting the impact of future climatic conditions specific to the Hunter Region.

The following section outlines the CSIRO and the DECC's report findings on potential pressures on human life, property and natural ecosystems from climate change.

Impacts on rivers and streams

A reduction in rainfall and higher evaporative demand may cause a reduction in flow rates in rivers and streams. Subsequent runoff from surrounding land coupled with increased water temperature have the potential to cause reduced water quality, a reduction in aquatic biodiversity, potential for eutrophication of waterways and increased potential for algal blooms.

Impacts on agriculture

Decreased flow rates may have a direct impact on both rural and urban water users due to a decrease in water available for irrigation and a decrease in the water entering dam storage areas. Decreases in available water for areas which require irrigation for cropping may offset the advantage of faster growth rates and cause a change in plant species produced. It is also expected that the possible decrease in rainfall combined with increased drying of the soil due to higher evaporation rates would lead to an 8-31 per cent reduction in native pasture growth (Commonwealth Scientific and Industrial Research Organisation 2004).

Impacts on urban environments and infrastructure

Urban environments may suffer the consequences of climate change with increased strain on sewerage and drainage systems during flash flooding, increased road maintenance (expected to rise up to 25 per cent in NSW) and elevated pressure on urban water and energy supplies from higher temperatures and lower average rainfall.

The predicted increase in extreme weather events in the area including floods, bushfires and strong winds has the potential to damage infrastructure and property (Australian Greenhouse Office 2005a). This damage is likely to cause insurance premiums to increase placing added financial pressure on the community. For dams, the increase in more frequent extreme rainfall events may exceed historic design standards. Dam overtopping and failure could have significant short and medium term effects in relation to human and economic losses (Australian Greenhouse Office 2005a).

Impacts on human health

Human health may suffer due to certain climatic changes but improve due to others. It is predicted that there will be a decrease in cold weather-related illnesses but warmer weather may cause an increase in heat-related health problems and could possibly contribute to the southward spread of infectious disease, although the potential for tropical diseases to spread to the Hunter region is likely to be limited (Commonwealth Scientific and Industrial Research Organisation 2007).

Impacts on biodiversity

Changes to the climate have potential to alter biodiversity within the area dramatically. It is likely there would be specific species unable to adapt, other species would be able to adapt and new species suited to the changed climate would have the opportunity to move into the area (National Resource Management Ministerial Council 2004). These changes may bring about a loss of biodiversity within the region and could isolate those species that have adapted due to a lack of other areas that are suitable for migration. The predicted increase in frequency of fires and droughts would place increased stress on flora and fauna species already pressured to adapt to warmer weather and higher evaporation rates. Pressure on wetlands could include higher evaporative demand, salinity and changes in rainfall patterns.

Impacts on forestry

Reduced rainfall, drought, increased fire hazard, pest infestations and soil erosion could adversely affect forest productivity and the sustainability of native forests. Immature forests are particularly susceptible to drought (Australian Greenhouse Office 2005a). Where forests are not water-limited, there may be positive effects from CO_2 fertilisation. Adaptive management is required to provide for sustainable forestry in the face of climate change impacts.

19.4 Climate change impacts and the Project

19.4.1 Climate risk, mitigation and adaptation measures

To assess the potential risk associated with climate change impacts, the vulnerability of the Project to climate change impacts requires consideration. Risk can be defined as a combination of the likelihood of an occurrence and the consequence of that occurrence. Risk can be reduced through the introduction of adaptation and mitigation measures. Consideration of adaptation and mitigation measures for the Project is important given the uncertainty associated with climate change impacts.

In the context of climate change, mitigation measures can be defined as response measures that reduce the emission of greenhouse gases into the atmosphere or enhance their sinks, aimed at reducing their atmospheric concentrations and therefore the probability of reaching a given level of climate change (Australian Greenhouse Office 2006).

Adaptation can be defined as adjustment in natural or human systems in response to actual or expected climatic changes or their effects, which moderates harm or exploits beneficial opportunities (Australian Greenhouse Office 2003). Adaptation plans are supported by the *NSW Greenhouse Gas Plan 2005*. Adaptation measures are likely to reduce the Project's vulnerability to climate risk (Hennessy and Jones 1999).

Table 19.2 identifies the potential climate change risks and opportunities associated with the Tillegra Dam project along with possible mitigation and adaptation measures to address those risks. These risks and opportunities are likely to change as climate change science and risk management capabilities improve. As such, the assessment of climate change impacts on the Project would necessarily be an on-going and progressive process. The list of potential risks and opportunities discussed are therefore not exhaustive. However, the current climate science and supporting documentation provides a sufficient basis at this time on which to assess the Project.

It should be noted that adaptation responses can not always be prescribed due to lack of current information and unpredictable variations in climate change impacts (Australian Greenhouse Office 2003). Therefore, adaptation planning should remain flexible to accommodate unpredicted changes in climate features. Adaptation planning may be facilitated through the NSW Dams Safety Committee process which requires regular monitoring and surveillance of prescribed dams, ongoing assessment of their behaviour and regular review to ensure that they comply with current standards. This includes regular appraisal of hydrological data and potential risks.

TABLE 19.2 POTENTIAL CLIMATE RISK AND OPPORTUNITIES TO THE PROJECT AND POSSIBLE MITIGATION AND ADAPTATION RESPONSES

CLIMATE CHANGE RISK AND OPPORTUNITIES	POTENTIAL MITIGATION	ADAPTATION
Environmental flows		
Reductions in rainfall from climate change could result in changes to environmental flow requirements	Design appropriate review period	Review of environmental flows in 10 years
Water quality		
Increased salinity in the Williams River estuary as a result of sea level rise	Increase fresh water flushing	Ongoing monitoring
Overtopping of Seaham Weir as a result of sea level rise	Raise weir level	Ongoing monitoring
Reduced water quality in the dam and downstream from reduced stream in-flow	Design appropriate review period	Water quality monitoring as part of HWC's Operating Licence
Increased soil erosion and sediment load into dam from severe weather events	Management of riparian zone to filter run-off	Strategies to remove sediment from waterways
Water supply		
Reductions of inflows could reduce fill time and water supply	See Section 19.4.2	See Section 19.4.2
Increased risk of waterborne diseases due to favourable warmer water temperatures for disease carrying insects.	Undertake regular monitoring for water-borne diseases such as E. coli, toxic algae and viruses	Ongoing maintenance and monitoring
Project structures		
Severe weather conditions such as strong winds may affect the stability and safety of buildings	Address in design process	Ongoing maintenance and monitoring
Flooding of roads in extreme rainfall events	Flood-proof infrastructure and plan transport routes and roads	Ongoing maintenance and monitoring
Damage/loss of infrastructure from bushfires		
Increased demand on power supply from extreme heat	Design process Implement ecologically sound hazard reduction programs in natural areas to reduce bushfire risk Investigate alternative power supplies in design process	Conduct risk assessments to identify infrastructure in high-risk fire prone areas and develop protection strategies

CLIMATE CHANGE RISK AND OPPORTUNITIES	POTENTIAL MITIGATION	ADAPTATION
Biodiversity		
Changes in water level may alter effectiveness of fishways	Upgrade design	Ongoing monitoring of fish migration success
Drought conditions may be exacerbated by the proposal and/or increased growth rates with higher CO^2 levels in the atmosphere, favouring exotic species over native species	Planting of hardy native species in proposed revegetation corridor Increase restoration efforts in vulnerable habitats and	Ongoing monitoring of restoration rates in the revegetation corridor
Reductions in the geographic range of species	for specific restricted species. Provide pathways for climate change retreat around the dam	Use mapping data to determine areas of potential habitat loss and gain across terrestrial and aquatic ecosystems
Carbon sequestration		
Increased bushfire risk could incur liability associated with a failed carbon offset system	Use fire tolerant, native species and prepare fire management plan	Maintain and revise bush fire management plan as appropriate
Increased storm severity and strong winds could damage carbon sequestration projects	Implement buffer for plantation protection	Maintain buffer and replace damaged individuals
Predicted water shortages could affect the viability of plantations of tree species that have high water requirements	Use drought tolerant species	Implement waste recycling program for plantation
Increased CO_2 in the atmosphere may increase plant growth rates which may improve the uptake of carbon dioxide in carbon sequestration projects	Ensure forest accounting model accounts for variations in carbon dioxide	Monitor CO_2 uptake in plantation
Growth of certain plant species could be inhibited if temperatures rise	Choose hardy species for use in plantation	Monitor impacts of temperature on the Project
Project management		
Lack of monitoring and review of actions taken to address climate change impacts could reduce ability to adapt	Project manager to allow flexibility in Project for climate change considerations	Project manager to ensure Project incorporates up to date climate change information
Recreation and heritage		
Low dam water levels could inhibit use of water body as a recreational facility	Develop a variety of recreational facilities and activities independent of dam water level	Promotion of recreational activities independent of dam water level
Degradation of contemporary or Aboriginal heritage sites	Consider preserving sites susceptible to climate impacts such as severe winds	Maintenance of heritage sites to minimise risk of degradation

19.4.2 Climate change impacts and water supply

Both the CSIRO and the DECC submit that reductions in runoff and streamflow may affect the capacity of dams to provide adequate drinking water supply (Commonwealth Scientific and Industrial Research Organisation 2004, Australian Greenhouse Office 2005a). Further, the DECC discusses the need for climate risk analysis into the demand and supply estimates of urban water supplies and dams (Australian Greenhouse Office 2005a). HWC has investigated potential climate change impacts coupled with demand and supply issues on water storage levels within the Hunter region. This has been documented in the HWC document *Why Tillegra Now?* (Hunter Water Corporation 2007d).

Due to the potential for rapid decreases in storage levels in the Hunter region, possibly exacerbated by climate change impacts, the Project offers water security and drought proofing for the region's water supply (Hunter Water Corporation 2007d). The Project is an adaptation measure to avoid climate risk, namely the possibility of water supply shortages, to the Hunter region.

19.5 Impacts of the Project on climate change

The potential impacts of the Project on climate change relate principally to the associated GHG emissions. Construction activities are estimated to contribute 36,581 t CO_2-e; a breakdown of the various contributing sources is provided in Table 19.3.

TABLE 19.3 ESTIMATED CONSTRUCTION-RELATED GHG EMISSIONS

PRESENT (1990)	PRESENT (1990)	PRESENT (1990)	PRESENT (1990)
Construction of dam embankment and associated infrastructure			
Electricity	amenities security lighting staff/personnel dewatering relocation of services construction site offices water treatment mechanical generators drilling	300 MWh[1]	360[2]
Diesel/petrol	concrete production dust suppression excavation of materials movement of excavation materials movement of other materials movement of spoil/fill operation of machinery construction site offices waste removal maintenance vehicle dewatering relocation of services water treatment mechanical generators drilling	8,000 kL[3,5]	21,600[4]

PRESENT (1990)	PRESENT (1990)	PRESENT (1990)	PRESENT (1990)
Road construction			
Electricity	bitumen production staff / personnel security lighting	50 MWh[1]	360[2]
Diesel/petrol	dust suppression excavation of fill/aggregates excavation/fill of road area movement of machinery operation of machinery bitumen production	3,500 kL[3,6]	21,600[4]
Construction of pipeline and associated infrastructure			
Electricity	drilling/excavation pump station construction operation of machinery staff/personnel security lighting caretakers cottages	50 MWh[1]	48[2]
Diesel/petrol	concrete production drilling movement of machinery movement of materials pumping station construction operation of machinery	1,750 kL[3,7]	5,075[4]
Total			**36,581**

1. Electricity consumption estimated from the intensity of site work, and previous audits of electricity use on major construction sites
2. Emissions estimate based on the predicted NSW pool coefficient
3. Fuel consumption based on number of heavy vehicles used on site, assumptions regarding the average distance travelled, and fuel efficiency (from NPI Workbooks and the National Transport Commission).
4. Emission factor of 2.7 t CO2-e/kL from the NGA Factors, January 2008
5. Intensity of construction work for dam wall as per Section 7.2
6. Intensity of construction work for road realignment as per section 7.2
7. Embodied energy is not included

Operation of the dam would also incur a certain level of GHG emissions. This has been estimated at 42 t CO_2-e annually, and would be associated with activities such as use of the site office, security lighting, operation of valves and the pump station, use of monitoring and control systems, etc.

During the initial years of operation, the Project would also contribute to GHG emissions through the decomposition of vegetation in the inundation area. This contribution has been estimated at approximately 172,825 t CO_2-e.

The overall estimate of GHG emissions is provided in Table 19.4 as follows broken down by the provenance of emissions (refer Working Paper F *Sustainable Resource Use*).

TABLE 19.4 SUMMARY OF SCOPE AND EMISSIONS FOR THE PROJECT

STAGE	SCOPE 1 (T CO_2-E)	SCOPE 21 (T CO_2-E)	TOTAL (T CO_2-E)
Construction	diesel/petrol: 36,125[1]	electricity: 456[1]	36,581
Operation	decomposition: 172,825[1]	electricity: 1,050[1,2]	173,875
Total	208,950	1,506	**210,456**

1 Scope 1 and Scope 2 emissions are covered by the mandatory reporting provisions of the *National Greenhouse and Energy Reporting Act 2008*
2 This figure is the total emissions for electricity usage over a 25 operational period.

19.6 Carbon offsetting approach

As part of the carbon offsetting approach a mini hydro electric plant is proposed that would have capacity to generate up to 3,000 MW hours of electricity annually. The onsite generation of renewable energy results in a reduction of emissions of 2,910 t CO_2-e per year.

Another key component of HWC's approach to offsetting the emissions in Table 19.4 is the implementation of a carbon sequestration initiative. The proposed carbon sequestration is based on a natural regeneration process, utilising the proposed habitat corridor. The aim of the carbon sequestration initiative is to offset the total residual GHG emissions from the dam following abatement provided by the proposed mini hydro electric plant. Table 19.5 provides a summary of the offset approach as well as an outline of the approximate number hectares and trees required where total emissions are offset over a 25 year period.

TABLE 19.5 SUMMARY OF OFFSET APPROACH

25 YEAR SCENARIO	
Total emissions to be offset	210,456 tonnes of CO_2-e
Mini hydro electric plant abatement	72,750 t CO_2-e total (2,910 t CO_2-e per year)
Residual emissions	137,706 tonnes of CO_2-e
Sequestration rate	249 tCO_2 per hectare[1,2]
Hectares required	553 hectares
Area available for planting in corridor	672 hectares
Residual land available	119 hectares
Trees planted per hectare	600[1] trees per hectare
Trees required	331,800 trees

1 Figure based on expert advice from the Department of Primary Industries (Barton 2009)
2 Nett sequestration rate is 497t per ha, however only 50% is sequestered with a 25 year period. Forest maturity is achieved at 100+ years.

Full details on estimation of GHG emissions and carbon offsetting approach are provided in Working Paper F.

19.7 Addressing climate change impacts

Understanding possible climate change impacts is difficult given limitations to existing knowledge and the complexity and unpredictability of climate systems and system responses. However, research undertaken by the CSIRO suggests a range of climate change impacts ranging from more extreme rainfall events to higher evaporation rates. These predicted impacts have implications for ecosystems, communities, industries and infrastructure, including dams. Despite the uncertainties surrounding climate change impacts, there is a need to adopt the precautionary principle by developing measures to mitigate and adapt to potential climate change impacts.

In adopting the precautionary principle, a number adaptation measures are proposed for the Project. As outlined in Table 19.2, a number of possible measures are identified to address the potential risks and opportunities associated with climate change, including:

- ongoing review of latest climate change scenarios for the Hunter Region
- ongoing monitoring of water quality to ensure effective adaptation responses
- monitoring and surveillance of dam structures (aligned with the NSW Dams Safety Committee process)
- monitoring and on-going management of surrounding aquatic and terrestrial biodiversity
- ongoing monitoring and management of carbon sequestration project.

An important consideration relating to the Project and climate change is that the Project offers water security in a region that is predicted to experience increased evaporation rates, increased number of droughts and increased temperature (Table 19.1). The Project is therefore important to the overall well-being of future populations in the Hunter Region.